ACADEMIC CURRICULA

UNDERGRADUATE DEGREE PROGRAMMES

Bachelor's Degree in Technology

(B.Tech - Four Years)

(Choice Based Flexible Credit System)

Regulations - 2018

Volume – 4

(Detailed Syllabus for Third & Fourth Year Courses)

SRM INSTITUTE OF SCIENCE AND TECHNOLOGY

(Deemed to be University u/s 3 of UGC Act, 1956)

Kattankulathur, Kancheepuram 603203, Tamil Nadu, India

Vision

To emerge as a World - Class University

in creating and disseminating knowledge,

and providing students a unique learning

experience in Science, Technology, Medicine,

Management and other areas of scholarship

that will best serve the world and

betterment of mankind.

Mission

MOVE UP through international alliances and collaborative initiatives to achieve global excellence.

ACCOMPLISH A PROCESS to advance knowledge in a rigorous academic and research environment.

ATTRACT AND BUILD PEOPLE in a rewarding and inspiring environment by fostering freedom, empowerment, creativity and innovation.

Contents (Volume –IV)

ACADEMIC CURRICULA

Humanities and Social Sciences
including Management Courses

Regulations - 2018

SRM INSTITUTE OF SCIENCE AND TECHNOLOGY

(Deemed to be University u/s 3 of UGC Act, 1956)

Kattankulathur, Kancheepuram, Tamil Nadu, India

Course Code	18PDH201T	Course Name	EMPLOYABILITY SKILLS AND PRACTICES	Course Category	H	Humanities and Social Sciences including Management	L	T	P	C
							0	0	2	1

Pre-requisite Courses	Nil	Co-requisite Courses	Nil	Progressive Courses	Nil
Course Offering Department	Career Development Centre	Data Book / Codes/Standards	Nil		

Course Learning Rationale (CLR):	*The purpose of learning this course is to:*
CLR-1 :	*identify problems*
CLR-2 :	*recognize the logical coherence of ideas*
CLR-3 :	*understand the structure and principles of writing*
CLR-4 :	*interpret the structure, organization, tone, and main idea of the content*
CLR-5 :	*hone comprehension skills*
CLR-6 :	*give the right knowledge, skill and aptitude to face any competitive examination*

		Learning			Program Learning Outcomes (PLO)														
		1	2	3	1	2	3	4	5	6	7	8	9	10	11	12	13	14	15
Course Learning Outcomes (CLO):	*At the end of this course, learners will be able to:*	Level of Thinking (Bloom)	Expected Proficiency (%)	Expected Attainment (%)	Engineering Knowledge	Problem Analysis	Design & Development	Analysis, Design, Research	Modern Tool Usage	Society & Culture	Environment & Sustainability	Ethics	Individual & Team Work	Communication	Project Mgt. & Finance	Life Long Learning	PSO - 1	PSO - 2	PSO – 3
CLO-1 :	*solve problems*	*3*	*80*	*75*	*L*	*H*	-	*M*	-	-	-	-	*M*	*L*	-	*H*	-	-	-
CLO-2 :	*grasp the approaches and strategies to find solutions*	*2*	*80*	*75*	*L*	*H*	-	*M*	-	-	-	-	*M*	*L*	-	*H*	-	-	-
CLO-3 :	*organize and articulate ideas clearly*	*2*	*80*	*75*	*L*	*H*	-	*M*	-	-	-	-	*M*	*L*	-	*H*	-	-	-
CLO-4 :	*analyze and evaluate contents critically in multifarious ways*	*2*	*80*	*75*	*L*	*H*	-	*M*	-	-	-	-	*M*	*L*	-	*H*	-	-	-
CLO-5 :	*understand, comprehend and provide logical conclusions*	*2*	*80*	*75*	*L*	*H*	-	*M*	-	-	-	-	*M*	*H*	-	*H*	-	-	-
CLO-6 :	*gain appropriate skills to succeed in preliminary selection process for recruitment*	*3*	*80*	*75*	*L*	*H*	-	*M*	-	-	-	-	*M*	*H*	-	*H*	-	-	-

Duration (hour)		6	6	6	6	6
S-1	SLO-1	*Arithmetic Divisibility Rules*	*Algebra Quadratic Equation*	*Modern Mathematics - Permutation*	*Geometry II*	*Data Interpretation - II*
	SLO-2	*Arithmetic LCM HCF Factors*	*Problem Solving*	*Modern Mathematics - Combination*	*Problem Solving*	*Problem Solving*
S-2	SLO-1	*Sentence Correction*	*Video Profiling*	*Group Discussion - Introduction*	*Group Discussion – Mock IV*	*Interview Skills – Mock I*
	SLO-2	*Practice*	*Video Profiling*	*Group Discussion – Mock I*	*Group Discussion – Mock IV*	*Interview Skills – Mock I*
S-3	SLO-1	*Arithmetic Unit Digit, Squares*	*Commercial Mathematics - Profit and Loss*	*Modern Mathematics - Probability*	*Mensuration*	*Data Sufficiency- I*
	SLO-2	*Problem Solving*	*Problem Solving*	*Problem Solving*	*Problem Solving*	*Problem Solving*
S-4	SLO-1	*Para Jumbles*	*Critical Reasoning – Type I,II and III*	*Group Discussion – Mock II*	*Resume writing – Tips and Strategies*	*Interview Skills – Mock II*
	SLO-2	*Practice*	*Practice*	*Group Discussion – Mock II*	*Resume Writing - Evaluation*	*Interview Skills – Mock II*
S-5	SLO-1	*Algebra Introduction*	*Commercial Mathematics - Discount and Rebate*	*Geometry I*	*Data Interpretation I*	*Data Sufficiency - II*
	SLO-2	*Algebra Linear Equation*	*Problem Solving*	*Problem Solving*	*Problem Solving*	*Problem Solving*
S-6	SLO-1	*Reading Comprehension*	*Critical Reasoning – Type IV,V and VI*	*Group Discussion – Mock III*	*Interview Skills - Introduction*	*Revision*
	SLO-2	*Practice*	*Practice*	*Group Discussion – Mock III*	*Interview Skills - Introduction*	*Revision*

Learning Resources	*1. Dinesh Khattar-The Pearson Guide to QUANTITATIVE APTITUDE for competitive examinations.* *2. Hari Mohan Prasad, Verbal Ability for Competitive Examinations, Tata McGraw Hill Publications* *3. Edgar Thrope, Test of Reasoning for Competitive Examinations, Tata McGraw Hill, 4th Edition, 2012* *4. Norman Lewis, Word Power Made Easy, W.R. Goyal Publications, 2011* *5. Joern Meissner, Manhattan Review, GRE Analytical Writing Guide, Manhattan Review Inc, 2011*	*6. GRE Analytical Writing, Solutions to the Real Essay Topics (Test Prep. Series), Vibrant Publishers, 2011* *7. Wiley's GMAT Reading Comprehension Grail, Wiley, 2016* *8. Manhattan Prep GRE : Reading Comprehension and Essays, 5th Edition* *9. Archana Ram, Placementor, Oxford University Press,2018* *10. P.A.Anand, Quantitative Aptitude for Competitive Examinations, Wiley Publication, 2016*

Learning Assessment

	Bloom's Level of Thinking	Continuous Learning Assessment (50% weightage)								Final Examination (50% weightage)	
		CLA – 1 (10%)		CLA – 2 (15%)		CLA – 3 (15%)		CLA – 4 (10%)#			
		Theory	Practice	Theory	Practice	Theory	Practice	Theory	Practice	Theory	Practice
Level 1	Remember Understand	-	40%	-	30%	-	30%	-	30%	-	30%
Level 2	Apply Analyze	-	40%	-	40%	-	40%	-	40%	-	40%
Level 3	Evaluate Create	-	20%	-	30%	-	30%	-	30%	-	30%
	Total	100 %		100 %		100 %		100 %		100 %	

CLA – 4 can be from any combination of these: Assignments, Seminars, Tech Talks, Mini-Projects, Case-Studies, Self-Study, MOOCs, Certifications, Conf. Paper etc.,

Course Designers		
Experts from Industry	Experts from Higher Technical Institutions	Internal Experts
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2. Mr Ajay Zenner, Career Launcher, ajay.z@careerlauncher.com	*2. Dr. Devamainthan, University of Madras*	*2. Dr.M.Snehalatha SRMIST*
3. Dr.Dinesh Khattar, Delhi University, dinesh.khattar31@gmail.com		*3. Mr Jayapragash J SRMIST*
4. Mr.Pratap Iyer, Study Abroad Mentors, Mumbai		*4. Mr.A.Clement SRMIST*

ACADEMIC CURRICULA

Basic Science Courses

Regulations - 2018

SRM INSTITUTE OF SCIENCE AND TECHNOLOGY

(Deemed to be University u/s 3 of UGC Act, 1956)

Kattankulathur, Kancheepuram, Tamil Nadu, India

Course Code	18MAB301T	Course Name	PROBABILITY AND STATISTICS FOR ENGINEERS	Course Category	B	Basic Sciences	L	T	P	C
							3	1	0	4

Pre-requisite Courses	18MAB201T/18MAB203T	Co-requisite Courses	Nil	Progressive Courses	Nil
Course Offering Department	Mathematics	Data Book / Codes/Standards	Statistical tables		

Course Learning Rationale (CLR):	The purpose of learning this course is to:
CLR-1 :	*To apply the basic rules and theorems of probability theory such as Baye's Theorem, to determine probabilities that help to solve engineering problems and to determine the expectation and variance of a random variable from its distribution.*
CLR-2 :	*To appropriately choose, define and/or derive probability distributions such as the Binomial, Poisson and Normal etc to model and solve engineering problems.*
CLR-3 :	*To learn how to formulate and test hypotheses about means, variances and proportions and to draw conclusions based on the results of statistical tests.*
CLR-4 :	*To understand how regression analysis can be used to develop an equation that estimates how two variables are related and how the analysis of variance procedure can be used to determine if means of more than two populations are equal.*
CLR-5 :	*To comprehend the fundamentals of quality control and the methods used to control systems and processes.*
CLR-6 :	*Acquired the knowledge of probability and statistics and its applications to the respective branches of Engineering.*

Course Learning Outcomes (CLO):	At the end of this course, learners will be able to:	Learning 1	Learning 2	Learning 3	PLO 1	PLO 2	PLO 3	PLO 4	PLO 5	PLO 6	PLO 7	PLO 8	PLO 9	PLO 10	PLO 11	PLO 12	PLO 13	PLO 14	PLO 15
		Level of Thinking (Bloom)	Expected Proficiency (%)	Expected Attainment (%)	Engineering Knowledge	Problem Analysis	Design & Development	Analysis, Design, Research	Modern Tool Usage	Society & Culture	Environment & Sustainability	Ethics	Individual & Team Work	Communication	Project Mgt. & Finance	Life Long Learning	PSO - 1	PSO - 2	PSO – 3
CLO-1 :	*To Pertain the Knowledge of probability concepts, to determine probabilities that help to solve engineering problems. and to determine the expectation and variance of a random variable from its distribution*	3	85	80	M	H	L						M	L		H			
CLO-2 :	*Gain familiarity in deriving probability distributions such as the Binomial, Poisson and Normal etc and apply them tn the problems involving Science and Engineering*	3	85	80	M	H		M	M				M			H			
CLO-3 :	*Acquire knowledge in formulating and testing hypotheses about means, variances and proportions*	3	85	80	M	H							M			H			
CLO-4 :	*Getting the knowledge of Regression analysis, ANOVA and apply them in the problems in Science and Engineering*	3	85	80	M	H	L	M					M	L		H			
CLO-5 :	*Understanding the concept and applications of statistical quality control charts in technology and industries*	3	85	80	M	H	M						M			H			
CLO-6 :	*To solve the problems based on probability and statistics in science and engineering*	3	85	80	M	H							M			H			

Duration (hour)		12	12	12	12	12
S-1	SLO-1	*probability concepts, Types of Events*	*Discrete distributions*	*Sampling*	*Correlation and Properties*	*Introduction and Process Control*
	SLO-2	*Axioms and theorems*	*Binomial distribution*	*Small and large samples*	*Karl pearson's correlation coefficient*	*Types of Control charts*
S-2	SLO-1	*Conditional probability Baye's theorem – without proof*	*M.G.F*	*Hypothesis Testing*	*Spearman's rank correlation coefficient*	*Control charts for variables*
	SLO-2	*Applications- Baye's Theorem.*	*mean*	*Large sample test-Test of significance for single proportion*	*Problems on rank correlation –non repeated ranks*	*Control chart for attributes*
S-3	SLO-1	*Random variables – Discrete case*	*variance*	*Test of significance for difference of proportions*	*Problems on repeated ranks*	*Control limits and drawing conclusions*
	SLO-2	*Probability Mass function*	*Fitting binomial distribution*	*More problems on test 2*	*Linear Regression lines and Properties*	*Control chart for mean and range when* $\overline{X}$ *and R data given directly*
S-4	SLO-1	*Problem solving using tutorial sheet 1*	*Problem solving using tutorial sheet 4*	*Problem solving using tutorial sheet 7*	*Problem solving using tutorial sheet 10*	*Problem solving using tutorial sheet 13*
	SLO-2	*Problem solving using tutorial sheet 1*	*Problem solving using tutorial sheet 4*	*Problem solving using tutorial sheet 7*	*Applications of correlation in engineering*	*Problem solving using tutorial sheet 14*
S-5	SLO-1	*Cumulative distribution function*	*Poisson distribution*	*Test of significance for single mean*	*regression coefficient Problems*	*More problems on* $\overline{X}$ *and R data given directly*
	SLO-2	*Mathematical expectation –discrete case*	*M.G.F, mean*	*Test of significance for difference of means*	*More problems in regression coefficients*	*Control chart for mean and range- when* $\overline{X}$ *and R data not given directly*

S-6	SLO-1	*Variance*	*variance*	*Small sample tests*	*Relation between correlation and regression*	*more problems on $\overline{X}$ and R data not given directly*
	SLO-2	*Probability density function*	*Fitting Poisson distribution*	*Student's t- test for single mean*	*problems on relation between correlation and regression*	*Control chart for mean and S.D when mean S.D values given directly*
S-7	SLO-1	*Cumulative distribution function*	*Geometric distribution-M.G.F, mean, variance*	*'t' test for the difference of means*	*Applications of regression in engineering*	*More problems on $\overline{X}$ and S*
	SLO-2	*Mathematical expectation-continuous case*	*Memory less property*	*More problems on t- test*	*Applications of regression in engineering*	*Control chart for mean and S.D when mean S.D values not given directly*
S-8	SLO-1	*Problem solving using tutorial sheet 2*	*Problem solving using tutorial sheet 5*	*Problem solving using tutorial sheet 8*	*Problem solving using tutorial sheet 11*	*Problem solving using tutorial sheet 14*
	SLO-2	*Problem solving using tutorial sheet 2*	*Problem solving using tutorial sheet 5*	*Problem solving using tutorial sheet 8*	*Problem solving using tutorial sheet 11*	*Problem solving using tutorial sheet 14*
S-9	SLO-1	*Variance*	*Continuous distribution:*	*Fisher's F-test*	*Introduction to ANOVA Analysis of Variance – One way Classification*	*More problems on $\overline{X}$ and S*
	SLO-2	*Raw Moments*	*Uniform distribution – MGF, Mean, Variance*	*Test of significance for two sample variances*	*Problems on one way classification*	*Control chart for attributes- np chart*
S-10	SLO-1	*Central Moments*	*Exponential distribution - MGF, Mean, Variance*	*Chi square test- for goodness of fit*	*More problems on one way classification*	*More problems on np-chart*
	SLO-2	*Moment generating function*	*Memory less property*	*Problems on goodness of fit*	*ANOVA – two way classification*	*p- chart*
S-11	SLO-1	*MGF- discrete random variable*	*Normal distribution*	*Chi square test- for independence of attributes*	*Problems on two way classification*	*More problems on p- chart*
	SLO-2	*MGF- continuous random variable*	*Problems on Normal distribution*	*More problems on Chi square test- for independence of attributes*	*More problems on two way classification*	*Control chart for the defects in a single unit- c- chart*
S-12	SLO-1	*Problem solving using tutorial sheet 3*	*Problem solving using tutorial sheet 6*	*Problem solving using tutorial sheet 9*	*Problem solving using tutorial sheet 12*	*Problem solving using tutorial sheet 15*
	SLO-2	*Applications of Probability and Random variables in Engineering field*	*Application of distributions in Engineering*	*Applications and the importance of sampling in various fields of engineering*	*Engineering Applications of ANOVA, Correlation and Regression*	*Engineering applications of control chart*

Learning Resources	1. *S. Ross, A First Course in Probability, 6th Ed., Pearson Education India, 2002.* 2. *Johnson. R.A., Miller &Freund's, Probability and Statistics for Engineers, 6th Edition, Pearson's Education, New Delhi, 2000.* 3. *Veerarajan T., Probability and Statistics, Tata McGraw-Hill, New Delhi, 2010.*	4. *Devore (JL), Probability and Statistics, 5th Edition: For Engineering and the Sciences, 2000.* 5. *Vijay K. Rohatgi., A.K. Md. Ehsanes Saleh, An Introduction to Probability and Statistics, 2 Edition, Wiley, 2008*

Learning Assessment											
	Bloom's Level of Thinking	Continuous Learning Assessment (50% weightage)								Final Examination (50% weightage)	
		CLA – 1 (10%)		CLA – 2 (15%)		CLA – 3 (15%)		CLA – 4 (10%)#			
		Theory	Practice	Theory	Practice	Theory	Practice	Theory	Practice	Theory	Practice
Level 1	Remember Understand	40%	-	30%	-	30%	-	30%	-	30%	-
Level 2	Apply Analyze	40%	-	40%	-	40%	-	40%	-	40%	-
Level 3	Evaluate Create	20%	-	30%	-	30%	-	30%	-	30%	-
	Total	100 %		100 %		100 %		100 %		100 %	

CA – 4 can be from any combination of these: Assignments, Seminars, Tech Talks, Mini-Projects, Case-Studies, Self-Study, MOOCs, Certifications, Conf. Paper etc.,

Course Designers		
Experts from Industry	Experts from Higher Technical Institutions	Internal Experts
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	2. Dr.Nanjundan, Bangalore University, nanzundan@gmail.com	*2. Dr.Srinivasan, SRMIST*

Course Code	18MAB302T	Course Name	DISCRTE MATHEMATICS FOR ENGINEERS	Course Category	B	Basic Sciences	L	T	P	C
							3	1	0	4

Pre-requisite Courses	18MAB102T	Co-requisite Courses	Nil	Progressive Courses	Nil
Course Offering Department	Mathematics	Data Book / Codes/Standards			

Course Learning Rationale (CLR):	*The purpose of learning this course is to:*
CLR-1 :	*Apply set theory, functions and relations in storage, communication and manipulation of data*
CLR-2 :	*Apply number theory concepts in computer engineering such as public key crypto system.*
CLR-3 :	*Apply mathematical reasoning in computer science such as design of computer circuit, verification of programs.*
CLR-4 :	*Learning about groups, rings and fields. Solving problems on coding theory.*
CLR-5 :	*Using graph models in computer network and shortest path problems Apply graph coloring in problems involving scheduling and assignments.*
CLR-6 :	*Apply mathematical reasoning, combinatorial analysis, algebraic structures and graph theory in solving mathematical problems as applied to the respective branches of Engineering.*

Course Learning Outcomes (CLO):	*At the end of this course, learners will be able to:*	Learning 1: Level of Thinking (Bloom)	2: Expected Proficiency (%)	3: Expected Attainment (%)	PLO 1: Engineering Knowledge	2: Problem Analysis	3: Design & Development	4: Analysis, Design, Research	5: Modern Tool Usage	6: Society & Culture	7: Environment & Sustainability	8: Ethics	9: Individual & Team Work	10: Communication	11: Project Mgt. & Finance	12: Life Long Learning	13: PSO - 1	14: PSO - 2	15: PSO – 3
CLO-1 :	*Problem solving in sets, relations and functions.*	3	85	80	M	H	L						M	L		H			
CLO-2 :	*Solving problems in basic counting principles, inclusion exclusion and number theory.*	3	85	80	M	H		M	M				M			H			
CLO-3 :	*Solving problems of mathematical logic, inference theory and mathematical induction.*	3	85	80	M	H							M			H			
CLO-4 :	*Gaining knowledge in groups, rings and fields. Solving problems in coding theory.*	3	85	80	M	H		M					M			H			
CLO-5 :	*Gaining knowledge in graphs and properties. Learning about trees, minimum spanning trees and graph coloring.*	3	85	80	M	H	L						M	L		H			
CLO-6 :	*Learning mathematical reasoning, combinatorial analysis, algebraic structures and graph theory.*	3	85	80	M	H							M			H			

Duration (hour)		12	12	12	12	12
S-1	SLO-1	*Sets and examples. Operations on sets.*	*Permutation and Combination*	*Propositions and Logical operators*	*Binary operation on a set- Groups and axioms of groups.*	*Basic concepts - Basic Definitions- degree and Hand shaking theorem.*
	SLO-2	*Laws of Set theory- Proving set identities using laws of set theory.*	*Simple problems using addition and product rules.*	*Truth values and truth tables.*	*Properties of groups.*	*Some Special Graphs – complete, regular and bipartite graphs.*
S-2	SLO-1	*Partition of a set – examples.*	*Principle of inclusion and exclusion*	*Propositions generated by a set-Symbolic writing using conditional and biconditional connectives.*	*Permutation group, equivalence classes with addition modulo m and multiplication modulo m.*	*Isomorphism of graphs – necessary conditions.*
	SLO-2	*Cartesian product of sets.*	*Problems using inclusion and exclusion principle.*	*Writing converse inverse and contra positive of a given conditional.*	*Cyclic groups and properties.*	*Isomorphism- simple examples.*
S-3	SLO-1	*Relations – Properties.*	*Pigeon-hole principle and generalized pigeon-hole principle.*	*Tautology, contradiction and contingency-examples.*	*Subgroups and necessary and sufficiency of a subset to be a subgroup.*	*Paths, cycles and circuits.*
	SLO-2	*Equivalence relation and partial order relation*	*Problems on pigeon-hole principle.*	*Proving tautology and contradiction using truth table method.*	*Group homomorphism and properties.*	*Connectivity in undirected graphs – connected graphs and odd degree vertices.*
S-4	SLO-1	*Problem solving using tutorial sheet 1*	*Problem solving using tutorial sheet 4*	*Problem solving using tutorial sheet 7*	*Problem solving using tutorial sheet 10*	*Problem solving using tutorial sheet 13*
	SLO-2	*Problem solving using tutorial sheet 1*	*Problem solving using tutorial sheet 4*	*Problem solving using tutorial sheet 7*	*Problem solving using tutorial sheet 10*	*Problem solving using tutorial sheet 13*
S-5	SLO-1	*Poset - Graphs of relations Digraphs*	*Divisibility and prime numbers.*	*Equivalences – truth table method to prove equivalences.*	*Rings- definition and examples..Zero devisors.*	*Eulerian and Hamiltonian graphs.*
	SLO-2	*Hasse diagram – problems.*	*Fundamental theorem of arithmetic – problems.*	*Implications- truth table method to prove implications.*	*Integral domain- definition , examples and properties.*	*Necessary and sufficient condition for a graph to be Eulerian- examples.*
S-6	SLO-1	*Closures of relations- examples*	*Finding prime factorization of a given number.*	*Laws of logic and some equivalences.*	*Fields – definition, examples and properties.*	*Matrix representation of graphs- adjacent and incidence matrices and examples.*
	SLO-2	*Transitive closure and warshall's algorithm*	*Some more problems using fundamental theorem of arithmetic.*	*Proving equivalences and implications using laws of logic.*	*Coding Theory – Encoders and decoders- Hamming codes.*	*Isomorphism using adjacency.*

S-7	SLO-1	*Functions – definitions, domain and range of a function - examples*	*Division algorithm- greatest common divisor and properties-problems.*	*Rules of inference – Rule P, Rule T and Rule CP*	*Hamming distance. Error detected by an encoding function.*	*Digraphs – in degree and out degree – Hand shaking theorem.*
	SLO-2	*Types of functions- one- one and onto-bijection- examples.*	*Euclid's algorithm for finding GCD(a,b)- examples..*	*Direct proofs*	*examples.*	*Verification of hand shaking theorem in digraphs.*
S-8	SLO-1	*Problem solving using tutorial sheet 2*	*Problem solving using tutorial sheet 5*	*Problem solving using tutorial sheet 8*	*Problem solving using tutorial sheet 11*	*Problem solving using tutorial sheet 14*
	SLO-2	*Problem solving using tutorial sheet 2*	*Problem solving using tutorial sheet 5*	*Problem solving using tutorial sheet 8*	*Problem solving using tutorial sheet 11*	*Problem solving using tutorial sheet 14*
S-9	SLO-1	*Composition of functions – examples.*	*Problems using Euclid's algorithm.*	*Problems using direct method.*	*Error correction using matrices.*	*Graph colouring – chromatic number-examples.*
	SLO-2	*Associatiivity of composition of functions – Identity and inverse of functions.*	*Least common Multiple(LCM)- relation between LCM and GCD.*	*Problems using CP rule.*	*Problems on error correction using matrices.*	*Four colour theorem(statement only) and problems.*
S-10	SLO-1	*Necessary and sufficiency of existence of inverse of a function.*	*Problems on LCM.*	*Inconsistency and indirect method of proof.*	*Group codes-error correction in group codes-parity check matrix.*	*Trees – definitions and examples. Properties.*
	SLO-2	*Uniqueness of identity*	*Finding LCM and GCD using prime factorization.*	*Inconsistent premises and proof by contradiction (indirect method).*	*Problems on error correction in group codes.*	*Properties continued.*
S-11	SLO-1	*Inverse of composition*	*Finding GCD and LCM using Euclid's algorithm.*	*Principle of mathematical induction.*	*Procedure for decoding group codes.*	*Spanning trees – examples.*
	SLO-2	*Checking if a given function is bijection and if so, finding inverse, domain and range-problems.*	*More problems on GCD and LCM.*	*Problems based on Mathematical Induction*	*Problems on decoding group codes.*	*Kruskal's algorithm for minimum spanning trees.*
S-12	SLO-1	*Problem solving using tutorial sheet 3*	*Problem solving using tutorial sheet 6*	*Problem solving using tutorial sheet 9*	*Problem solving using tutorial sheet 12*	*Problem solving using tutorial sheet 15*
	SLO-2	*Applications of sets, relations and functions in Engineering.*	*Applications of sets, relations and functions in Engineering.*	*Applications of sets, relations and functions in Engineering.*	*Applications of sets, relations and functions in Engineering.*	*Applications of sets, relations and functions in Engineering.*

Learning Resources	1. *Kenneth H.Rosen, Discrete Mathematics and its Application, Seventh edition, Tata McGraw-Hill Publishing company PVT .Ltd., New Delhi, 2012.* 2. *Tremblay J. P. and Manohar R., Discrete Mathematical Structures with applications to Computer Science, Tata Mc Graw Hill Publishing Co., 35th edition,2008.*	3. *Narsing Deo, Graph Theory with applications to Engineering and Computer science, Prentice-Hall of India pvt. Ltd., New Delhi, 2004.* 4. *C.L. Liu, Elements of Discrete Mathematics, 4th Edition, McGraw Higher ED, 2012.* 5. *T.Veerarajan, Discrete Mathematics with Graph Theory and Combinatorics, Tata McGraw Hill, 2015.*

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Level 1	Remember Understand	40%	-	30%	-	30%	-	30%	-	30%	-
Level 2	Apply Analyze	40%	-	40%	-	40%	-	40%	-	40%	-
Level 3	Evaluate Create	20%	-	30%	-	30%	-	30%	-	30%	-
	Total	100 %		100 %		100 %		100 %		100 %	

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Experts from Industry	Experts from Higher Technical Institutions	Internal Experts
1. Mr.V.Maheshwaran, CTS, Chennai, maheshwaranv@yahoo.com	*1. Dr.K.C.Sivakumar, IIT Madras, kcskumar@iitm.ac.in*	*1. Dr.A.Govindarajan, SRMIST*
	2. Dr.Nanjundan, Bangalore University, nanzundan@gmail.com	*2. Dr.Sundarammal kesavan, SRMIST*

Course Code	18MAB303T	Course Name	BIO STATISTICS FOR BIOTECHNOLOGISTS	Course Category	B	Basic Sciences	L	T	P	C
							3	1	0	4

Pre-requisite Courses	18MAB102T	Co-requisite Courses	Nil	Progressive Courses	Nil
Course Offering Department	Mathematics	Data Book / Codes/Standards	Statistical tables		

Course Learning Rationale (CLR):	*The purpose of learning this course is to:*
CLR-1 :	*gain knowledge in measures of central tendency, dispersion, Skewness and moments in Biotechnology.*
CLR-2 :	*appropriately choose, define and / or derive probability distributions such as Binomial, Poisson and Normal distributions to solve biology related problems.*
CLR-3 :	*learn how to formulate and test the hypothesis of single means and difference of means for large samples and to understand and apply Chi-square test for goodness of fit and independence of attributes in Biological topics.*
CLR-4 :	*learn to formulate and test the hypothesis about means, variances for small samples using t and F test and to have knowledge in ANOVA in Biology related topics.*
CLR-5 :	*gain knowledge in correlation and regression lines and also get expose to Non- Parametric tests in Biology*
CLR-6 :	*Assess problems and determine the appropriate method to solve problems in application areas of Biotechnology*

Course Learning Outcomes (CLO):	*At the end of this course, learners will be able to:*	Learning 1: Level of Thinking (Bloom)	Learning 2: Expected Proficiency (%)	Learning 3: Expected Attainment (%)	PLO 1: Engineering Knowledge	PLO 2: Problem Analysis	PLO 3: Design & Development	PLO 4: Analysis, Design, Research	PLO 5: Modern Tool Usage	PLO 6: Society & Culture	PLO 7: Environment & Sustainability	PLO 8: Ethics	PLO 9: Individual & Team Work	PLO 10: Communication	PLO 11: Project Mgt. & Finance	PLO 12: Life Long Learning	PLO 13: PSO - 1	PLO 14: PSO - 2	PLO 15: PSO – 3
CLO-1 :	*Understand solve numerical problems in measures of central tendency and dispersion.*	*3*	*85*	*80*	*M*	*H*	*L*						*M*	*L*		*H*			
CLO-2 :	*Solving problems related to probability distributions applicable to bio technologists.*	*3*	*85*	*80*	*M*	*H*		*M*	*M*				*M*			*H*			
CLO-3 :	*Evaluate the given problems relating to large sample test of mean and difference of mean and Chi-square tests.*	*3*	*85*	*80*	*M*	*H*							*M*			*H*			
CLO-4 :	*Choose and solve problems with t test, F test and ANOVA.*	*3*	*85*	*80*	*M*	*H*		*M*					*M*	*L*		*H*			
CLO-5 :	*Evaluate problems on concepts of correlation, regression and non parametric tests.*	*3*	*85*	*80*	*M*	*H*	*L*						*M*			*H*			
CLO-6 :	*The learners will be able to mathematically formulate and solve numerical problems related to Biotechnogy.*	*3*	*85*	*80*	*M*	*H*							*M*						

Duration (hour)		12	12	12	12	12
S-1	SLO-1	*Introduction to discrete types of statistical data*	*Introduction to probability concepts, Random experiment, Trail, Sample space, Sample size,*	*Sampling Theory - Basic concepts*	*Introduction to small sample test*	*Introduction to Correlation and Regression*
	SLO-2	*Introduction to continuous types of statistical data*	*Events(only definitions, properties without proof and simple problems) Problems on Probability related to biological applications.*	*Population, Sample, Sampling distribution, population parameters and sample statistic*	*small sample tests based on t-distribution for single mean*	*Karl Pearson's coefficient of correlations*
S-2	SLO-1	*Measures of central tendency – Introduction to Arithmetic mean, median, Mode*	*Types of Events: Impossible, Simple, Mutually Exclusive and Independent events(only definitions, properties without proof)*	*Testing of hypothesis, Null and Alternate hypothesis, Single tailed and two tailed tests, Type- I and Type – II errors*	*Problems on t-test for single mean*	*Problems on Karl Pearson's coefficient of correlations*
	SLO-2	*Problems in Arithmetic mean*	*Simple problems*	*Acceptance and Rejection Regions, Level of Significance, Degrees of freedom and Confidence limits*	*Small sample tests based on t-distribution for difference of means*	*Spearman's rank correlation coefficient problems*
S-3	SLO-1	*Problems in median*	*Problems based on Addition and Multiplication Theorems*	*Large sample tests based on normal distribution (Z - test)*	*Problems on t- distribution for difference of means*	*Spearman's rank correlation coefficient problems*
	SLO-2	*Problems in mode*	*Baye's Theorem (without proof) and its applications*	*Z-Test for single proportion and difference of proportions and problems*	*Paired t-test*	*Regression lines and its applications*
S-4	SLO-1	*Problem solving using tutorial sheet 1*	*Problem solving using tutorial sheet 4*	*Problem solving using tutorial sheet 7*	*Problem solving using tutorial sheet 10*	*Problem solving using tutorial sheet 13*
	SLO-2	*Problem solving using tutorial sheet 1*	*Problem solving using tutorial sheet 4*	*Problem solving using tutorial sheet 7*	*Problem solving using tutorial sheet 10*	*Problem solving using tutorial sheet 13*
S-5	SLO-1	*Measures of dispersion, Range , Quartile deviation*	*Introduction to one dimensional random variables*	*Z-Test for single mean*	*Problems on Paired t-test*	*Problems related to Regression lines.*
	SLO-2	*Mean deviation*	*Discrete Random variable, Probability mass function , Distribution function, Properties (without proof), Applications*	*Problems on Z-Test for single mean*	*F-test for equality of variances*	*Non-parametric tests - The sign test*

S-6	SLO-1	*Standard deviation and Co-efficient of variation*	*Continuous Random variable, Probability density function , Distribution function, Properties (without proof), Applications*	*Z-Test for difference of means*	*Problems on F-test for equality of variances*	*The sign test additional problems*
	SLO-2	*Problems on Standard deviation and Co-efficient of variation*	*Simple problems on discrete random variables and continuous random variables*	*Problems on Z-Test for difference of means*	*Problems on F-test for equality of variances*	*The Wilcoxon rank sum test or The Man Whitney U test problems*
S-7	SLO-1	*Karl Pearson's coefficient of Skewness*	*Mathematical Expectation*	*Introduction to Chi- square test*	*Introduction to Analysis of Variance (ANOVA)*	*The Wilcoxon rank sum test or The Man Whitney U test problems*
	SLO-2	*Problems on coefficient of Skewness*	*Variance, Properties (without proof), Application related problems*	*Chi -square test for goodness of fit*	*Problems on ANOVA –One -way classifications*	*The Kruskal Walis test problems*
S-8	SLO-1	*Problem solving using tutorial sheet 2*	*Problem solving using tutorial sheet 5*	*Problem solving using tutorial sheet 8*	*Problem solving using tutorial sheet 11*	*Problem solving using tutorial sheet 14*
	SLO-2	*Problem solving using tutorial sheet 2*	*Problem solving using tutorial sheet 5*	*Problem solving using tutorial sheet 8*	*Problem solving using tutorial sheet 11*	*Problem solving using tutorial sheet 14*
S-9	SLO-1	*Introduction to moments*	*Binomial distribution, Application to population Genetics*	*Problems on Chi -square test for goodness of fit*	*Problems on ANOVA –One -way classifications*	*The Kruskal Walis test problems*
	SLO-2	*Raw and Central moments problems*	*Simple problems on Binomial distribution*	*Chi -square test for Independence of attributes – Problems formulations*	*Problems on ANOVA –One -way classifications*	*The Kruskal Walis test problems*
S-10	SLO-1	*Moments about the point x=a problems.*	*Poisson Distribution, Application to population Genetics*	*Chi -square test for Independence of attributes using contingency table*	*ANOVA –Two -way classifications*	*The Wilcoxon signed ranked test problems*
	SLO-2	*Additional problems on moments*	*Normal Distribution, Application to population Genetics*	*Problems on Chi -square test for Independence of attributes using contingency table*	*Applications of ANOVA –Two –way classification problems.*	*The Wilcoxon signed ranked test problems*
S-11	SLO-1	*Problems on finding central moments given moments about a point*	*Problems on Poisson and Normal distribution*	*Additional problems on Chi-square test*	*ANOVA –Two –way classification problems.*	*Additional problems on all the non parametric tests*
	SLO-2	*Additional problems on finding central moments*	*Additional problems on Normal distribution.*	*Problems on Chi-square test.*	*ANOVA –Two –way classification problems*	*Additional problems on all the non parametric tests*
S-12	SLO-1	*Problem solving using tutorial sheet 3*	*Problem solving using tutorial sheet 6*	*Problem solving using tutorial sheet 9*	*Problem solving using tutorial sheet 12*	*Problem solving using tutorial sheet 15*
	SLO-2	*Engineering applications of Measures of central tendency and dispersion*	*Application of distributions in Engineering*	*Engineering applications of sampling techniques*	*Applications of ANOVA in engineering fields*	*Engineering Applications of Correlation, Regression and Non-parametric methods*

Learning Resources	1. *Myra L. Samuels, Jeffery A. Witner, Andrew schaffner, Statistics for the Life Sciences, Pearson, 5th ed.,, 2015.* 2. *Bernard Rosner, Fundamentals of Biostatistics, Brooks/core, Seventh edition, 2011.* 3. *B K Mahajan, Methods in Bio-statistics for Medical students and Research workers, Seventh Edition, 2010.*	4. *K. Kalyanaraman, Hareesh N.Ramanathan, P. N. Harikumar,Statistical methods for Research A step by step Approach Using IBM SPSS, Atlantic, First Edition, 2016.* 5. *Gupta & Kapoor, Fundamentals of Mathematical Statistics, 10th ed., Sultan Chand & Sons, 2017*

Learning Assessment

	Bloom's Level of Thinking	Continuous Learning Assessment (50% weightage)								Final Examination (50% weightage)	
		CLA – 1 (10%)		CLA – 2 (15%)		CLA – 3 (15%)		CLA – 4 (10%)#			
		Theory	Practice	Theory	Practice	Theory	Practice	Theory	Practice	Theory	Practice
Level 1	Remember Understand	40%	-	30%	-	30%	-	30%	-	30%	-
Level 2	Apply Analyze	40%	-	40%	-	40%	-	40%	-	40%	-
Level 3	Evaluate Create	20%	-	30%	-	30%	-	30%	-	30%	-
	Total	100 %		100 %		100 %		100 %		100 %	

CA – 4 can be from any combination of these: Assignments, Seminars, Tech Talks, Mini-Projects, Case-Studies, Self-Study, MOOCs, Certifications, Conf. Paper etc.,

Course Designers

Experts from Industry	Experts from Higher Technical Institutions	Internal Experts
1. Mr.V.Maheshwaran, CTS, Chennai, maheshwaranv@yahoo.com	*1. Dr.K.C.Sivakumar, IIT Madras, kcskumar@iitm.ac.in*	*1. Dr.A.Govindarajan, SRMIST*
	2. Dr.Nanjundan, Bangalore University, nanzundan@gmail.com	*2. Dr.Srinivasan, SRMIST*

Course Code	18PYB201T	Course Name	WAVES AND OPTICS	Course Category	B	Basic Sciences	L	T	P	C
							3	1	0	4

Pre-requisite Courses	Nil	Co-requisite Courses	Nil	Progressive Courses	Nil
Course Offering Department	Physics and Nanotechnology	Data Book / Codes/Standards	Nil		

Course Learning Rationale (CLR):	The purpose of learning this course is to:
CLR-1 :	*Familiarize with the concepts of simple harmonic motion*
CLR-2 :	*Analyze the principle of transverse and longitudinal wave-motion*
CLR-3 :	*Identify the significance of propagation of light*
CLR-4 :	*Create insights to the concepts of interference and diffraction*
CLR-5 :	*Understanding the basics of geometrical optics*
CLR-6 :	*Understand the basics of lasers*

Course Learning Outcomes (CLO):	At the end of this course, learners will be able to:	Learning 1: Level of Thinking (Bloom)	Learning 2: Expected Proficiency (%)	Learning 3: Expected Attainment (%)	PLO 1: Engineering Knowledge	PLO 2: Problem Analysis	PLO 3: Design & Development	PLO 4: Analysis, Design, Research	PLO 5: Modern Tool Usage	PLO 6: Society & Culture	PLO 7: Environment & Sustainability	PLO 8: Ethics	PLO 9: Individual & Team Work	PLO 10: Communication	PLO 11: Project Mgt. & Finance	PLO 12: Life Long Learning	PLO 13: PSO - 1	PLO 14: PSO - 2	PLO 15: PSO – 3
CLO-1 :	*Identify the problems regarding harmonic motion*	2	85	75	H	H	-	-	-	-	-	-	-	-	-	-	-	-	-
CLO-2 :	*Analyze thevarious types of wave motions*	2	80	70	H	-	-	M	-	-	-	-	-	-	-	-	-	-	-
CLO-3 :	*Apply the principles of propagation of light*	2	75	70	H	H	-	-	-	-	-	-	-	-	-	-	-	-	-
CLO-4 :	*Utilize the concepts of interference and diffraction in applications*	2	85	80	H	H	-	-	-	-	-	-	-	-	-	-	-	-	-
CLO-5 :	*Apply the principles of geometrical optics.*	2	85	75	H	-	H	-	-	-	-	-	-	-	-	-	-	-	-
CLO-6 :	*Utilizing the principles of laser in holography and microscopy*	2	80	70	H	-	-	-	-	-	-	-	-	-	-	-	-	-	-

Duration (hour)		12	12	12	12	12
S-1	SLO-1	*Simple harmonic motion – Basics*	*Transverse and longitudinal waves: Basics*	*Propagation of light*	*Superposition of waves*	*Introduction to modern optics*
	SLO-2	*Energy of a simple harmonic oscillator*	*Velocity in wave motion*	*Huygens' principle*	*Conditions for interference*	*Lasers - principle*
S-2	SLO-1	*Simple harmonic oscillations in an electrical system*	*Wave equation*	*Fermat's principle of stationary time*	*Interference –Constructive and Destructive*	*Einstein A and B coefficients,*
	SLO-2	*Simple harmonic oscillations in a mechanical system -*	*Transverse wave on a string*	*Optical path length*	*Temporal coherence*	*Population inversion, metastable state*
S-3	SLO-1	*Superposition of two simple harmonic vibrations in one dimension –vibrations having equal frequencies*	*Characteristic impedance of a string*	*Mirage effect*	*Spatial coherence*	*Gas Lasers: He – Ne Laser*
	SLO-2	*Superposition of two simple harmonic vibrations in one dimension –vibrations having different frequencies*	*Reflection of waves at a boundary*	*Laws of reflection and refraction*	*Wave splitting Interference - Young's double slit experiment*	*Argon Ion laser*
S-4	SLO-1	*Solving Problems*	*Solving Problems*	*Solving Problems*	*Solving Problems*	*Solving Problems*
	SLO-2	*Solving Problems*	*Solving Problems*	*Solving Problems*	*Solving Problems*	*Solving Problems*
S-5	SLO-1	*Damped simple harmonic motion*	*Transmission of waves at a boundary*	*Fresnel equations – Derivation*	*Amplitude splitting Interference*	*Gas dynamic laser*
	SLO-2	*Heavy damping*	*Impedance matching*	*Fresnel equations – Different cases*	*Newton's ring experiment*	*Solid state Lasers: Ruby Laser*
S-6	SLO-1	*Critical damping*	*Normal modes and Eigen frequencies*	*Fresnel equation – Interpretation - Reflectance*	*Discussion of fringe formation in Newton's ring experiment*	*Dye Lasers*

	SLO-2	*Application of critical damping to a Ballistic galvanometer*	*Energy in normal mode of operation*	*Fresnel equation – Interpretation - Transmittance*	*Michelson's Interferometer- principle and construction*	*Excimer laser*
S-7	SLO-1	*Light damping*	*Longitudinal waves - wave equation*	*Total internal reflection*	*Michelson's Interferometer – formation of fringes*	*Chemical laser*
	SLO-2	*Methods of describing the damping of an oscillator*	*Sound waves in gases*	*Brewster's angle*	*Mach – Zehnder interferometer*	*X-Ray laser*
S-8	SLO-1	*Solving Problems*	*Solving Problems*	*Solving Problems*	*Solving Problems*	*Solving Problems*
	SLO-2	*Solving Problems*	*Solving Problems*	*Solving Problems*	*Solving Problems*	*Solving Problems*
S-9	SLO-1	*Energy decay in a damped harmonic oscillator*	*Energy distribution in sound waves*	*Evanescent waves*	*Diffraction*	*Free electron laser*
	SLO-2	*Quality factor of a damped harmonic oscillator*	*Longitudinal waves in a solid*	*Lenses – Refraction at a spherical surfaces*	*Fraunhofer diffraction from a single slit*	*Laser Speckles*
S-10	SLO-1	*Forced oscillator*	*Young's Modulus and Poisson's ratio*	*Refraction at spherical surfaces*	*Fraunhofer diffraction from a circular aperture*	*Q – Switching*
	SLO-2	*The impedance of a mechanical circuit*	*Application to earthquakes*	*Thin Lenses*	*Fraunhofer diffraction from a circular aperture – Quantitative approach*	*Mode Locking*
S-11	SLO-1	*Steady state motion of forced damped harmonic oscillator*	*Longitudinal waves in periodic structure*	*Thin Lenses - Equations*	*Diffraction grating*	*Applications of laser- Holography*
	SLO-2	*Forced oscillator - behavior*	*Reflection and transmission of sound waves at boundaries.*	*Quantum Electrodynamics (QED)*	*Resolving power of grating*	*Applications of lasers- Fluorescence microscopy, eye surgery*
S-12	SLO-1	*Solving Problems*	*Solving Problems*	*Solving Problems*	*Solving Problems*	*Solving Problems*
	SLO-2	*Solving Problems*	*Solving Problems*	*Solving Problems*	*Solving Problems*	*Solving Problems*

Learning Resources	*1. H.J. Pain, The physics of vibrations and waves, J.Wiley & Sons, 2010* *2. Eugene Hecht, A.R. Ganesan, Optics, Pearson Education, 4th Edition, 2008* *3. O. Srelto, Principles of Lasers, Springer, 2010*	*4.Ajay Ghatak, Optics, Tata McGraw Hill Education, 5th Edition, 2012* *5. David Halliday, Fundamentals of Physics, 7th Edition, John Wiley & Sons Australia, Ltd, 2004*

Learning Assessment

	Bloom's Level of Thinking	Continuous Learning Assessment (50% weightage)								Final Examination (50% weightage)	
		CLA – 1 (10%)		CLA – 2 (15%)		CLA – 3 (15%)		CLA – 4 (10%)#			
		Theory	Practice	Theory	Practice	Theory	Practice	Theory	Practice	Theory	Practice
Level 1	Remember Understand	40%	-	30%	-	30%	-	30%	-	30%	-
Level 2	Apply Analyze	40%	-	40%	-	40%	-	40%	-	40%	-
Level 3	Evaluate Create	20%	-	30%	-	30%	-	30%	-	30%	-
	Total	100 %		100 %		100 %		100 %		100 %	

CA – 4 can be from any combination of these: Assignments, Seminars, Tech Talks, Mini-Projects, Case-Studies, Self-Study, MOOCs, Certifications, Conf. Paper etc.,

Course Designers

Experts from Industry	Experts from Higher Technical Institutions	Internal Experts
Mr. Sameer Sharda, New Age Instruments & Materials Pvt. Ltd, Gurgaon, sameer@newagein.com	*Prof .C.Vijayan, IITM, Chennai, cvijayan@iitm.ac.in*	*Dr. Junaid Masud Laskar, SRMIST*
Mr. Mohammed Shafi, Holmarc Opto-Mechatronics Pvt. Ltd, Cochin, optics@holmarc.com	*Prof . V. Subramanian, IITM, Chennai, manianvs@iitm.ac.in*	*Dr. P. Mohamed Ameen,SRMIST*

ACADEMIC CURRICULA

Engineering Science Courses

Regulations - 2018

SRM INSTITUTE OF SCIENCE AND TECHNOLOGY

(Deemed to be University u/s 3 of UGC Act, 1956)

Kattankulathur, Kancheepuram, Tamil Nadu, India

Course Code	18CHS253L	Course Name	CHEMICAL ENGINEERING PRACTICE	Course Category	S	Engineering Sciences	L	T	P	C
							0	0	4	2

Pre-requisite Courses	*Nil*	Co-requisite Courses	*Nil*	Progressive Courses	*Nil*
Course Offering Department	Chemical Engineering	Data Book / Codes/Standards	*Heat and Mass Transfer Data Book*		

Course Learning Rationale (CLR):	*The purpose of learning this course is to:*
CLR-1 :	*Understand various modes of heat transfer mechanism, Fourier's law of heat conduction and Newton's law of cooling.*
CLR-2 :	*Understand difference between natural and forced convection heat transfer. Analyze LMTD for different flow patterns.*
CLR-3 :	*Understand Stefan-Boltzmann law and gain knowledge on diffusivity and mass transfer coefficient.*
CLR-4 :	*Gain knowledge on the mechanism of drying, batch and steam distillation.*
CLR-5 :	*Analyze the difference between single and multi stage leaching.*
CLR-6 :	*Provide students first hand experience of verifying various theoretical concepts learnt in Heat and Mass Transfer.*

Course Learning Outcomes (CLO):	*At the end of this course, learners will be able to:*	Learning			Program Learning Outcomes (PLO)														
		1	2	3	1	2	3	4	5	6	7	8	9	10	11	12	13	14	15
		Level of Thinking (Bloom)	Expected Proficiency (%)	Expected Attainment (%)	Engineering Knowledge	Problem Analysis	Design & Development	Analysis, Design, Research	Modern Tool Usage	Society & Culture	Environment & Sustainability	Ethics	Individual & Team Work	Communication	Project Mgt. & Finance	Life Long Learning	PSO - 1	PSO - 2	PSO – 3
CLO-1 :	*Determine the thermal conductivity of a material.*	2	80	75	H	H	H	H									H	H	
CLO-2 :	*Determine heat transfer coefficient for natural, forced convection. Design double pipe and shell and tube heat exchanger.*	2	80	70	H	H	H	M									H	H	M
CLO-3 :	*Determine the Stefan-Boltzmann constant, Diffusivity and mass transfer coefficient.*	2	80	70	H	H	M	M									H	H	
CLO-4 :	*Verify Rayleigh's equation for batch distillation and determine vapor efficiency for steam distillation*	2	80	75	H	H	H	H									H	H	M
CLO-5 :	*Determine the percentage recovery of solute by leaching.*	2	80	75	H	H	H	H									H	H	
CLO-6 :	*Verify the governing relations for heat and mass transfer phenomena.*	2	75	70	H	H	M	M									H	H	M

Duration (hour)		12	12	12	12	12
S 1-4	SLO-1 / SLO-2	Heat transfer through Composite wall	Heat transfer by forced convection	Stefan-Boltzmann apparatus	Drying characteristics	Estimation of percentage recovery of solute using Soxhlet apparatus
S 5-8	SLO-1 / SLO-2	Heat transfer through Composite lagged pipe	Double pipe Heat Exchanger	Estimation of Diffusivity	Verification of Rayleigh equation for simple batch distillation	Estimation of percentage recovery of solute for single stage leaching
S 9-12	SLO-1 / SLO-2	Heat transfer by natural convection	Shell and tube heat exchanger	Estimation of mass transfer coefficients	Determination of vapor efficiency for simple steam distillation	Estimation of percentage recovery of solute for multi stage leaching

Learning Resources	
	1. *Warren L. McCabe, Julian C. Smith and Peter Harriott, "Unit Operations of Chemical Engineering", 7th Edn., McGraw Hill Education (India) Edition, 2014* 2. *Robert E. Treybal," Mass-Transfer Operations", 3rd Edn., McGraw Hill Education (India) Edition, 2012* 3. *Binay K Dutta, "Heat Transfer: Principles and Applications", PHI Publishers, Delhi,2010* 4. *Laboratory Manual*

Learning Assessment											
	Bloom's Level of Thinking	Continuous Learning Assessment (50% weightage)								Final Examination (50% weightage)	
		CLA – 1 (10%)		CLA – 2 (15%)		CLA – 3 (15%)		CLA – 4 (10%)#			
		Theory	Practice	Theory	Practice	Theory	Practice	Theory	Practice	Theory	Practice
Level 1	Remember Understand	-	40 %	-	30 %	-	30 %	-	30 %	-	30%
Level 2	Apply Analyze	-	40 %	-	40 %	-	40 %	-	40 %	-	40%
Level 3	Evaluate Create	-	20 %	-	30 %	-	30 %	-	30 %	-	30%
	Total	100 %		100 %		100 %		100 %		100 %	

CA – 4 can be from any combination of these: Assignments, Seminars, Tech Talks, Mini-Projects, Case-Studies, Self-Study, MOOCs, Certifications, Conf. Paper etc.,

Course Designers		
Experts from Industry	Experts from Higher Technical Institutions	Internal Experts
1. Mr. A. Subramaniam, PESCO Beam Environmental Solutions Pvt. Ltd.,	*1. Dr. Lima Rose Miranda, Anna University, email: limamiranda2007@gmail.com*	*1 Ms. E.POONGUZHALI SRM Inst. of Science & Technology, poonguzhali.e@ktr.srmuniv.ac.in*
2. Mr. S. T. Kalaimani, CPCL, Chennai	*2. Dr. T. R. Sundararaman, Rajalakshmi Engineering College*	*2 Dr. K.SOFIYA SRM Inst. of Science & Technology, sofiya.k@ktr.srmuniv.ac.in*

ACADEMIC CURRICULA

Mandatory Courses

Regulations - 2018

SRM INSTITUTE OF SCIENCE AND TECHNOLOGY

(Deemed to be University u/s 3 of UGC Act, 1956)

Kattankulathur, Kancheepuram, Tamil Nadu, India

Course Code	18PDM301L	Course Name	ANALYTICAL AND LOGICAL THINKING SKILLS	Course Category	M	Mandatory	L	T	P	C
							0	0	2	0

Pre-requisite Courses	Nil	Co-requisite Courses	Nil	Progressive Courses	Nil
Course Offering Department	Career Development Centre	Data Book / Codes/Standards	Nil		

Course Learning Rationale (CLR):	*The purpose of learning this course is to:*
CLR-1 :	*Recapitulate fundamental mathematical concepts and skills*
CLR-2 :	*Sharpen logical reasoning through skillful conceptualization*
CLR-3 :	*Enable to solve problems and to crack competitive exams.*
CLR-4 :	*understand and master the mathematical concepts to solve types of problem*
CLR-5 :	*identify problems*
CLR-6 :	*give the right knowledge, skill and aptitude to face any competitive examination*

		Learning			Program Learning Outcomes (PLO)														
		1	2	3	1	2	3	4	5	6	7	8	9	10	11	12	13	14	15
Course Learning Outcomes (CLO):	*At the end of this course, learners will be able to:*	Level of Thinking (Bloom)	Expected Proficiency (%)	Expected Attainment (%)	Engineering Knowledge	Problem Analysis	Design & Development	Analysis, Design, Research	Modern Tool Usage	Society & Culture	Environment & Sustainability	Ethics	Individual & Team Work	Communication	Project Mgt. & Finance	Life Long Learning	PSO - 1	PSO - 2	PSO – 3
CLO-1 :	*build a strong base in the fundamental mathematical concepts*	*1*	*80*	*75*	*L*	*H*		*M*					*M*	*L*		*H*			
CLO-2 :	*Apply the learn conditions towards solving problems analytically*	*1*	*80*	*75*	*L*	*H*		*M*					*M*	*L*		*H*			
CLO-3 :	*grasp the approaches and strategies to solve problems with speed and accuracy*	*2*	*80*	*75*	*L*	*H*		*M*					*M*	*L*		*H*			
CLO-4 :	*Collectively solve problems in teams and groups*	*2*	*80*	*75*	*L*	*H*		*M*					*M*	*L*		*H*			
CLO-5 :	*solve problems*	*1*	*80*	*75*	*L*	*H*		*M*					*M*	*H*		*H*			
CLO-6 :	*gain appropriate skills to succeed in preliminary selection process for recruitment*	*3*	*80*	*75*	*L*	*H*		*M*					*M*	*H*		*H*			

Duration (hour)		6	6	6	6	6
S-1	SLO-1	*Arithmetic Progression*	*Clocks*	*Time, Speed, Distance*	*Geometry - Triangles*	*Data sufficiency Introduction*
	SLO-2	*Solving Problems*	*Solving Problems*	*Solving Problems*	*Geometry – Lines and Angles*	*Data sufficiency Type 1*
S-2	SLO-1	*Geometric Progressions*	*Calendar*	*Time, Speed, Distance-Races*	*Geometry - Circles*	*Data sufficiency Type 2*
	SLO-2	*Harmonic Progression*	*Solving Problems*	*Solving Problems*	*Solving Problems*	*Solving Problems*
S-3	SLO-1	*Averages*	*Ratio*	*Problems on Trains*	*Mensuration Area*	*Data Interpretation - Introduction*
	SLO-2	*Solving Problems*	*Proportion*	*Solving Problems*	*Solving Problems*	*Data Interpretation - Table*
S-4	SLO-1	*Weighted Averages*	*Variation*	*Boats & Streams*	*Mensuration – Volume and Surface Area*	*Data Interpretation - Pie Chart*
	SLO-2	*Solving Problems*	*Solving Problems*	*Solving Problems*	*Solving Problems*	*Data Interpretation - Line Graphs*
S-5	SLO-1	*Sets Two Variables*	*Mixtures & Solutions*	*Time and work*	*Trigonometry- Identities*	*Data Interpretation – Bar Graphs*
	SLO-2	*Sets Three Variables*	*Solving Problems*	*Solving Problems*	*Solving Problems*	*Solving Problems*
S-6	SLO-1	*Functions*	*Allegation Method*	*Pipes and Cisterns*	*Trigonometry - Height and Distances*	*Revision I*
	SLO-2	*Graphs*	*Solving Problems*	*Solving Problems*	*Solving Problems*	*Revision II*

Learning Resources		
	1. *Abhijit Guha, Quantitative Aptitude for Competitive Examinations,Tata McGraw Hill, 3rd Edition, 2011*	4. *Edgar Thrope, Test of Reasoning for Competitive Examinations, Tata McGraw Hill, 4th Edition, 2012*
	2. *Arun Sharma-Quantitative aptitude for CAT, Tata McGraw Hill*	5. *Archana Ram, Placementor, Oxford University Press,2018*
	3. *Dinesh Khattar-The Pearson Guide to QUANTITATIVE APTITUDE for competitive examinations.*	6. *P.A.Anand, Quantitative Aptitude for Competitive Examinations, Wiley Publication, 2016*

Learning Assessment											
	Bloom's Level of Thinking	Continuous Learning Assessment (100% weightage)								Final Examination	
		CLA – 1 (20%)		CLA – 2 (30%)		CLA – 3 (30%)		CLA – 4 (20%)#			
		Theory	Practice	Theory	Practice	Theory	Practice	Theory	Practice	Theory	Practice
Level 1	Remember Understand	-	*40%*	-	*30%*	-	*30%*	-	*30%*	-	-
Level 2	Apply Analyze	-	*40%*	-	*40%*	-	*40%*	-	*40%*	-	-
Level 3	Evaluate Create	-	*20%*	-	*30%*	-	*30%*	-	*30%*	-	-
	Total	100 %		100 %		100 %		100 %		-	

CLA – 4 can be from any combination of these: Assignments, Seminars, Tech Talks, Mini-Projects, Case-Studies, Self-Study, MOOCs, Certifications, Conf. Paper etc.,

Course Designers		
Experts from Industry	Experts from Higher Technical Institutions	Internal Experts
1. Mr Nishith Sinh, dueNorth India Academics LLP, Dehradun, nsinha.alexander@gmail.com		*1. Dr.P.Madhusoodhanan SRMIST*
2. Mr Ajay Zenne, Career Launcher, ajay.z@careerlauncher.com		*2. Dr.M.Snehalatha SRMIST*
3. Mr.Pratap Iyer, Study Abroad Mentors, Mumbai, pratap.iyer30@gmail.com		*3. Mr Murali K SRMIST*
		4. Mr.Harinarayana Rao SRMIST

Course Code	18PDM302L	Course Name	ENTREPRENEURSHIP MANAGEMENT	Course Category	M	Mandatory	L	T	P	C
							0	0	2	0

Pre-requisite Courses	Business Basics for Entrepreneurs	Co-requisite Courses	Nil	Progressive Courses	Nil
Course Offering Department	Career Development Centre	Data Book / Codes/Standards	Nil		

Course Learning Rationale (CLR):	*The purpose of learning this course is to:*
CLR-1 :	*Provide the knowledge of Legal Systems and trains the students in application skills that enable students to understand the Law and Legal management concepts.*
CLR-2 :	*Comprehend and Practice Ethical Governance*
CLR-3 :	*Understand different HRM concepts*
CLR-4 :	*Understand Project Management and its application*
CLR-5 :	*Use the Project Management skills learnt in the entrepreneurial venture*
CLR-6 :	*Acquire knowledge on validation and Launch of startup*

Course Learning Outcomes (CLO):	*At the end of this course, learners will be able to:*	Learning 1: Level of Thinking (Bloom)	Learning 2: Expected Proficiency (%)	Learning 3: Expected Attainment (%)	PLO 1: Engineering Knowledge	2: Problem Analysis	3: Design & Development	4: Analysis, Design, Research	5: Modern Tool Usage	6: Society & Culture	7: Environment & Sustainability	8: Ethics	9: Individual & Team Work	10: Communication	11: Project Mgt. & Finance	12: Life Long Learning	13: PSO - 1	14: PSO - 2	15: PSO – 3
CLO-1 :	*Acquire knowledge about the Business law, legal procedures, Intellectual Properties and patents.*	1	80	75	L	H	-	M	-	-	-	-	M	L	-	H	-	-	-
CLO-2 :	*Learn the role of government in supporting entrepreneurship to develop the society as well as the role of an entrepreneur as an individual with the government.*	1	80	75	L	H	-	M	-	-	-	-	M	L	-	H	-	-	-
CLO-3 :	*Identify and be able to critically analyze the regulation of governance including that in national and international codes of practice, legislation, common law, norms of practice and ethics.*	2	80	75	L	H	-	M	-	-	-	-	M	L	-	H	-	-	-
CLO-4 :	*Evaluate the effectiveness of HRM practices in supporting the strategic and operational needs of the startup.*	2	80	75	L	H	-	M	-	-	-	-	M	L	-	H	-	-	-
CLO-5 :	*Adapt project management practices to meet the needs of stakeholders from multiple sectors of the economy. Apply project management practices to the launch of new programs, initiatives, products, services, and events relative to the needs of stakeholders.*	3	80	75	L	H	-	M	-	-	-	-	M	H	-	H	-	-	-
CLO-6 :	*Implement project management knowledge, processes, lifecycle and the embodied concepts, tools and techniques in order to achieve project success.*	3	80	75	L	H	-	M	-	-	-	-	M	H	-	H	-	-	-

		Law and Legal Systems	Impact of Governance on ED	HRM	Entrepreneurial Project Management	Project Validation and Launch
Duration (hour)		6	6	6	6	6
S-1	SLO-1	*Introduction to Law and Legal Systems*	*Corporate Governance for Startups*	*HRM – Introduction and Overview*	*Project Management and Entrepreneurship -Introduction*	*Entrepreneur – Pitching the idea "Pitch Fest 01"*
	SLO-2	*Types of Laws and its Impact*	*Governance Structure and Practice*	*Role of HRM in entrepreneurship development*	*Project Management and Entrepreneurship – Concepts and Process*	*Entrepreneur – Pitching the idea "Pitch Fest 02"*
S-2	SLO-1	*Contractual Law*	*Government Programs*	*Functions of HRM*	*Project Management – Aims and Objectives*	*Entrepreneur – Pitching the idea "Pitch Fest 03"*
	SLO-2	*Dispute Resolution*	*Public Policy and its impact on Startups*	*Challenges of Performance and Appraisal in Startups*	*Review of Best Projects – Startup India*	*Entrepreneur – Pitching the idea "Pitch Fest 04"*
S-3	SLO-1	*Intellectual Property Rights - Introduction*	*Market and Institutional mechanisms in Governance*	*HRM - Models and Systems*	*Project Formulation – Concepts and Processed*	*Idea Valuation and Assessment 01*
	SLO-2	*Intellectual Property Rights - Types and Trademarks*	*Ethics in Governance*	*Cultures and Value system for startups*	*Importance and Implementation – Project Formulation*	*Idea Valuation and Assessment 02*
S-4	SLO-1	*Patent Law - Introduction*	*Measuring business performance*	*Employee Motivation*	*Entrepreneurial Project Process Life Cycle - Introduction*	*Project Creation and Setup*
	SLO-2	*Rules and Regulations for Patenting*	*Financial growth for Startups*	*Employee Engagement and Development*	*Entrepreneurial Project Process Life Cycle – Concepts and Methods*	*Project Validation and Assessment*

S-5	SLO-1	*Company Law and Regulations*	*Governance Model for Startups*	*HRM – Key challenges n strategies*	*Project Boundaries and Integration*	*Final Project Launch 01*
	SLO-2	*Types of Companies*	*Structuring Governance for your startup*	*Employee Safety and Security – HRM*	*Core Functionalities in Project Implementation*	*Final Project Launch 02*
S-6	SLO-1	*Business Incorporation – Startup India*	*Risk Management*	*Best HR practices for a startup*	*Stakeholder Management*	*Final Project Launch 03*
	SLO-2	*Make In India*	*Entrepreneurial Risks and its Impact*	*Review for Best Practises in Startup*	*Stakeholder Engagement and analysis*	*Final Project Launch 04*

Learning Resources	*www.wfnen.org; National Entrepreneurship Network – Wadhwani Foundation* *https://www.forbes.com/sites/.../2017/.../top-entrepreneur-stories-to-inspire-you-in-2017/* *https://bizztor.com/in/successful-indian-entrepreneurs-stories* *https://www.entrepreneur.com/article/299214* *https://www.fundera.com/blog/young-entrepreneurs* *The Entrepreneurs: Success and Sacrifice - by Kip Marlow* cbseacademic.nic.in/web_material/Curriculum19/Main.../20_Entrepreneurship.pdf	*Elon Musk – Ashley Vance- Virgin Books-2015* *Think and Grow Rich – Napolean Hill - The Ralston Society – 1937* *The Lean Startup – Eric Ries - Crown Publishing Group (USA) – 2011* *The $100 Startup – Chris Gullibeau - Crown Business- 2012* *Creativity, Innovation, and Entrepreneurship: The Only Way to Renew Your Organization - H. James Harrington - Productivity Press- December 2018*

Learning Assessment

	Bloom's Level of Thinking	Continuous Learning Assessment (100% weightage)								Final Examination	
		CLA – 1 (20%)		CLA – 2 (30%)		CLA – 3 (30%)		CLA – 4 (20%)#			
		Theory	Practice	Theory	Practice	Theory	Practice	Theory	Practice	Theory	Practice
Level 1	Remember Understand	-	*40%*	-	*30%*	-	*30%*	-	*30%*	-	-
Level 2	Apply Analyze	-	*40%*	-	*40%*	-	*40%*	-	*40%*	-	-
Level 3	Evaluate Create	-	*20%*	-	*30%*	-	*30%*	-	*30%*	-	-
	Total	100 %		100 %		100 %		100 %		-	

CLA – 4 can be from any combination of these: Assignments, Seminars, Tech Talks, Mini-Projects, Case-Studies, Self-Study, MOOCs, Certifications, Conf. Paper etc.,

Course Designers

Experts from Industry	Experts from Higher Technical Institutions	Internal Experts
Mr. Vijay Nayar, Director, Education Matters, vijayn@edumat.com	*Mr. Ashok Kumar V – Professor, NITTE School Of Management Entrepreneurship Development, ashokkumarvv2007@gmail.com*	*Dr. Shantanu Patil, Professor and Head of Department, Department of Translational Medicine and Research, Shantanu.s@ktr.srmuniv.ac.in*
Mr. Ajay Zenner, Career Launcher, ajay.z@careerlauncher.com	*Dr. A.K. Sheik Manzoor, Anna University, sheikmanzoor@annauniv.edu*	*Dr. Revathi Venkataraman, Professor, Department of Computer Science and Engineering, revathi.n@ktr.srmuniv.ac.in*
		Mr. Ananth Kumar, Assistant Professor (Mgmt.) & Executive Secretary, psecy.director.et@srmuniv.ac.in
		Mrs. Deepa Narayanan *Assistant Professor – CDC, deepa.na@ktr.srmuniv.ac.in*

Course Code	18LEM110L	Course Name	INDIAN ART FORM	Course Category	M	Mandatory	L	T	P	C
							0	0	2	0

Pre-requisite Courses	Nil	Co-requisite Courses	Nil	Progressive Courses	Nil
Course Offering Department	*English and Foreign Languages*	Data Book / Codes/Standards	Nil		

Course Learning Rationale (CLR):	*The purpose of learning this course is to:*
CLR-1 :	*Introduce the learners to the changing art forms in different periods of time: richness, variety and significance of various Indian art forms*
CLR-2 :	*Enable the students to recognize and appreciate paintings of different schools prevalent in the different geographical locations*
CLR-3 :	*Draw the learner's attention towards the various types of sculpture based on the materials used and the themes behind them*
CLR-4 :	*Cultivate a sense of appreciation about the aesthetics of drawing as an integral part of our daily life*
CLR-5 :	*Orient the learners about the changing Indian social scenario and the ways they are reflected in the changing facets of Modern Indian Art Forms*

Course Learning Outcomes (CLO):	*At the end of this course, learners will be able to:*	Learning 1	Learning 2	Learning 3	Program Learning Outcomes (PLO) 1	2	3	4	5	6	7	8	9	10	11	12	13	14	15
		Level of Thinking (Bloom)	Expected Proficiency (%)	Expected Attainment (%)	Engineering Knowledge	Problem Analysis	Design & Development	Analysis, Design, Research	Modern Tool Usage	Society & Culture	Environment & Sustainability	Ethics	Individual & Team Work	Communication	Project Mgt. & Finance	Life Long Learning	PSO - 1	PSO - 2	PSO – 3
CLO-1 :	*equip with an awareness of the rich cultural heritage of India*	*3*	*90*	*85*	-	-	-	-	-	*H*	*M*	*H*	*H*	*H*	-	*H*	-	-	-
CLO-2 :	*understand the contexts and significance of various Indian art forms*	*3*	*90*	*85*	-	-	-	-	-	*H*	*M*	*M*	*H*	*H*	-	*H*	-	-	-
CLO-3 :	*understand how the confluence of the diverse art forms of India create the mosaic of the Indian nation*	*3*	*90*	*85*	-	-	-	-	-	*H*	*M*	*H*	*H*	*H*	-	*H*	-	-	-

Duration (hour)		Indian Art over Ages - An Overview	Indian painting	Indian sculpture	The Indian Art of Floor Decoration	Modern Art
S-1	SLO-1	*Ancient India: An Overview*	*Indus Valley civilization paintings on pottery*	*Sculpture during the Harappan period*	*Kolam - the traditional floor drawing of South India*	*Nationalist School of Bengal Art- Introduction*
	SLO-2	*Raj-Ravi Verma: religious stories like mythologies of Hindu gods*	*Cave paintings from different parts of India*	*Terra Cota – What? Where? When? – A discussion*	*Daily life and Kolam - Line drawings, geometric designs and natural world - Some examples*	*Matching the picture with the artist*
S-2	SLO-1	*Mysore and Tanjore Art : included themes revolving around Hindu epics like Ramayana and Mahabharata*	*The paintings of the Ajanta and Ellora caves*	*Rock cut sculpture – Differences between rock cut sculpture and stone sculpture*	*Beliefs behind Kolam*	*Tracing the major ideas through paintings – Going back to Hindu themes*
	SLO-2	*Indian artists from different fields*	*Paintings of North India, South India, East India, West India, Central and Deccan India*	*Sculptures in religious buildings*	*Rangoli – Occasions and motifs*	*Student presentations on individual artists*
S-3	SLO-1	*Folk Art*	*Thanjavur, Madhubani paintings*	*Buddhism, Hinduism, and Jainism in sculpures*	*Kalamezhuthu in Kerala - Religious significance*	*Tracing the major ideas through paintings – Indian Village Life and nationalist themes*
	SLO-2	*Folk art and popular culture: classical and folk art*	*Analysing the recurrent themes style through selected illustrations*	*Visit to Mahabalipuram and submitting a report by the students*	*Mandana paintings of Rajasthan and Madhya Pradesh by oldest tribal communities*	*Student presentations on individual artists*
S-4	SLO-1	*Influential factors giving rise to modern art*	*Kalamkari paintings – Features of organic art; obtaining colours from natural sources*	*Bronze sculptures in India*	*Bengal's floor art-Alpona*	*European influences (British) – Trends in painting – portrait, landscape and realistic*
	SLO-2	*Concepts and Motifs behind modern art*	*Attempting simple Kalamkari/Madhubani paintings using natural colours*	*Cultural stonework in India - in the form of primitive cupule art*	*Festival specific Floor Art across India*	*Collection and display of paintings by various artists*
S-5	SLO-1	*Mughal paintings*	*Pattachitra paintings*		*Festival specific Floor Art across India*	*British Gothic and Indo Saracenic*

				the Buddhist Pillars of Ashoka of the Mauryan period		*architecture through examples*
	SLO-2	*Astonishing contemporary paintings by Indian artists*	*Students presenting and sharing their paintings*	*The figurative Greco-Buddhist sculpture of the Gandhara and Mathura schools, and the Hindu art of the Gupta period: Brief Introduction*	*Pookalam: The Onam Floral Rangoli*	*Field trip to places in Chennai which have Indo Saracenic architecture and report submission*
S-6	SLO-1	*Fairs, festivals and local deities in the development of art forms*	*Moghal paintings*	*Khajuraho Temples in Madhya Pradesh*	*Body Art: Traditional Mehendi*	*Indian Art post-Independence Progressive Artists' Group and their Influence*
	SLO-2	*myth, legends, snippets from epic, multitudinous gods born out of dream and fantasy in art forms*	*Moghal paintings from the various Moghal dynasties and identification of the common features*	*Debate on "Religion and Art Today"*	*Mehendi designs, religious and cultural significances*	*Fusion of western style and Indian themes*

Learning Resources	1. *Ketkar, Anil Rao Sandhya. The History of Indian Art (Paperback). Jyotsna Prakashan, 2017.* 2. *Chaturvedi, P. N. Encyclopedia of Indian Art and Architecture. M. D. Publications Pvt. Ltd., 2009.*	3. *Gupta, S. P. Elements of Indian Art:Including Temple Architecture, Iconography and Iconometry. D. K. World Ltd., 2006* 4. *Goswamy, B. N. Ed. Oxford Readings in Indian Art. OUP, 2018.* 5. *https://courses.lumenlearning.com/boundless-arthistory/chapter/contemporary-indian-art/*

Learning Assessment

	Bloom's Level of Thinking	Continuous Learning Assessment (100% weightage)								Final Examination	
		CLA – 1 (20%)		CLA – 2 (30%)		CLA – 3 (30%)		CLA – 4 (20%)#			
		Theory	Practice	Theory	Practice	Theory	Practice	Theory	Practice	Theory	Practice
Level 1	Remember Understand	-	*40%*	-	*30%*	-	*30%*	-	*30%*	-	-
Level 2	Apply Analyze	-	*40%*	-	*40%*	-	*40%*	-	*40%*	-	-
Level 3	Evaluate Create	-	*20%*	-	*30%*	-	*30%*	-	*30%*	-	-
	Total	100 %		100 %		100 %		100 %		-	

CLA – 4 can be from any combination of these: Assignments, Seminars, Tech Talks, Mini-Projects, Case-Studies, Self-Study, MOOCs, Certifications, Conf. Paper etc.,

Course Designers		
Experts from Industry	Experts from Higher Technical Institutions	Internal Experts

Course Code	18LEM109T	Course Name	INDIAN TRADITIONAL KNOWLEDGE	Course Category	M	Mandatory	L	T	P	C
							1	0	0	1

Pre-requisite Courses	Nil	Co-requisite Courses	Nil	Progressive Courses	Nil
Course Offering Department	*English and Foreign Languages*	Data Book / Codes/Standards	Nil		

Course Learning Rationale (CLR):	*The purpose of learning this course is to:*
CLR-1 :	*Introduce the learners to the early and traditional environmental friendly agricultural practices*
CLR-2 :	*Enable the students to recognize and appreciate the contribution of India to astronomical studies*
CLR-3 :	*Draw the learner's attention towards the holistic approach behind Indian system of medicine*
CLR-4 :	*Cultivate a sense of appreciation about ancient Indian Engineering and Technology as diverse, culture and resource specific*
CLR-5 :	*Develop an understanding about the connection of daily life to the environment and a healthy lifestyle through a comparison of the linguistic phrases and sayings and analyzing them from today's science*

Course Learning Outcomes (CLO):	*At the end of this course, learners will be able to:*	Learning 1	2	3	Program Learning Outcomes (PLO) 1	2	3	4	5	6	7	8	9	10	11	12	13	14	15
		Level of Thinking (Bloom)	Expected Proficiency (%)	Expected Attainment (%)	Engineering Knowledge	Problem Analysis	Design & Development	Analysis, Design, Research	Modern Tool Usage	Society & Culture	Environment & Sustainability	Ethics	Individual & Team Work	Communication	Project Mgt. & Finance	Life Long Learning	PSO - 1	PSO - 2	PSO – 3
CLO-1 :	*equip with an awareness of the ancient India's eco consciousness and India's contribution to astronomy and the beliefs associated with it*	*3*	*90*	*85*	-	-	-	-	-	*H*	*H*	*H*	*H*	*H*	-	*H*	-	-	-
CLO-2 :	*appreciate the Indian aesthetic sensibility which is evidenced in the architectural monuments, economic life and religious worship*	*3*	*90*	*85*	-	-	-	-	*L*	*H*	*M*	*M*	*H*	*H*	-	*H*	-	-	-
CLO-3 :	*understand how Indians have had a holistic approach towards human life integrating the body, mind and soul*	*3*	*90*	*85*	-	-	-	-	-	*H*	*H*	*H*	*H*	*H*	-	*H*	-	-	-

Duration (hour)		Agriculture	Mathematics & Astronomy	Medicine	Engineering & Technology	Customs, Sayings And Life Truths
S-1	SLO-1	*Early agricultural settlements - Influencing Factors – locale and climate*	*Concepts of time and space - Knowledge of the Universe*	*Introduction to the school of Ayurveda, Siddha and Naturopathy:*	*Architecture – Temples, forts, palaces, houses and town planning*	*Regional myths, beliefs,,and cultural practices*
	SLO-2	*Locating the early agricultural settlements in the Indian map and indicating the timeline*	*Quiz based on the Indian concept of time and distance between the planets*	*Compare and Contrast of the methodologies, popular beliefs, myths and truths about medications*	*Group Discussions through examples from different historical periods and geographical locations*	*Noting the idioms, proverbs in mother tongues connected to seasons and festivals*
S-2	SLO-1	*Crop cultivation - Community based Environment friendly practices*	*Great astronomers and mathematicians of ancient India*	*Common features - Holistic Therapeutic Approach – Natural elements, individual constitution (Humours), and the balance recommended*	*Metallurgy – Coins, Traditional Indian Metal Carvings*	*Traditional Foods of India in accordance with the climate and availability of the resources*
	SLO-2	*Group presentations on the traditional agricultural practices in selected states*	*The respective contributions of Astronomers and Mathematicians*	*Understanding the rationale behind selected sample treatments provided or advised, Case Studies*	*Discussions on historical periods and their architectural influences*	*Collecting old sayings in specific regions of India*
S-3	SLO-1	*Ancient Indian Water management and irrigation methods*	*The planetary system and Indian Astrology: Basic Facts*	*Yoga and its Universal Appeal*	*Textile technology – Region / Culture specific Fiber, Fabric and weaving*	*Translating Regional sayings into English*
	SLO-2	*A region based study of natural water resources and aquifers and types of irrigation*	*Discussion on a few sample birth charts and predictions made*	*Discussions on worldwide popularity of Yoga and meditation*	*Comparing the Temple Architecture of North and Southern Indian States*	*Traditional sayings about Hygiene and practices pertaining to them*

Learning Resources	1. *V. Sivaramakrishnan (Ed.), Cultural Heritage of India-course material, Bharatiya Vidya Bhavan, Mumbai. 5th Edition, 2014.* 2. *Basham, A.L. ed. A Cultural History of India. OUP, 1997.* 3. *Thapar, Romila. Indian Cultures as Heritage: Contemporary Past. Aleph Book Company, 2018.* 4. *GN Jha (Eng. Trans.), Ed. RN Jha, Yoga-darshanam with Vyasa Bhashya, Vidyanidhi Prakashan, Delhi 2016.*

Learning Assessment

	Bloom's Level of Thinking	Continuous Learning Assessment (100% weightage)								Final Examination	
		CLA – 1 (20%)		CLA – 2 (30%)		CLA – 3 (30%)		CLA – 4 (20%)#			
		Theory	Practice	Theory	Practice	Theory	Practice	Theory	Practice	Theory	Practice
Level 1	Remember Understand	-	*40%*	-	*30%*	-	*30%*	-	*30%*	-	-
Level 2	Apply Analyze	-	*40%*	-	*40%*	-	*40%*	-	*40%*	-	-
Level 3	Evaluate Create	-	*20%*	-	*30%*	-	*30%*	-	*30%*	-	-
	Total	100 %		100 %		100 %		100 %		-	

CLA – 4 can be from any combination of these: Assignments, Seminars, Tech Talks, Mini-Projects, Case-Studies, Self-Study, MOOCs, Certifications, Conf. Paper etc.,

Course Designers		
Experts from Industry	Experts from Higher Technical Institutions	Internal Experts

Course Code	18BTM191T	Course Name	BIOETHICS AND IPR	Course Category	M	Mandatory Course	L	T	P	C
							1	0	0	0

Pre-requisite Courses	Nil	Co-requisite Courses	Nil	Progressive Courses	Nil
Course Offering Department	Biotechnology	Data Book / Codes/Standards	Nil		

Course Learning Rationale (CLR):	*The purpose of learning this course is to:*
CLR-1 :	*Realize the need for ethical values in Biotechnolgy Research*
CLR-2 :	*Realize the need for ethical values in Health Care*
CLR-3 :	*Apply biosafety rules and regulations in research*
CLR-4 :	*Know the different forms of IPR*
CLR-5 :	*Analyze the requirements for patentability of an invention or innovation*
CLR-6 :	*Realize the need for conservation of Biodiversity and sustainable development*

Course Learning Outcomes (CLO):	*At the end of this course, learners will be able to:*	Learning 1 Level of Thinking (Bloom)	Learning 2 Expected Proficiency (%)	Learning 3 Expected Attainment (%)	PLO 1 Engineering Knowledge	PLO 2 Problem Analysis	PLO 3 Design & Development	PLO 4 Analysis, Design, Research	PLO 5 Modern Tool Usage	PLO 6 Society & Culture	PLO 7 Environment & Sustainability	PLO 8 Ethics	PLO 9 Individual & Team Work	PLO 10 Communication	PLO 11 Project Mgt. & Finance	PLO 12 Life Long Learning	PLO 13 PSO - 1	PLO 14 PSO - 2	PLO 15 PSO – 3
CLO-1 :	*Comprehend ethical issues in Biotechnology Research*	2	80	80	L	H	L			H	H	H	H	H	H	H	H	H	H
CLO-2 :	*Comprehend ethical issues in Health Care*	2	85	75	L	H	L			H	H	H	H	H	H	H	H	H	H
CLO-3 :	*Learn Good Laboratory Practices*	2	75	80	L	H	L			H	H	H	H	H	H	H	H	H	H
CLO-4 :	*Understand different forms of IP*	2	85	80	L	H	L			H	H	H	H	H	H	H	H	H	H
CLO-5 :	*Predict the novelty and hence patentability of an invention*	3	85	75	L	H	L			H	H	H	H	L	H	H	H	H	H
CLO-6 :	*Shoulder ethical responsibility*	2	80	80	L	H	L			H	H	H	H	H	H	H	H	H	H

Duration (hour)		3	3	3	3	3
S-1	SLO-1	*Ethics and Bioethics*	*Health Systems and Institutions*	*Biosafety regulations*	*Forms of IPR*	*Patents and methods of application of patents-Legal implications*
	SLO-2	*Basic Principles of Bioethics*	*Global Health Ethics*	*Transgenic Research and Field Trials*	*Designs, Copyrights and Geographical indications*	*Objectives of the patent system*
S-2	SLO-1	*Ethical Theories*	*Ethical issues in Organ transplantation*	*Roles of various regulatory bodies*	*Basic principles and general requirements of patent law*	*TRIPs-GATT-International conventions*
	SLO-2	*Use of animals in research and Ethical issues in Clinical Trials*	*Biobanking*	*Biosafety Rules for GMOs*	*Novelty and Utility*	*Patent Cooperation Treaty*
S-3	SLO-1	*Ethical issues in Stem Cell Research*	*Ethical issues in Regenerative Medicine*	*Biodiversity and Environment conservation*	*Patentable subjects and protection in biotechnology*	*Plant variety protection and farmer rights.*
	SLO-2	*Ethical Issues in In vitro Fertilization*	*Religious and Cultural Perspectives in Bioethics I*	*CBD and Cartagena Protocol*	*Biodiversity*	*Other forms of IP*

Learning Resources	1.Singer and Viens (Eds.) Bioethics – Cambridge University Press, Cambridge,2008 2. The Indian Patent Act and Rules, 2015,GoI, India .

Learning Assessment											
	Bloom's Level of Thinking	Continuous Learning Assessment (100% weightage)								Final Examination	
		CLA – 1 (20%)		CLA – 2 (30%)		CLA – 3 (30%)		CLA – 4 (20%)#			
		Theory	Practice	Theory	Practice	Theory	Practice	Theory	Practice	Theory	Practice
Level 1	Remember Understand	-	*40%*	-	*30%*	-	*30%*	-	*30%*	-	-
Level 2	Apply Analyze	-	*40%*	-	*40%*	-	*40%*	-	*40%*	-	-
Level 3	Evaluate Create	-	*20%*	-	*30%*	-	*30%*	-	*30%*	-	-
	Total	100 %		100 %		100 %		100 %		-	

CLA – 4 can be from any combination of these: Assignments, Seminars, Tech Talks, Mini-Projects, Case-Studies, Self-Study, MOOCs, Certifications, Conf. Paper etc.,

Course Designers		
Experts from Industry	Experts from Higher Technical Institutions	Internal Experts
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Dr. Sharana Gowda, IPO, Guindy, Chennai, gouda.ipo@nic.in	*Prof. R. B. Narayanan, SVCE, Chennai, rbn@svce.ac.in*	*Dr.Pandima Devi, SRMIST*

Course Code	18CEM401J	Course Name	PROFESSIONAL ENHANCEMENT I	Course Category	M	Mandatory Courses	L	T	P	C
							1	0	2	0

Pre-requisite Courses	Nil	Co-requisite Courses	Nil	Progressive Courses	Nil
Course Offering Department	Civil Engineering	Data Book / Codes/Standards	Nil		

Course Learning Rationale (CLR):	*The purpose of learning this course is to:*	Learning			Program Learning Outcomes (PLO)														
		1	2	3	1	2	3	4	5	6	7	8	9	10	11	12	13	14	15
CLR-1 :	*To introduce fundamentals of building design*	Level of Thinking (Bloom)	Expected Proficiency (%)	Expected Attainment (%)	Engineering Knowledge	Problem Analysis	Design & Development	Analysis, Design, Research	Modern Tool Usage	Society & Culture	Environment & Sustainability	Ethics	Individual & Team Work	Communication	Project Mgt. & Finance	Life Long Learning	PSO - 1	PSO - 2	PSO – 3
CLR-2 :	*Understanding architecture and suggest suitable structural scheme*																		
CLR-3 :	*To impart understanding of integrated design concepts including other trades in building construction*																		
CLR-4 :	*To train manual design for RCC and steel structures.*																		
CLR-5 :	*To train in using software and applications for designing RCC and Steel structures.*																		
CLR-6 :	*Awareness to be created in 3dimensional modelling, analysis and design.*																		
Course Learning Outcomes (CLO):	*At the end of this course, learners will be able to:*																		
CLO-1 :	*Identify various types of design for buildings*	*2*	*85*	*80*	*H*	*H*	-	-	-	-	-	-	-	-	-	-	*H*	*H*	-
CLO-2 :	*Analyze the architectural view and structural design concepts*	*3*	*85*	*75*	*H*	*H*	-	-	-	-	-	-	-	-	-	-	*H*	*H*	-
CLO-3 :	*Understand software and manual designs like beam, slab and column*	*3*	*85*	*75*	*H*	*H*	-	-	-	-	-	-	-	-	-	-	*H*	*H*	-
CLO-4 :	*Analyze the steel structure as per IS 800-2007*	*2*	*85*	*80*	*H*	*H*	-	-	-	-	-	-	-	-	-	-	*H*	*H*	-
CLO-5 :	*Understand about the steel design and its optimization*	*2*	*80*	*75*	*H*	*H*	-	-	-	-	-	-	-	-	-	-	*H*	*H*	-
CLO-6 :	*Understand about the 3D-7D planning.*	*3*	*85*	*75*	*H*	*H*	-	-	-	-	-	-	-	-	-	-	*H*	*H*	-

Duration (hour)		6	6	6	6	6
S-1	SLO-1	*Structural Engineering concepts*	*Aligning with architecture, suitable structural scheme to suite architectural plans,*	*Using equivalent systems in manual analysis and computer analysis.*	*Wind loading considerations Seismic loading considerations*	*Integration of Structural Design*
	SLO-2		*Usage of transfer girders, long spans, irregular building configurations. usage of masonry structures*	*Designing for architectural features, loading pattern and building typologies based on usage parameters*	*Steel optimization method in design*	*Interface with other trades and services*
S-2	SLO-1	*Practical : Overview of structural analysis of building*	*Practical: load combination as per IS codes for proportioning members*	*Practical : Reinforcement detailing for RC elements – columns and beams*	*Practical: Bar bending details and scheduling*	*Practical: Drawing preparation*
S-3	SLO-1	*Practical : Overview of structural design of building*	*Practical : checking of pre and post analysis in software*	*Practical : Reinforcement detailing for RC elements – slabs, staircases etc.*	*Practical : Performing steel structure design as per IS800- 2007*	*Practical: Drawing preparation*
S-4	SLO-1	*Classification of Structures*	*Loading definition and equivalent static methods .Using equivalent systems in manual analysis and computer analysis.*	*Manual design for slabs as per IS456 2000*	*Reinforcement ductile detailing as per IS 13920 - 2016*	*BIM and its uses*
S-5	SLO-1	*Practical : Load calculations of real buildings*	*Practical: Using software's for automated seismic and wind loading*	*Practical: Design of Beams and Columns using software*	*Practical :Seismic detailing practices*	*Practical: construction interfacing*
S-6	SLO-1	*Practical : Load calculations of special structures like bridges as per IRC codes*	*Practical : Manual design for beams and columns as per IS456 2000*	*Practical: Using software's for slab modeling and analysis*	*Practical : Usage of Custom spreadsheets*	*Practical 3D to 7D& planning*

Learning Resources	1. Varghese.P.C, "Limit State Design Of Reinforced Concrete", 2nd Ed,PHI Learning Pvt. Ltd., 2004 2. Francis .D.K Ching- "Architecture: Form Space & Order" Van Nastrand Reinhold, 1996 3. Subramanian.N, "Design of Steel Structures-Limit State Method", Oxford University Press, New Delhi, 2016.	4. https://www.bentley.com/en/products/brands/staad 5. https://www.csiamerica.com/products/etabs 6. https://www.csiamerica.com/products/sap2000 7. Prasanna Chandra, "Projects -Planning Analysis Selection Implementation & Review", Fourth Edition,. Tata McGraw Hill Publishing Company Ltd., New Delhi.2005.

Learning Assessment											
	Bloom's Level of Thinking	Continuous Learning Assessment (100% weightage)								Final Examination	
		CLA – 1 (20%)		CLA – 2 (30%)		CLA – 3 (30%)		CLA – 4 (20%)#			
		Theory	Practice	Theory	Practice	Theory	Practice	Theory	Practice	Theory	Practice
Level 1	Remember Understand	-	*40%*	-	*30%*	-	*30%*	-	*30%*	-	-
Level 2	Apply Analyze	-	*40%*	-	*40%*	-	*40%*	-	*40%*	-	-
Level 3	Evaluate Create	-	*20%*	-	*30%*	-	*30%*	-	*30%*	-	-
	Total	100 %		100 %		100 %		100 %		-	

CLA – 4 can be from any combination of these: Assignments, Seminars, Tech Talks, Mini-Projects, Case-Studies, Self-Study, MOOCs, Certifications, Conf. Paper etc.,

Course Designers		
Experts from Industry	Experts from Higher Technical Institutions	Internal Experts
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2. Er. G. Hariharanath, GA Consultants, Chennai, gac1996@hotmail.com	*2. Dr. P. Jayabalan, NIT, Trichy, pjeya@nitt.edu*	*Dr. K.S. Satyanarayanan, SRMIST*

Course Code	18CEM402J	Course Name	PROFESSIONAL ENHANCEMENT COURSE II	Course Category	M	Mandatory Course	L	T	P	C
							1	0	0	0

Pre-requisite Courses	Nil	Co-requisite Courses	Nil	Progressive Courses	Nil
Course Offering Department	Civil Engineering	Data Book / Codes/Standards	Nil		

Course Learning Rationale (CLR):	*The purpose of learning this course is to:*
CLR-1 :	*Create insights into various post tensioning elements.*
CLR-2 :	*Address concepts related to prefabricated buildings*
CLR-3 :	*Analyze concepts of BIM, 3D printing and recent trends*
CLR-4 :	*Address concepts related to LIDAR, UAV, SAR and its recent trends*
CLR-5 :	*Create insights into Scatterometry and polorimetry applications*
CLR-6 :	*Analyze concepts of soil strengthening and stabilization.*

Course Learning Outcomes (CLO):	*At the end of this course, learners will be able to:*	Learning			Program Learning Outcomes (PLO)														
		1	2	3	1	2	3	4	5	6	7	8	9	10	11	12	13	14	15
		Level of Thinking (Bloom)	Expected Proficiency (%)	Expected Attainment (%)	Engineering Knowledge	Problem Analysis	Design & Development	Analysis, Design, Research	Modern Tool Usage	Society & Culture	Environment & Sustainability	Ethics	Individual & Team Work	Communication	Project Mgt. & Finance	Life Long Learning	PSO - 1	PSO - 2	PSO – 3
CLO-1 :	*Analyse Post tensioning sections and design of elements.*	*2*	*85*	*80*	*H*	*H*	-	-	-	-	-	-	-	-	-	-	*H*	*H*	-
CLO-2 :	*Understand Prefabricated structural buildings*	*2*	*85*	*75*	*H*	*H*	-	-	-	-	-	-	-	-	-	-	*H*	*H*	-
CLO-3 :	*Understand recent trends in BIM, Top down construction and sustainability in construction.*	*1*	*85*	*75*	*H*	*H*	-	-	-	-	-	-	-	-	-	-	*H*	*H*	-
CLO-4 :	*Analyse about waste management and environmental impact assessment.*	*2*	*85*	*80*	*H*	*H*	-	-	-	-	-	-	-	-	-	-	*H*	*H*	-
CLO-5 :	*Understand recent trends in SAR, LIDAR etc:*	*2*	*80*	*75*	*H*	*H*	-	-	-	-	-	-	-	-	-	-	*H*	*H*	-
CLO-6 :	*Analyze about the soil strengthening and recent trends in soil stabilization.*	*2*	*85*	*75*	*H*	*H*	-	-	-	-	-	-	-	-	-	-	*H*	*H*	-

Duration (hour)		3	3	3	3	3
S-1	SLO-1	Structural Engineering – Post Tensioning	CEM : Top down construction,BIM,3D printing	Environmental impact assessment	Empherical and semi empherical modelling of SAR	Trends interferometry in land slide application and recent trends.
S-2	SLO-2	Prefabricated structural design	Safety and other recent trends, Sustainability in construction, OR in CEM	Hazardous waste management – rain harvesting.	ANN in optimization in SAR, Altimetry for ocean studies and geoidal modelling	Soil strengthening measures , Geosynthesis
S-3	SLO-3	Recent trends in structural engineering	Water resources and Environmental Engineering, Climate change and impacts	Remote sensing and GIS : LIDAR,UAV	Scatterometry and polorimetry applications and recent trends	Biotechnology , slope stabilization and other recent trends

Learning Resources		
Learning Resources	1. *Krishnaraju .N, "Prestressed Concrete", Tata McGraw-Hill Education, 2008, New Delhi* 2. *Laszlo Mokk, "Prefabricated Concrete for Industrial and Public Structures", AkademiaiKiado, Budapest, 2007.* 3. *Kumar NeerajJha, "Construction project management", Dorling Kindersley,New Delhi.2013* 4. *"Decision making and operations research techniques for construction management". C.m.tam, thomask.l.tongh.zhang* 5. *Asawa .G.L, "Irrigation and Water Resources Engineering", New Age International Publishers, New Delhi, 2005*	6. *"Decision making and operations research techniques for construction management". C.m.tam, thomask.l.tongh.zhang* 7. *Charles J.Kibert,"Sustainable Construction: Green Buildings Design And Delivery", John Wiley & Sons, 2005* 8. *Paneerselvam .R "Environmental Engineering", Vol. I, SPGS Publishers Chennai, 2010* 9. *Anji Reddy .M, "Remote sensing and Geographical information system," B.S Publications* 10. *Terzaghi K., Peck R.B., Soil Mechanics in Engineering Practice, John Wiley Ltd., 1967*

Learning Assessment											
	Bloom's Level of Thinking	Continuous Learning Assessment (100% weightage)								Final Examination	
		CLA – 1 (20%)		CLA – 2 (30%)		CLA – 3 (30%)		CLA – 4 (20%)#			
		Theory	Practice	Theory	Practice	Theory	Practice	Theory	Practice	Theory	Practice
Level 1	Remember Understand	-	*40%*	-	*30%*	-	*30%*	-	*30%*	-	-
Level 2	Apply Analyze	-	*40%*	-	*40%*	-	*40%*	-	*40%*	-	-
Level 3	Evaluate Create	-	*20%*	-	*30%*	-	*30%*	-	*30%*	-	-
	Total	100 %		100 %		100 %		100 %		-	

CLA – 4 can be from any combination of these: Assignments, Seminars, Tech Talks, Mini-Projects, Case-Studies, Self-Study, MOOCs, Certifications, Conf. Paper etc.,

Course Designers		
Experts from Industry	Experts from Higher Technical Institutions	Internal Experts
1. Er. AGV. Desigan, Design Group Engineering Consultancy Pvt Ltd. Chennai, designan.agv@gmail.com	*1. Dr. R. Santhakumar, Professor, Centre for Rulal Department, NITTTR*	*1. Dr. K.S. Satyanarayanan, SRMIST*
2. Er. G. Hariharanath, GA Consultants, Chennai, gac1996@hotmail.com	*2. Dr. P. Jayabalan, NIT, Trichy, pjeya@nitt.edu*	*2. Mr. N. Parthasarathi, SRMIST*

ACADEMIC CURRICULA

Open Elective Courses

Regulations - 2018

SRM INSTITUTE OF SCIENCE AND TECHNOLOGY

(Deemed to be University u/s 3 of UGC Act, 1956)

Kattankulathur, Kancheepuram, Tamil Nadu, India

Course Code	18AUO101T	Course Name	HYBRID AND ELECTRIC VEHICLES	Course Category	O	Open Elective	L	T	P	C
							3	0	0	3

Pre-requisite Courses	Nil	Co-requisite Courses	Nil	Progressive Courses	Nil
Course Offering Department	Automobile Engineering	Data Book / Codes/Standards		Nil	

Course Learning Rationale (CLR):	*The purpose of learning this course is to:*
CLR-1 :	*Provide an insight into how electric vehicle operate*
CLR-2 :	*Demonstrate the functional requirements of Battery management system in detail.*
CLR-3 :	*Demonstrate how Electric and Hybrid Vehicle vary as per design requirements.*
CLR-4 :	*Perform the detailed analysis on the drives and driveline.*
CLR-5 :	*Selection of the appropriate drive and driveline system for the different cases.*

Course Learning Outcomes (CLO):	*At the end of this course, learners will be able to:*	Learning 1 Level of Thinking (Bloom)	Learning 2 Expected Proficiency (%)	Learning 3 Expected Attainment (%)	PLO 1 Engineering Knowledge	PLO 2 Problem Analysis	PLO 3 Design & Development	PLO 4 Analysis, Design, Research	PLO 5 Modern Tool Usage	PLO 6 Society & Culture	PLO 7 Environment & Sustainability	PLO 8 Ethics	PLO 9 Individual & Team Work	PLO 10 Communication	PLO 11 Project Mgt. & Finance	PLO 12 Life Long Learning	PLO 13 PSO - 1	PLO 14 PSO - 2	PLO 15 PSO – 3
CLO-1 :	*Learn the basic concepts of electric vehicle technology and electric vehicles.*	2	90	85	H	M	L	L	L	L	L	M	L	M	M	H	H	H	M
CLO-2 :	*Develop and analyze hybrid and electric drive trains.*	2	90	80	H	H	H	H	H	L	M	H	H	H	M	H	H	H	H
CLO-3 :	*Interpret various vehicle power sources in hybrid vehicle technology*	2	90	80	H	M	M	M	M	L	M	H	M	H	M	H	M	M	H
CLO-4 :	*Analyze data to determine appropriate design calculations of hybrid system under study.*	2	90	80	H	H	M	H	M	L	M	H	M	H	M	M	H	M	H
CLO-5:	*Apply the concepts in sizing the electric motors*	2	90	80	H	H	M	H	H	L	L	M	H	H	M	H	H	H	M

Title		Electric Vehicle Propulsion and Energy Sources	Electric Vehicle Powerplant And Drives	Hybrid and Electric Drivetrains	Electric and Hybrid Vehicle Design	Electric And Hybrid Vehicles – Case Studies
Duration (hour)		9	9	9	9	9
S-1	SLO-1	*Basic concepts and problems concerning the electrification in Mobility*	*Basic concepts of electric vehicle power plant*	*Functional requirements of Hybrid Vehicle*	*Design perspectives of Hybrid vehicle*	*Parallel Hybrid, Series Hybrid -Charge Sustaining*
	SLO-2	*Functional components in an electric and hybrid vehicle*	*Power and Torque plot*		*Power plant energy distribution*	
S-2	SLO-1	*Vehicle Mechanics - Kinetics*	*Construction of Induction Machines,*	*Operational difference between the Fully Electric, Hybrid and Mild Hybrid*	*Matching the Electric Machine and the Internal Combustion Engine*	*Parallel Hybrid, Series Hybrid –Charge Depleting*
	SLO-2	*Vehicle Mechanics – Dynamics & Roadway Fundamentals*	*Operating cycle and application in traction*			
S-3	SLO-1	*Propulsion System Design - Force Velocity Characteristics,*	*Construction of Permanent Magnet Machines*	*Topological Phenomena and Social Importance of e-mobility*	*Parameter optimization – IC Engine*	*Hybrid Vehicle Case Study –Toyota Prius*
	SLO-2	*Calculation Of Tractive Power And Energy Required*	*Construction of Switch Reluctance Machines*		*Position and Types of arrangements*	
S-4	SLO-1	*Electric Vehicle Power Source - Battery Capacity*	*Role of Power Electronic Converters- DC/DC Converters*	*Role of modern drivetrain and the conversion efficiency and power consumption*	*Parameter optimization – Motor*	*Hybrid Vehicle Case Study –Honda Insight*
	SLO-2	*Battery Construction and Types*	*Description of Buck Boost Converter*		*Position and Types of arrangements*	
S-5	SLO-1	*State of Charge and Discharge*	*Isolated DC/DC Converter*	*Description of Hybrid Traction*	*Sizing of Propulsion Motor*	*Hybrid Vehicle Case Study –Chevrolet Volt*
	SLO-2		*Functional Requirements and Operating limits*		*Power Electronics & Drive System*	
S-6	SLO-1	*Calculation of Specific Energy and Specific Power & Ragone Plot Relationship*	*Two Quadrant Chopper*	*Description of Electric Traction.*	*Selection of Energy Storage Technology*	*42 V System for Traction Applications*
	SLO-2		*Switching Modes*		*Topological Optimization*	
S-7	SLO-1	*Battery Modeling - Run Time Battery Model, First Principle Model*	*AC Drives- PWM*	*Topological Optimization for Hybrid Traction*	*Communications & Supporting Subsystem*	*Lightly Hybridized Vehicles and Low Voltage System*

	SLO-2		*Current Control Method*	*Topological Optimization for Electric Traction*		
S-8	SLO-1	*Battery Management System- SOC Measurement, Battery Cell Balancing.*	*Role of Switch Reluctance Machine Drives*	*Power Flow Control & Energy Efficiency Analysis*	*Energy Management Strategies in Hybrid Vehicles- Classification, Comparison, Implementation*	*Electric Vehicle Case Study - GM EV1, Nissan Leaf, Mitsubishi Miev*
	SLO-2			*Configuration and Control of DC Motor Drives*		
S-9	SLO-1	*Traction Batteries - Nickel Metal Hydride Battery, Li-Ion, Li-Polymer Battery.*	*Voltage Control*	*Induction Motor Drive.*	*Energy Management Strategies in Electric Vehicles- Classification, Comparison, Implementation*	*Hybrid Electric Heavy-Duty Vehicles, Fuel Cell Heavy Duty Vehicles*
	SLO-2		*Current Control*	*Permanent Magnet Motor Drives, Switch Reluctance Motor Drives, Drive System Efficiency.*		

Learning Resources	1. *Iqbal Husain, "Eclectic and Hybrid vehicles Design Fundamentals" , CRC Press, second edition 2013, ISBN 9781439811757* 2. *James Larminie, John Lowry, "Electric vehicle technology Explained" second Edition, Wiley 2012, ISBN-13: 978-1119942733*	3. *Ali Emadi, "Hand book of Automotive Power Electronics and Motor Drives", CRC Press 2005, ISBN 9780824723613.* 4. *Ali Emadi, Mehrdad Ehsani, John M. Muller,"Vehicular Electric Power Systems" Marcel Dekker, Inc., 2004*

Learning Assessment

	Bloom's Level of Thinking	Continuous Learning Assessment (50% weightage)								Final Examination (50% weightage)	
		CLA – 1 (10%)		CLA – 2 (15%)		CLA – 3 (15%)		CLA – 4 (10%)#			
		Theory	Practice	Theory	Practice	Theory	Practice	Theory	Practice	Theory	Practice
Level 1	Remember Understand	*60%*		*50%*		*40%*		*15%*		*50%*	
Level 2	Apply Analyze	*40%*		*50%*		*60%*		*20%*		*50%*	
Level 3	Evaluate Create	-		-		-		*15%*		-	
	Total	100 %		100 %		100 %		100 %		100%	

CLA – 4 can be from any combination of these: Assignments, Seminars, Tech Talks, Mini-Projects, Case-Studies, Self-Study, MOOCs, Certifications, Conf. Paper etc.,

Course Designers

Experts from Industry	Experts from Higher Technical Institutions	Internal Experts
1. Mr.K.V. Simmom, Royal Enfield, kvsimmon1@royalenfield.com	*1. Dr..A.Samuel Raja, Thiyagarajar college of Engineering Madurai, samuel1973@tce.edu*	*1. Mr. Kaviyarasu T, SRMIST*
2. Mr.R.Srikanth, Altair, srikanth.r@altair.com	*2. Mr. N.Ravikumar, Crescent Institute of Science and Technology, ravikumar@crescent.education*	*2. Mr. Jerome Stanley M, SRMIST*

Course Code	18AUO102T	Course Name	RENEWABLE SOURCES OF ENERGY	Course Category	O	Open Elective	L	T	P	C
							3	0	0	3

Pre-requisite Courses	Nil	Co-requisite Courses	Nil	Progressive Courses	Nil
Course Offering Department	Automobile Engineering	Data Book / Codes/Standards	Nil		

Course Learning Rationale (CLR):	The purpose of learning this course is to:
CLR-1 :	*Explain the concept of wind energy*
CLR-2 :	*Create insight on solar energy and its application*
CLR-3 :	*Evaluate the use of geothermal and hydro power for power generation*
CLR-4 :	*Analyze the biomass energy and ocean energy*
CLR-5 :	*Develop knowledge on various energy conversion devices*

Course Learning Outcomes (CLO):	At the end of this course, learners will be able to:	Learning 1	Learning 2	Learning 3	PLO 1	2	3	4	5	6	7	8	9	10	11	12	13	14	15
		Level of Thinking (Bloom)	Expected Proficiency (%)	Expected Attainment (%)	Engineering Knowledge	Problem Analysis	Design & Development	Analysis, Design, Research	Modern Tool Usage	Society & Culture	Environment & Sustainability	Ethics	Individual & Team Work	Communication	Project Mgt. & Finance	Life Long Learning	PSO - 1	PSO - 2	PSO – 3
CLO-1 :	*Apply the knowledge of using wind energy for power production*	2	80	75	H	L	L	M	M	H	H	L	L	M	L	H	H	H	M
CLO-2 :	*Analyze the economy of using solar power*	2	85	80	H	L	L	M	M	H	H	L	L	M	L	H	H	H	M
CLO-3 :	*Rationalize geothermal and hydro power plants*	2	80	75	H	M	M	M	H	H	H	L	M	M	L	H	M	H	M
CLO-4 :	*Perceive the concept of biomass and ocean energy for power production*	2	80	75	H	L	M	M	M	H	H	L	L	M	L	H	M	M	L
CLO-5 :	*Demonstrate the working of various energy conversion devices*	2	85	80	H	L	M	M	M	H	H	L	L	M	L	H	M	M	L

		Wind Energy	Solar Energy	Geo thermal and Hydro power	Ocean energy and Biomass based energy	Energy Conversions
Duration (hour)		9	9	9	9	9
S-1	SLO-1 / SLO-2	*Introduction- Renewable energy sources-statistics and technologies*	*Basic properties of solar energy*	*Geothermal – Resources, Types of wells*	*Ocean Energy – Principle, Utilization*	*Need for direct energy conversion (DEC), carnot cycle*
S-2	SLO-1 / SLO-2	*Wind Energy - Introduction*	*Application of solar energy*	*Method of harnessing power and its potential in India*	*Setting of power plants*	*Limitations and principle of DEC*
S-3	SLO-1 / SLO-2	*Application of wind energy*	*Transformation of solar energy*	*Hydropower – Properties and availability*	*Thermodynamic cycles*	*Thermo electric generators*
S-4	SLO-1 / SLO-2	*Transformation of wind energy*	*Solar heat collectors*	*Transformation of water energy*	*Tidal and wave energy*	*Seebeck, peltier and joule Thompson effect and application*
S-5	SLO-1 / SLO-2	*Wind Turbines*	*Solar photovoltaic collectors*	*Hydro power plants*	*Biomass - Principle of biomass conversion*	*Magneto hydrodynamic generator (MHD) – Working principle*
S-6	SLO-1 / SLO-2	*Operating characteristics*	*Application of solar collectors*	*Applications of hydro power plants*	*Anaerobic/aerobic digestion*	*MHD accelerator, MHD engine*
S-7	SLO-1 / SLO-2	*Wind power plant*	*Solar power plant*	*Special hydropower plants*	*Biogas digestors, gas yield and combustion characteristics*	*Electron gas dynamic conversion*
S-8	SLO-1 / SLO-2	*Utilization of wind power*	*Economic study*	*Economic study*	*Utilization for cooking and economic aspects*	*Fuel cell – basic principle*
S-9	SLO-1 / SLO-2	*Trends in wind energy utilization*	*Trends in solar energy utilization*	*Trends in hydro power utilization*	*Utilization in IC engine*	*Hybrid vehicle – Basic principle*

Learning Resources	1. *Boyle, Godfrey. 2004. Renewable Energy (2nd edition). Oxford University Press.*	2. *Boyle, Godfrey, Bob Everett, and Janet Ramage (eds.) 2004. Energy Systems and Sustainability: Power for a Sustainable Future. Oxford University Press, 619 pages (ISBN: 0-19-926179-2)*

Learning Assessment											
	Bloom's Level of Thinking	Continuous Learning Assessment (50% weightage)								Final Examination (50% weightage)	
		CLA – 1 (10%)		CLA – 2 (15%)		CLA – 3 (15%)		CLA – 4 (10%)#			
		Theory	Practice	Theory	Practice	Theory	Practice	Theory	Practice	Theory	Practice
Level 1	Remember Understand	*40 %*	-	*30 %*	-	*30 %*	-	*30 %*	-	*30%*	-
Level 2	Apply Analyze	*40 %*	-	*40 %*	-	*40 %*	-	*40 %*	-	*40%*	-
Level 3	Evaluate Create	*20 %*	-	*30 %*	-	*30 %*	-	*30 %*	-	*30%*	-
	Total	100 %		100 %		100 %		100 %		100 %	

CLA – 4 can be from any combination of these: Assignments, Seminars, Tech Talks, Mini-Projects, Case-Studies, Self-Study, MOOCs, Certifications, Conf. Paper etc.,

Course Designers		
Experts from Industry	Experts from Higher Technical Institutions	Internal Experts
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2. Mr. Ram Prasanth A, Caterpillar India Pvt Ltd, anjaneyulu_ram_p@cat.com	*2.Dr.S.Natrajan, Assistant Professor(Senior Grade),Mechanical Engineering, Sri Venkateswara College of Engineering,Email: natraj@svce.ac.in*	*2. Dr. V. Edwin Geo, SRMIST*

Course Code	18AUO103T	Course Name	SPECIAL TYPE OF VEHICLES	Course Category	O	Open Elective	L	T	P	C
							3	0	0	3

Pre-requisite Courses	Nil	Co-requisite Courses	Nil	Progressive Courses	Nil
Course Offering Department	Automobile Engineering	Data Book / Codes/Standards	Nil		

Course Learning Rationale (CLR):	*The purpose of learning this course is to:*
CLR-1 :	*Identify the special type of vehicles, their applications*
CLR-2 :	*Define the principles and design considerations of farm equipments*
CLR-3 :	*Define and Classify earth moving equipments*
CLR-4 :	*Identify the special vehicles used in construction industry*
CLR-5 :	*Classify the special application vehicles*

Course Learning Outcomes (CLO):	*At the end of this course, learners will be able to:*	Learning 1: Level of Thinking (Bloom)	2: Expected Proficiency (%)	3: Expected Attainment (%)	PLO 1: Engineering Knowledge	2: Problem Analysis	3: Design & Development	4: Analysis, Design, Research	5: Modern Tool Usage	6: Society & Culture	7: Environment & Sustainability	8: Ethics	9: Individual & Team Work	10: Communication	11: Project Mgt. & Finance	12: Life Long Learning	13: PSO - 1	14: PSO - 2	15: PSO – 3
CLO-1 :	*Acquire the knowledge of construction and operation of special type vehicle.*	*1,2*	*90*	*85*	*H*	*M*	*M*	*L*	*L*	*L*	*H*	*M*	*M*	*M*	*L*	*H*	*H*	*M*	*L*
CLO-2 :	*Understand the tractors operation principles and their types.*	*1,2*	*90*	*85*	*H*	*M*	*M*	*H*	*M*	*M*	*M*	*L*	*M*	*L*	*L*	*H*	*H*	*M*	*M*
CLO-3 :	*Know the fundamentals of earth moving machines and their types.*	*2*	*90*	*85*	*H*	*H*	*M*	*H*	*M*	*M*	*M*	*L*	*M*	*L*	*L*	*M*	*H*	*M*	*M*
CLO-4 :	*Applications of special type vehicles in construction industry for material handling.*	*3*	*85*	*80*	*H*	*H*	*M*	*H*	*M*	*M*	*M*	*L*	*M*	*L*	*L*	*M*	*H*	*M*	*M*
CLO-5 :	*Learn the basics of special application machines*	*2*	*85*	*80*	*H*	*H*	*M*	*H*	*M*	*M*	*M*	*L*	*M*	*L*	*L*	*H*	*H*	*M*	*L*

		Off Road Equipments	Farm Equipments	Earth Moving Machines	Construction Equipments	Special purpose vehicles
Duration (hour)		9	9	9	9	9
S-1	SLO-1	*Classification of Special Purpose Vehicles,*	*Classification of farm equipments*	*Introduction of Earth moving equipments*	*Scrapers - Introduction*	*Introduction to special application machines*
	SLO-2	*wheel type & track type, applications*	*Introduction to tractors*	*capacity and applications of earthmovers*	*Scrappers Constructional Details, Applications*	*Power Shovel – Introduction and types*
S-2	SLO-1	*Transport Equipment: Powered Equipment, Trolleys, - Constructional Details, Applications*	*lay out of wheeled tractor*	*Basic considerations for equipment selection*	*Scrappers and their types*	*Power Shovel- Constructional details and applications*
	SLO-2	*Trailers Constructional Details, Applications*	*Classification of tractors*	*Bulldozers- Constructional details and operations and applications*	*Graders- Introduction*	*Drag lines*
S-3	SLO-1	*Platform Lift Trucks Constructional Details, Applications*	*Wheeled Tractor - Constructional Details, Applications*	*Types of Bull dozers*	*Motor graders Constructional Details, Applications*	*Revolving shovels –constructional details and applications*
	SLO-2	*Fork Lift Trucks Constructional Details, Applications*	*Crawler Tractor - Constructional Details, Applications*	*Cable And Hydraulic Dozers*	*Classifications of Motor graders*	*Stripper Shovels - constructional details and applications*
S-4	SLO-1	*Containers And Supports.- Constructional Details, Applications*	*Recent Trends In Tractor Design*	*Running And Steering Gears*	*Bush Cutters - Introductions*	*Capacity Of Shovels*
	SLO-2	*Hauling Equipment: Types Of Dump Trucks, On-High Way Vehicles, Constructional Details, Applications*	*Power transmission system In Caterpillar Tractor. – Mechanism*	*Dump Traction- Introduction*	*Bush Cutters- Constructional Details, Applications*	*Ditchers - Introduction*
S-5	SLO-1	*Off High Way Vehicles Constructional Details, Applications.*	*Steering system*	*Dump Trucks and their types*	*Stumpers -Introduction*	*Ditchers - constructional details and applications*
	SLO-2	*Hoisting Equipment: Jacks, Truck Mounted Crane*	*Accessories of wheeled tractors*	*Rigid Dump Trucks Constructional Details,*	*Stumpers - Constructional Details, Applications*	*Articulated vehicles- constructional details and applications*
S-6	SLO-1	*Crawler Constructional Details, Applications*	*Hydraulic control system*	*Articulated Dump Trucks Constructional Details*	*Dozer- Introduction*	*Ambulance*

	SLO-2	*Crane Constructional Details, Applications*	*Power take off unit.*	*Loaders: Single Bucket Constructional Details, Applications*	*Dozer-- Constructional Details, Applications*	*fire extinguishing vehicle*
S-7	SLO-1	*Outriggers. - Constructional Details, Applications*	*Motor Grader: Recent Trends*	*Multi Bucket Constructional Details, Applications*	*Rippers -Constructional Details, Applications*	*Hover craft*
	SLO-2	*Vibratory compactors Constructional Details, Applications*	*Control Mechanism Of A Caterpillar Motor Grader*	*Skid steer loaders constructional details and applications*	*Dragline Excavator -Introduction*	*oil tankers*
S-8	SLO-1	*Human factors in special purpose vehicle*	*Ride and stability characteristics*	*Trenchers- Introduction*	*Dragline Excavator - Constructional Details, Applications*	*Introduction to tankers*
	SLO-2	*Safety features*	*Safety features in tractors*	*Trenchers-Principles and operations*	*Vibratory roller - introduction*	*Special features and constructional details of tankers*
S-9	SLO-1	*Regulatory requirements of special purpose vehicles*	*Human factors in tractor design*	*criteria for selection of prime mover fro dumpers*	*Vibratory roller – Constructional details and applications*	*gun carriers - Introduction*
	SLO-2	*Economics of special purpose vehicle utilization*	*Procedure of testing and standard code for testing of tractor performance*	*criteria for selection of prime mover for front end loaders*	*Concrete mixer– Constructional details and applications*	*gun carriers - constructional details*

Learning Resources	*1. Wong J, "Terramechanics and Off-Road Vehicle Engineering", Butterworth-Heinemann, 2009* *2. "Off the Road Wheeled and Combined Traction Devices"., - Ashgate Publishing Co. Ltd. 1998* *3. Construction Equipment Management for Engineers, Estimators, and Owners, 1st Edition, CRC Press, 2006* *4. Rodhiev and Rodhiev, "Tractors and Automobiles", MIR Publishers, Moscow, 1984.*	*5. Abrosimov. K. Bran berg.A. and Katayer.K,"Road making Machinery", MIR Publishers, Moscow, 1971.* *6. RoviraMás, Francisco, Zhang, Qin, Hansen, Alan C, "Mechatronics and Intelligent Systems for Off-road Vehicles", Springer, 2011*

Learning Assessment

	Bloom's Level of Thinking	Continuous Learning Assessment (50% weightage)								Final Examination (50% weightage)	
		CLA – 1 (10%)		CLA – 2 (15%)		CLA – 3 (15%)		CLA – 4 (10%)#			
		Theory	Practice	Theory	Practice	Theory	Practice	Theory	Practice	Theory	Practice
Level 1	Remember Understand	*40 %*	-	*40%*	-	-	-	*30 %*	-	*30*	-
Level 2	Apply Analyze	*40 %*	-	*20%*	-	*60%*	-	*40 %*	-	*40*	-
Level 3	Evaluate Create	*20 %*	-	*20%*	-	*40%*	-	*30 %*	-	*30*	-
	Total	100 %		100 %		100 %		100 %		100 %	

CLA – 4 can be from any combination of these: Assignments, Seminars, Tech Talks, Mini-Projects, Case-Studies, Self-Study, MOOCs, Certifications, Conf. Paper etc.,

Course Designers

Experts from Industry	Experts from Higher Technical Institutions	Internal Experts
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2. Mr.K.V.Simmom, Royal Enfield, kvsimmon1@royalenfield.com	*2.Dr.S.Ramkumar,Vel Tech, drsramkumar@veltech.edu*	*2. Mr. .S.Kiran,SRMIST*

Course Code	18AUO104T	Course Name	FUEL CELLS AND APPLICATIONS	Course Category	O	Open Elective	L	T	P	C
							3	0	0	3

Pre-requisite Courses	Nil	Co-requisite Courses	Nil	Progressive Courses	Nil
Course Offering Department	Automobile Engineering	Data Book / Codes/Standards	Nil		

Course Learning Rationale (CLR):	The purpose of learning this course is to:
CLR-1 :	*Impart knowledge on fuel cell technology and applications*
CLR-2 :	*Know the concept of electrochemistry in fuel cells*
CLR-3 :	*Distinguish different types of fuel cells and operations*
CLR-4 :	*Inferring different hydrogen production techniques*
CLR-5 :	*Identify the application of fuel cells in power generation*

Course Learning Outcomes (CLO):	At the end of this course, learners will be able to:	Learning 1: Level of Thinking (Bloom)	2: Expected Proficiency (%)	3: Expected Attainment (%)	PLO 1: Engineering Knowledge	2: Problem Analysis	3: Design & Development	4: Analysis, Design, Research	5: Modern Tool Usage	6: Society & Culture	7: Environment & Sustainability	8: Ethics	9: Individual &Team Work	10: Communication	11: Project Mgt. & Finance	12: Life Long Learning	13: PSO - 1	14: PSO - 2	15: PSO – 3
CLO-1 :	*Understand the basics of fuel cell technology*	1,2	90	85	H	M	H	H	H	M	M	L	M	M	L	M	H	H	H
CLO-2 :	*Infer the concepts of fuel cell electrochemistry*	1,2	90	85	H	M	H	H	H	L	L	L	M	M	L	M	H	H	H
CLO-3 :	*Classify the major types of fuel cells and their modes of operation*	1,2	90	80	H	M	H	H	H	L	L	L	M	M	L	L	H	H	H
CLO-4 :	*Categorize the methods of production, storage and utilization of hydrogen as a fuel*	1,2	80	75	H	H	H	H	H	L	L	L	M	M	L	L	H	H	H
CLO-5 :	*Gain knowledge on application of fuel cells in power cogeneration*	1,2	90	85	H	H	H	H	M	L	L	L	M	M	L	M	H	H	H

		Introduction to fuel cells and fuel cell thermodynamics	Fuel cell electrochemistry	Types of fuel cells	Hydrogen production, storage and utilization	Application of fuel cells in power cogeneration
Duration (hour)		9	9	9	9	9
S-1	SLO-1	*Introduction and overview of fuel cell technology*	*Introduction to electrode kinetics.*	*Classification of fuel cells*	*Hydrogen : Its merit as a fuel,*	*Balance of fuel cell power plant,*
	SLO-2	*A simple fuel cell, fuel cell advantages and disadvantages*	*Introduction to electrode kinetics.*	*Polymer electrolyte membrane fuel cell (PEMFC)*	*Production methods: from fossil fuels, electrolysis, thermal decomposition,*	*Balance of fuel cell power plant,*
S-2	SLO-1	*Basic fuel cell operation,*	*Fuel cell reaction kinetics*	*Electrodes and Electrode Structurein PEMFC*	*Production methods: from fossil fuels, electrolysis, thermal decomposition,*	*Fuel cell power plant structure*
	SLO-2	*Layout of a Real Fuel Cell*	*Fuel cell reaction kinetics*	*Water Management in the PEMFC*	*photochemical, photocatalytic*	*Cogeneration*
S-3	SLO-1	*The Hydrogen–Oxygen Fuel Cell with Liquid Electrolyte.*	*Conversion of chemical energy to electricity in a fuel cell.*	*PEMFuel Cell Cooling and Air Supply*	*Hybrid methods of hydrogen production*	*Fuel cell electric vehicles*
	SLO-2	*Difference between fuel cell and batteries, fuel choice*	*Conversion of chemical energy to electricity in a fuel cell.*	*Direct methanol fuel cells (DMFC)*	*Hydrogen storage methods:*	*Fuel cell in Motor cycles and bicycles, airplanes*
S-4	SLO-1	*Overview of types of fuel cells (with emphasis on PEMFC and DMFC technology)*	*Reaction rate of fuel cell*	*Anode, cathode Reaction and Catalysts in DMFC*	*Onboard hydrogen storage.*	*Case study: fuel cell vehicles with electric vehicles*
	SLO-2	*Fuel cell thermodynamics: Thermodynamics review*	*Reaction rate of fuel cell*	*Anode, cathode Reaction and Catalysts in DMFC*	*Chemical storage*	*Case study: fuel cell vehicles with electric vehicles*
S-5	SLO-1	*Application of first and second law to fuel cells*	*Butler -Volmer equation.*	*Methanol Production, Storage, and Safety*	*physical storage of hydrogen*	*Case study: different fuel cell powered Indian vehicles*
	SLO-2	*Heat Potential of a fuel*	*Butler -Volmer equation.*	*Methanol Production, Storage, and Safety*	*Storage in metal and alloy hydrides.*	*Case study: different fuel cell powered Indian vehicles*
S-6	SLO-1	*Enthalpy of reaction,*	*Fuel cell charge transfer*	*Alkaline fuel cell (PAFC)*	*Storage in metal and alloy hydrides.*	*Fueling stations*
	SLO-2	*Work potential of a fuel:*	*Fuel cell charge transfer*	*Types of Alkaline Electrolyte Fuel Cell*	*Carbon nanotubes*	*Fuel processor and fuel cell stack*

S-7	SLO-1	*Gibbs free energy*	*Mass transfer in fuel cells*	*Electrodes for Alkaline Electrolyte Fuel Cells*	*Carbon nanotubes*	*Water Management*
	SLO-2	*Predicting reversible voltage of a fuel cell under nonstandard-state conditions.*	*Mass transfer in fuel cells*	*Molten Carbonate fuel cell (MCFC)*	*Glass capillary arrays*	*Water Management*
S-8	SLO-1	*Basic Parameters of Fuel Cells.*	*Implications and use of fuel cell polarization curve*	*Molten Carbonate fuel cell (MCFC)*	*Glass capillary arrays*	*Thermal Management*
	SLO-2	*Fuel cell efficiency.*	*Implications and use of fuel cell polarization curve*	*Solid oxide fuel cell (SOFC)*	*pipeline storage*	*Thermal Management*
S-9	SLO-1	*Comparison with Carnot efficiency*	*Activation polarization, ohmic polarization*	*Comparison of fuel cell, Performance behavior*	*hydrogen utilization.*	*Safety issues and cost expectation*
	SLO-2	*Comparison with Carnot efficiency*	*Concentration Polarization, polarization losses*	*Comparison of fuel cell, Performance behavior*	*hydrogen utilization.*	*Safety issues and cost expectation*

Learning Resources	*1. O'Hayre, R. P., S. Cha, W. Colella, F. B. Prinz, "Fuel Cell Fundamentals", Wiley, 3rd edition 2016* *2. Viswanathan. B, AuliceScibioh, M, "Fuel Cells – Principles and Applications", Universities Press (India) Pvt., Ltd., 2009.*	*3. Bagotsky .V.S, "Fuel Cells",Wiley, 2009.* *4. DetlefStolten, "Hydrogen and Fuel Cells: Fundamentals, Technologies and Applications", 2011.*

Learning Assessment

	Bloom's Level of Thinking	Continuous Learning Assessment (50% weightage)								Final Examination (50% weightage)	
		CLA – 1 (10%)		CLA – 2 (15%)		CLA – 3 (15%)		CLA – 4 (10%)			
		Theory	Practice	Theory	Practice	Theory	Practice	Theory	Practice	Theory	Practice
Level 1	Remember Understand	*40 %*	-	*30 %*	-	*30 %*	-	*30 %*	-	*30%*	-
Level 2	Apply Analyze	*40 %*	-	*40 %*	-	*40 %*	-	*40 %*	-	*40%*	-
Level 3	Evaluate Create	*20 %*	-	*30 %*	-	*30 %*	-	*30 %*	-	*30%*	-
	Total	100 %		100 %		100 %		100 %		100 %	

CLA – 4 can be from any combination of these: Assignments, Seminars, Tech Talks, Mini-Projects, Case-Studies, Self-Study, MOOCs, Certifications, Conf. Paper etc.,

Course Designers		
Experts from Industry	Experts from Higher Technical Institutions	Internal Experts
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2. Mr.R.Srikanth, Altair, srikanth.r@altair.com	*2. Mr. N.Ravikumar, Crescent Institute of Science and Technology, ravikumar@crescent.education*	*2. Mr.K.Devanathan, SRMIST*

Course Code	18AUO105T	Course Name	TRANSPORT MANAGEMENT	Course Category	O	Open Elective	L	T	P	C
							3	0	0	3

Pre-requisite Courses	Nil	Co-requisite Courses	Nil	Progressive Courses	Nil
Course Offering Department	Automobile Engineering	Data Book / Codes/Standards	Nil		

Course Learning Rationale (CLR):	The purpose of learning this course is to:
CLR-1 :	*acquire knowledge about Motor Vehicle Act and Laws Governing Transport system*
CLR-2 :	*familiarize with Transport Taxation and Traffic controls.*
CLR-3 :	*know the various methods of fare charging and fleet management.*
CLR-4:	*acquire knowledge in Goods Transport system and Bus scheduling*
CLR-5:	*familiarize with insurance policies and vehicle maintenance.*

Course Learning Outcomes (CLO):	At the end of this course, learners will be able to:	Learning 1	2	3	Program Learning Outcomes (PLO) 1	2	3	4	5	6	7	8	9	10	11	12	13	14	15
		Level of Thinking (Bloom)	Expected Proficiency (%)	Expected Attainment (%)	Engineering Knowledge	Problem Analysis	Design & Development	Analysis, Design, Research	Modern Tool Usage	Society & Culture	Environment & Sustainability	Ethics	Individual & Team Work	Communication	Project Mgt. & Finance	Life Long Learning	PSO - 1	PSO - 2	PSO – 3
CLO-1 :	*.Able to understand and apply the Motor vehicle Act*	1,2	90	85	H	M	H	H	H	M	M	L	M	M	L	M	H	H	H
CLO-2 :	*Can able to get knowledge about ownership of vehicle and tax methods*	1,2	90	85	H	M	H	H	H	L	L	L	M	M	L	M	H	H	H
CLO-3 :	*Able to apply the knowledge about fleet management.*	1,2	90	80	H	M	H	H	H	L	L	L	M	M	L	L	H	H	H
CLO-4 :	*Thorough knowledge about various Goods vehicles and scheduling*	1,2	80	75	H	H	H	H	H	L	L	L	M	M	L	L	H	H	H
CLO-5 :	*Able to know the insurance claim and how to register accident case.*	1,2	90	85	H	H	H	H	M	L	L	L	M	M	L	M	H	H	H

		Motor Vehicle Act	Transport systems and Taxation	Passenger Transport operation	Scheduling and Goods Transport operation	Vehicle Maintenance and insurance
Duration (hour)		9	9	9	9	9
S-1	SLO-1	*Introduction – Motor Vehicle Act*	*Introduction – Transport systems and Taxation*	*Introduction – Passenger Transport operation*	*Introduction – scheduling and Goods Transport operation*	*Introduction – vehicle Maintenance and insurance*
	SLO-2	*Traffic rules and signals – fitness certificate*	*various transport systems.*	*Structure of passenger transport organisation*	*Scheduling - introduction*	*Preventive maintenance system in Transport industry*
S-2	SLO-1	*Registration of vehicle*	*Advantages of Motor Transport*	*Requirement on fleet management*	*Basic factors of Bus scheduling* *Problems in Bus scheduling*	*Tyre maintenance procedure* *Causes for uneven tyre wear*
	SLO-2	*Permit insurance*	*Areas of improvement in Motor Transportation*	*Problems on fleet management*		
S-3	SLO-1	*Constructional regulations of vehicles*	*Principal function of Administration*	*Fleet maintenance*	*Structure of Goods transport organisation*	*Remedies for tyre wear* *Maintenance procedure for better fuel economy*
	SLO-2		*Functions of Traffic and Engineering divisions*	*Public relations - propaganda*	*Scheduling of Goods transport* *Management information system(MIS)*	
S-4	SLO-1	*Government administration structure – personal, Authorities.*	*Chain of responsibility*	*Publicity and passenger amenities*	*Storage of petroleum products*	*Design of Bus depot layout.*
	SLO-2		*Forms of ownership by state Government.*	*Parcel traffic*	*Transportation of petroleum products*	*Insurance types - significance*
S-5	SLO-1	*Responsibilities of Driver, public - offences*	*Public body undertakings*	*Theory of Fares*	*Description of Tipper, tanker, power wagons vehicles*	*Comprehensive insurance*
	SLO-2	*Accidents – causes and analysis – preventive measures*		*Basic principle of fare charging*		*Third party insurance*
S-6	SLO-1	*State and interstate permits*	*Forms of ownership by municipality,private undertakings*	*Method of drawing up of a fare table*	*Description of recovery vans, delivery vans.*	*Furnishing of particulars of vehicle involved in accident*
	SLO-2	*Test for competence to drive*		*Various types of fare collecting methods*		*MACT – hit and run case*
S-7	SLO-1	*Licensing of Drivers and conductors*	*Taxation - objectives*	*Estimating the cost for transport vehicles*	*Advance technique in Traffic management*	*Solatium fund*
	SLO-2					

S-8	SLO-1	*Rules regarding construction of motor vehicles.*	*Structure of laving tax*	*Different rates for different type of service*	*Traffic navigation*	*Duty of Driver in case of accident.*
	SLO-2		*Methods of laving tax.*	*Principal features of operating cost*		*Surveyor and loss assessor*
S-9	SLO-1	*Laws Governing to use of Motor vehicle.*	*One time tax – Tax exemption*	*Operation cost - revenues*	*Global positioning system*	*Surveyor's report*
	SLO-2		*Tax renewal*	*Economics - records*		

Learning Resources	*1. "Motor vehicle Act" – Govt of India publications.* *2. Shrivastava s k, "Transport Development in India", S Chand & co Pvt Ltd., New Delhi* *3. John Duke, "Fleet Management", Mc Graw Hill, USA - 1984*	*4. Government Motor vehicle Act – Eastern Book Company, Lucknow – 1989* *5. Kitchin. L. D – Bus operation – ILLiffee and sons Co., London, 3rd edition - 1992*

Learning Assessment

	Bloom's Level of Thinking	Continuous Learning Assessment (50% weightage)								Final Examination (50% weightage)	
		CLA – 1 (10%)		CLA – 2 (15%)		CLA – 3 (15%)		CLA – 4 (10%)#			
		Theory	Practice	Theory	Practice	Theory	Practice	Theory	Practice	Theory	Practice
Level 1	Remember Understand	*40 %*	-	*30 %*	-	*30 %*	-	*30 %*	-	*30%*	-
Level 2	Apply Analyze	*40 %*	-	*40 %*	-	*40 %*	-	*40 %*	-	*40%*	-
Level 3	Evaluate Create	*20 %*	-	*30 %*	-	*30 %*	-	*30 %*	-	*30%*	-
	Total	100 %		100 %		100 %		100 %		100 %	

CLA – 4 can be from any combination of these: Assignments, Seminars, Tech Talks, Mini-Projects, Case-Studies, Self-Study, MOOCs, Certifications, Conf. Paper etc.,

Course Designers

Experts from Industry	Experts from Higher Technical Institutions	Internal Experts
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2. Mr.A.Venugopal, WABCO, venugopal.a@wabco-auo.com	*2. Dr.T.R.Tamilarasan, Crescent Institute of Science and Technology, tamilarasanr@crescent.education*	*2. Mr. S. Palanisamy, SRMIST*

Course Code	18AUO106T	Course Name	COMPOSITE MATERIAL IN AUTOMOBILE APPLICATIONS	Course Category	O	Open Elective	L	T	P	C
							3	0	0	3

Pre-requisite Courses	Nil	Co-requisite Courses	Nil	Progressive Courses	Nil
Course Offering Department	Automobile Engineering	Data Book / Codes/Standards	Nil		

Course Learning Rationale (CLR):	*The purpose of learning this course is to:*
CLR-1 :	*Study matrix material, reinforcements of polymer matrix composites, metal and ceramic matrix composites.*
CLR-2 :	*Understand the fundamentals of composite material strength and its mechanical behavior*
CLR-3 :	*Develop knowledge on processing, interfacial properties and application of composites.*

Course Learning Outcomes (CLO):	*At the end of this course, learners will be able to:*	Learning 1: Level of Thinking (Bloom)	Learning 2: Expected Proficiency (%)	Learning 3: Expected Attainment (%)	PLO 1: Engineering Knowledge	PLO 2: Problem Analysis	PLO 3: Design & Development	PLO 4: Analysis, Design, Research	PLO 5: Modern Tool Usage	PLO 6: Society & Culture	PLO 7: Environment & Sustainability	PLO 8: Ethics	PLO 9: Individual & Team Work	PLO 10: Communication	PLO 11: Project Mgt. & Finance	PLO 12: Life Long Learning	PLO 13: PSO - 1	PLO 14: PSO - 2	PLO 15: PSO – 3
CLO-1 :	*Understand the basics of reinforcements and matrix material*	*1,2*	*90*	*85*	*H*	*M*	*H*	*H*	*H*	*M*	*M*	*L*	*M*	*M*	*L*	*M*	*H*	*H*	*H*
CLO-2 :	*Use of mathematical techniques to predict the macroscopic properties of different laminates*	*1,2*	*90*	*85*	*H*	*M*	*H*	*H*	*H*	*L*	*L*	*L*	*M*	*M*	*L*	*M*	*H*	*H*	*H*
CLO-3 :	*Choose suitable material to design composites*	*1,2*	*90*	*80*	*H*	*M*	*H*	*H*	*H*	*L*	*L*	*L*	*M*	*M*	*L*	*L*	*H*	*H*	*H*
CLO-4 :	*Select suitable manufacturing process for different types of composites*	*1,2*	*80*	*75*	*H*	*H*	*H*	*H*	*H*	*L*	*L*	*L*	*M*	*M*	*L*	*L*	*H*	*H*	*H*
CLO-5 :	*Compare/evaluate the relative merits of using various conventional and composite materials for important engineering and other applications.*	*1,2*	*90*	*85*	*H*	*H*	*H*	*H*	*M*	*L*	*L*	*L*	*M*	*M*	*L*	*M*	*H*	*H*	*H*

		Introduction to composites	Polymer matrix composites	Metal matrix composites	Ceramic matrix composites	Advances in composites
Duration (hour)		9	9	9	9	9
S-1	SLO-1	*Fundamentals of composites*	*Reinforcement material-Fibres*	*Metallic Matrix Matrix*	*Ceramic Matrix Material*	*Carbon /Carbon composites*
	SLO-2	*Need for composites*	*Glass fibre, Carbon fibre-Processing*	*Selection of reinforcement*	*Failure Behavior of CMCs*	*Carbon Fiber Reinforcements*
S-2	SLO-1	*Classification of composites*	*Aramid fibre and Boron fibre-Processing*	*Processing of MMC*	*Toughening of CMCs*	*Matrix Systems-Thermosetting*
	SLO-2	*Advantages of Composite*	*Properties and Application*	*Liquid state processes*		
S-3	SLO-1	*Disadvantage of Composite*	*Particle reinforcement*	*Stir Casting, Squeeze Casting*	*Processing of CMCs*	*Thermoplastic and Gaseous precursor*
	SLO-2	*Properties of Composite:*	*Nano reinforcement*	*Slurry Casting, Melt Infiltration*	*Ceramic Particle Based Processes*	
S-4	SLO-1	*Particulate Composites*	*Polymer matrix material*	*Spray deposition*	*Cold Compaction*	*Processing of C/C Composites*
	SLO-2	*Fibre reinforced Composite*	*Thermosetting resins, thermoplastic resins*	*Solid state processes*	*Slurry Impregnation*	*Thermosetting Resin Based Processing*
S-5	SLO-1	*Elastic Behavior under Longitudinal Loading,*	*Fillers-Additives*	*Powder Metallurgy technique*	*Sol-gel Processing*	*Thermoplastic Pitch Based Processing*
	SLO-2	*Problems on Elastic Behavior under Longitudinal Loading,*	*Pre-Processed Material-Molding compound*	*Hot Pressing*	*Reaction Bonding Processes*	*Chemical Vapor Infiltration*
S-6	SLO-1	*Elastic Behavior under Transverse Loading*	*Prepegs-PMC processes*	*Diffusion Bonding*	*In Situ Ceramic Composite Processing*	*Properties of C/C Composites*
	SLO-2	*Problems on Elastic Behavior under Transverse Loading*	*Hand layup, Spray up processes*	*Gaseous state processes*	*Melt Processing*	*Oxidation Protection of C/C composites*

S-7	SLO-1	*Longitudinal Tensile Strength*	*Compression molding, Injection molding*	*Deposition techniques*	*Polymer Infiltration and Pyrolysis*	*Application of C/C Composites*
	SLO-2	*Transverse Tensile Strength*	*Autoclave molding*	*Machining and joining of MMCs*		*Nanocomposites*
S-8	SLO-1	*Discontinuous Fiber Reinforced Composites*	*Resin transfer molding*	*Properties of MMCs*	*Properties of CMCs*	*Polymer Nanocomposites*
	SLO-2		*Pultrusion, Filament winding*	*Parameters affecting properties of MMC*		*Metal Nanocomposites*
S-9	SLO-1	*Applications of composite*	*Properties of PMCs*	*Interfacial Problems*	*Automotive Application of CMCs*	*Ceramic Nanocomposites*
	SLO-2		*Automotive Application of PMCs.*	*Automotive Application of MMCs.*		*Nanocomposites- Properties and Applications*

Learning Resources	*1. Krishnan K Chawla, Composite Materials: Science and Engineering, International Edition, Springer, 2012.* *2. Mallick, P.K. and Newman.S, Composite Materials Technology, Hanser Publishers, 2003.* *3. M. Balasubramanian, "Composite Materials and Processing", CRC press, Taylor and Francis Group, 2014.*	*4. Sanjay K Mazumdar, "Composites Manufacturing: Materials, Product and Process Engineering", CRC Press, New York, 2010.* *5. ASM Handbook – Composites, Vol-21, 2001*

Learning Assessment

	Bloom's Level of Thinking	Continuous Learning Assessment (50% weightage)								Final Examination (50% weightage)	
		CLA – 1 (10%)		CLA – 2 (15%)		CLA – 3 (15%)		CLA – 4 (10%)#			
		Theory	Practice	Theory	Practice	Theory	Practice	Theory	Practice	Theory	Practice
Level 1	Remember Understand	*40 %*	-	*30 %*	-	*30 %*	-	*30 %*	-	*30%*	-
Level 2	Apply Analyze	*40 %*	-	*40 %*	-	*40 %*	-	*40 %*	-	*40%*	-
Level 3	Evaluate Create	*20 %*	-	*30 %*	-	*30 %*	-	*30 %*	-	*30%*	-
	Total	100 %		100 %		100 %		100 %		100 %	

CLA – 4 can be from any combination of these: Assignments, Seminars, Tech Talks, Mini-Projects, Case-Studies, Self-Study, MOOCs, Certifications, Conf. Paper etc.,

Course Designers

Experts from Industry	Experts from Higher Technical Institutions	Internal Experts
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2. Mr.A.Venugopal, WABCO, venugopal.a@wabco-auo.com	*2. Dr.T.R.Tamilarasan, Crescent Institute of Science and Technology tamilarasanr@crescent.education*	*2.Dr. J.Chandradass, , SRMIST, chandraj@srmist.edu.in*

Course Code	18AUO107T	Course Name	NON DESTRUCTIVE TESTING AND EVALUATION	Course Category	O	Open Elective	L	T	P	C
							3	0	0	3

Pre-requisite Courses	Nil	Co-requisite Courses	Nil	Progressive Courses	Nil
Course Offering Department	Automobile Engineering	Data Book / Codes/Standards	Nil		

Course Learning Rationale (CLR):	The purpose of learning this course is to:
CLR-1 :	*Understand the basic principle, importance and applications of various NDT techniques*
CLR-2 :	*Acquire proper skills and equip with proper competencies to locate flaws in various materials and products.*
CLR-3 :	*Equip themselves familiar with industrial applications*

Course Learning Outcomes (CLO):	*At the end of this course, learners will be able to:*	Learning 1: Level of Thinking (Bloom)	Learning 2: Expected Proficiency (%)	Learning 3: Expected Attainment (%)	PLO 1: Engineering Knowledge	PLO 2: Problem Analysis	PLO 3: Design & Development	PLO 4: Analysis, Design, Research	PLO 5: Modern Tool Usage	PLO 6: Society & Culture	PLO 7: Environment & Sustainability	PLO 8: Ethics	PLO 9: Individual & Team Work	PLO 10: Communication	PLO 11: Project Mgt. & Finance	PLO 12: Life Long Learning	PLO 13: PSO - 1	PLO 14: PSO - 2	PLO 15: PSO – 3
CLO-1 :	*Understand various Non Destructive Techniques to detect defects*	*1*	*90*	*90*	*H*	*M*	*L*	*M*	*H*	*M*	*M*	*M*	*H*	*M*	*L*	*M*	*H*	*M*	*M*
CLO-2 :	*Apply scientific and technical knowledge to the field of non-destructive testing*	*1,2*	*90*	*80*	*H*	*H*	*M*	*H*	*H*	*M*	*M*	*M*	*H*	*M*	*M*	*M*	*M*	*M*	*H*
CLO-3 :	*Use the relevant non-destructive testing methods for various engineering practice*	*1,2*	*85*	*85*	*H*	*H*	*H*	*H*	*H*	*M*	*M*	*M*	*H*	*M*	*M*	*M*	*H*	*M*	*H*
CLO-4 :	*Recognize and achieve high levels of professionalism in their work*	*1,2*	*90*	*80*	*H*	*H*	*M*	*M*	*M*	*H*	*M*	*H*	*M*	*M*	*M*	*M*	*M*	*M*	*M*
CLO-5 :	*Engage in lifelong learning, thought process and development*	*1.2*	*85*	*90*	*H*	*M*	*H*	*M*	*M*	*H*	*H*	*H*	*M*	*M*	*M*	*M*	*M*	*M*	*H*

		Overview of NDT	Surface NDE Methods	Thermography and Eddy Current Testing	Ultrasonic Testing (UT) and Acoustic Emission	Radiography
Duration (hour)		09	09	09	09	09
S-1	SLO-1	*Introduction to NDT*	*Liquid Penetrate Testing-Principle, Characteristics and types of penetrant*	*Principle of Thermography,*	*Ultrasonic Testing-Introduction, Basic Properties of sound beam, Acoustic Impedance*	*Radiography- Principle*
	SLO-2			*IR-radiation-Properties, Factors affecting Thermal measurements*		*Electromagnetic radiation sources*
S-2	SLO-1	*Comparison of Destructive and Non Destructive Methods*	*Developers-Function, Properties and types*	*Contact and non contact temperature sensors*	*Ultrasonic Transducers,*	*Radiation Attenuation and Effect of radiation on film*
	SLO-2					
S-3	SLO-1	*Overview of Non Destructive Testing Methods*	*Cleaning Methods and Emulsifiers*	*Non Contact Thermography System*	*Inspection Methods-Transmission and pulse-echo method*	*Radiographic Imaging*
	SLO-2					
S-4	SLO-1	*Casting Defects*	*Liquid penetrant Testing procedure and Interpretation of results*	*Advantages, Disadvantages and applications of Thermography*	*Inspection Methods- Angle beam pulse echo method*	*Inspection Techniques- Single wall and double wall penetration techniques*
	SLO-2					
S-5	SLO-1	*Welding Defects*	*Penetrant Removal Process, Advantage and Limitation of Liquid penetrate Test*	*Eddy Current Testing-Introduction and principle*	*Ultrasonic Flaw Detection Equipment, Mode of Display-A-Scan, B-scan, C-scan*	*Inspection Techniques-Multiwall penetration technique*
	SLO-2					
S-6	SLO-1	*Visual Testing-Principle and Tools*	*Magnetic Particle Testing-Introduction, Method of Magnetization*	*Factors affecting eddy current*	*Advantages, limitations and application of Ultrasonic testing method*	*Advantages, disadvantages and applications of radiography*
	SLO-2					
S-7	SLO-1	*Optical Aid used for Visual Inspection-Microscope, Rigid Borescope, Mini and Hybrid Borescope*	*Procedure for Magnetic Particle Testing*	*Instrumentation of eddy current testing*	*Acoustic Emission Testing-Principle and Technique*	*Real time Radiography-Microfocal Radiography*

	SLO-2					
S-8	SLO-1	*Optical Aid used for Visual Inspection-Extendable borescope, Flexible borescope, Endoscope, Telescope and Holography*	*Residual Magnetism.*	*Types of probes*	*Instrumentation of Acoustic Emission Testing*	*Advantages and limitations of Microfocal Radiography*
	SLO-2					
S-9	SLO-1	*Merits and Demerits of Visual Testing*	*Demagnetization-Method of Demagnetization*	*Advantages, Limitations and application of eddy current testing*	*Applications*	*Xero Radiography*
	SLO-2					

Learning Resources	*1. Baldev Raj, T.Jayakumar, M.Thavasimuthu "Practical Non-Destructive Testing", Narosa Publishing, 3rd Edition, 2014* *2. Ravi Prakash, "Non-Destructive Testing Techniques", 1st revised edition, New Age International Publishers, 2010* *3. ASM Metals Handbook, "Non-Destructive Evaluation and Quality Control",American Society of Metals, Park, Ohio, USA, 200, Volume-1, 2018..*	*4. Paul E Mix, "Introduction to Non-destructive testing: a training guide", Wiley, 2nd Edition New Jersey, 2005* *5. Charles, J. Hellier, "Handbook of Nondestructive evaluation", McGraw Hill, New York, 2nd Edition, 2013.*

Learning Assessment

	Bloom's Level of Thinking	Continuous Learning Assessment (50% weightage)								Final Examination (50% weightage)	
		CLA – 1 (10%)		CLA – 2 (15%)		CLA – 3 (15%)		CLA – 4 (10%)#			
		Theory	Practice	Theory	Practice	Theory	Practice	Theory	Practice	Theory	Practice
Level 1	Remember Understand	*40 %*	-	*30 %*	-	*30 %*	-	*30 %*	-	*30%*	-
Level 2	Apply Analyze	*40 %*	-	*40 %*	-	*40 %*	-	*40 %*	-	*40%*	-
Level 3	Evaluate Create	*20 %*	-	*30 %*	-	*30 %*	-	*30 %*	-	*30%*	-
	Total	100 %		100 %		100 %		100 %		100 %	

CLA – 4 can be from any combination of these: Assignments, Seminars, Tech Talks, Mini-Projects, Case-Studies, Self-Study, MOOCs, Certifications, Conf. Paper etc.,

Course Designers		
Experts from Industry	Experts from Higher Technical Institutions	Internal Experts
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Course Code	18AUO108T	Course Name	ADVANCED ENGINE TECHNOLOGY	Course Category	O	Open Elective	L	T	P	C
							3	0	0	3

Pre-requisite Courses	Nil	Co-requisite Courses	Nil	Progressive Courses	Nil
Course Offering Department	Automobile Engineering	Data Book / Codes/Standards	Nil		

Course Learning Rationale (CLR):	*The purpose of learning this course is to:*
CLR-1	*Explore the sustainable development, energy conservation, efficiency and environmental preservation.*
CLR-2 :	*Provide a comprehensive reference to understand the current trends in Advanced engines*

Course Learning Outcomes (CLO):	*At the end of this course, learners will be able to:*	Learning 1: Level of Thinking (Bloom)	2: Expected Proficiency (%)	3: Expected Attainment (%)	PLO 1: Engineering Knowledge	2: Problem Analysis	3: Design & Development	4: Analysis, Design, Research	5: Modern Tool Usage	6: Society & Culture	7: Environment & Sustainability	8: Ethics	9: Individual & Team Work	10: Communication	11: Project Mgt. & Finance	12: Life Long Learning	13: PSO - 1	14: PSO - 2	15: PSO – 3
CLO-1 :	*Acquire knowledge about the Thermodynamic Analysis of SI Engine Combustion process.*	*2*	*90*	*90*	*H*	*H*	*M*	*H*	*L*	*L*	*M*	*L*	*H*	*M*	*M*	*M*	*H*	*M*	*H*
CLO-2 :	*Acquire knowledge about the Thermodynamic Analysis of CI Engine Combustion process.*	*2*	*90*	*90*	*H*	*M*	*M*	*M*	*M*	*L*	*L*	*M*	*H*	*M*	*M*	*M*	*H*	*M*	*H*
CLO-3 :	*Understand the Various Fuel injection system for SI & CI engine*	*2*	*90*	*90*	*H*	*M*	*H*	*H*	*M*	*H*	*L*	*L*	*H*	*M*	*H*	*M*	*H*	*M*	*H*
CLO-4 :	*Gain knowledge about the engine modification required for alternative fuels.*	*2*	*90*	*90*	*M*	*H*	*M*	*M*	*H*	*M*	*H*	*H*	*M*	*L*	*H*	*M*	*H*	*M*	*H*
CLO-5 :	*Acquire knowledge about recent trends in IC engines.*	*2*	*90*	*90*	*H*	*H*	*M*	*H*	*L*	*H*	*M*	*L*	*L*	*H*	*M*	*M*	*H*	*M*	*H*

		Spark Ignition Engines	Compression Ignition Engines	Fuel systems	Alternate Fuels	Recent Trends
Duration (hour)		9	9	9	9	9
S-1	SLO1	*Introduction to Spark ignition engines*	*Introduction to Compression Ignition Engines*	*Introduction to Fuel Injection System*	*Introduction to Engine Modifications For Alternative Fuels*	*Recent Trends*
	SLO2	*Air-Fuel Ratio Requirements*	*Stages Of Combustion in CI Engine*	*Fuel Injection System Functions And Components*	*Alternative fuels Properties , Suitability*	*Homogeneous Charge Compression Ignition Engine*
S-2	SLO1	*Design Of Carburetor*	*Stages Of Combustion in CI Engine*	*Petrol Injection - Open Loop Systems*	*Alcohols as a Fuel for IC engines*	*Homogeneous Charge Compression Ignition Engine*
	SLO2	*Carburetor –Fuel Jet Size And Venture Size*	*Normal And Abnormal Combustion – Factors Affecting Knock*	*Petrol Injection - Closed Loop Systems*	*Vegetable Oils And Bio-Diesel*	*Lean Burn Engine*
S-3	SLO1	*Carburetor –Fuel Jet Size And Venture Size*	*Normal And Abnormal Combustion – Factors Affecting Knock*	*Mono Point And Multi Point Injection System*	*Bio-Gas*	*Lean Burn Engine*
	SLO2	*Stages Of Combustion*	*Direct And Indirect Injection Systems*	*Mono Point And Multi Point Injection System*	*Natural Gas*	*Stratified Charge Engine*
S-4	SLO1	*Stages Of Combustion*	*Direct And Indirect Injection Systems*	*Direct Injection Systems*	*Liquefied Petroleum Gas*	*Stratified Charge Engine*
	SLO2	*Normal And Abnormal Combustion*	*Combustion Chambers*	*Fuel Injection In-Line, Rotary Pumps*	*Liquefied Petroleum Gas*	*Surface Ignition Engine*
S-5	SLO1	*Normal And Abnormal Combustion*	*Combustion Chambers*	*Testing-Governing- Injection Lag*	*Hydrogen as a fuel in IC engines*	*Surface Ignition Engine*
	SLO2	*Factors Affecting Knock*	*Turbo Charging*	*Fuel Injector - Types Of Injection Nozzle*	*Hydrogen as a fuel in IC engines*	*Four Valve And Overhead Cam Engines*
S-6	SLO1	*Combustion Chambers*	*Turbo Charging*	*Fuel Injector - Types Of Injection Nozzle*	*Engine Modifications*	*Four Valve And Overhead Cam Engines*
	SLO2	*Combustion Chambers*	*Introduction To Thermodynamic Analysis Of CI Engine*	*Fuel Spray Characteristics*	*Engine Modifications*	*Four Valve And Overhead Cam Engines*

S-7	SLO1	*Introduction To Thermodynamic Analysis Of SI Engine*	*Thermodynamic Analysis Of CI Engine*	*Fuel Injection Timing*	*Performance, emission and combustion characteristics of SI engines*	*Alternative Power Sources: Wankel Rotary Engine*
	SLO2	*Thermodynamic Analysis Of SI Engine*	*Combustion Process in CI Engines*	*Factors Influencing Fuel Spray Atomization, Penetration And Dispersion Of Diesel*	*Performance, emission and combustion characteristics of SI engines*	*Sterling Engine, Gas Turbine Engine*
S-8	SLO1	*Thermodynamic Analysis Of SI Engine*	*Combustion Process in CI Engines*	*Factors Influencing Fuel Spray Atomization, Penetration And Dispersion Of Diesel*	*Performance, emission and combustion characteristics of CI engines*	*Sterling Engine, Gas Turbine Engine*
	SLO2	*Thermodynamic Analysis Of SI Engine Combustion Process*	*Combustion Process in CI Engines*	*Electronic Engine Management system*	*Performance, emission and combustion characteristics of CI engines*	*Cycle test-I*
S-9	SLO1	*Recent Developments In SI Engines*	*Recent Developments In CI Engines*	*Electronic Engine Management System*	*Alternative fuels used in CI engines*	*Cycle test-II*
	SLO2	*Recent Developments In SI Engines*	*Recent Developments In CI Engines*	*Common Rail Direct Injection Diesel Engine*	*Alternative fuels used in CI engines*	*Surprise test*

Learning Resources	*1. Heinz Heisler, "Advanced Engine Technology"., SAE International Publications, USA,1998* *2. Ganesan V. "Internal Combustion Engines"., Third Edition, Tata Mcgraw-Hill ,2007* *3. John B Heywood. "Internal Combustion Engine Fundamentals"., Tata McGraw-Hill 1988*	*4. Patterson D.J. and Henein N.A,"Emissions from combustion engines and their control"., Ann Arbor Science publishers Inc, USA,* *5. Gupta H.N, "Fundamentals of Internal Combustion Engines". ,Prentice Hall of India, 2006* *6. Ultrich Adler , "Automotive Electric / Electronic Systems"., Published by Robert Bosh GmbH,1995*

Learning Assessment											
	Bloom's Level of Thinking	Continuous Learning Assessment (50% weightage)								Final Examination (50% weightage)	
		CLA – 1 (10%)		CLA – 2 (15%)		CLA – 3 (15%)		CLA – 4 (10%)#			
		Theory	Practice	Theory	Practice	Theory	Practice	Theory	Practice	Theory	Practice
Level 1	Remember Understand	*40 %*	-	*30 %*	-	*30 %*	-	*30 %*	-	*30%*	-
Level 2	Apply Analyze	*40 %*	-	*40 %*	-	*40 %*	-	*40 %*	-	*40%*	-
Level 3	Evaluate Create	*20 %*	-	*30 %*	-	*30 %*	-	*30 %*	-	*30%*	-
	Total	100 %		100 %		100 %		100 %		100%-	

CLA – 4 can be from any combination of these: Assignments, Seminars, Tech Talks, Mini-Projects, Case-Studies, Self-Study, MOOCs, Certifications, Conf. Paper etc.,

Course Designers		
Experts from Industry	Experts from Higher Technical Institutions	Internal Experts
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2. Mr.P.MohamedAzarudeen,Renault Nissan Technology and Business Centre, mohamedazarudeen.pakkirmohideen@rntbci.com	*2. Dr.S.RamKumar, Vel Tech RangarajanDr.Sagunthala R&D Institute of Science and Technology , drsramkumar@veltech.edu.in*	*2. Mr.T.Prakash, SRM IST*

Course Code	18AUO109T	Course Name	NEW PRODUCT DEVELOPMENT	Course Category	O	Open Elective	L	T	P	C
							3	0	0	3

Pre-requisite Courses	Nil	Co-requisite Courses	Nil	Progressive Courses	Nil
Course Offering Department	Automobile Engineering	Data Book / Codes/Standards	Nil		

Course Learning Rationale (CLR):	*The purpose of learning this course is to:*
CLR-1 :	*understand the new product process*
CLR-2 :	*learn and apply the concepts and tools necessary through case examples and assignments*
CLR-3 :	*actually use the new product development process by conceiving your own new product or service and introductory launch plan*

Course Learning Outcomes (CLO):	*At the end of this course, learners will be able to:*	Learning 1: Level of Thinking (Bloom)	Learning 2: Expected Proficiency (%)	Learning 3: Expected Attainment (%)	PLO 1: Engineering Knowledge	PLO 2: Problem Analysis	PLO 3: Design & Development	PLO 4: Analysis, Design, Research	PLO 5: Modern Tool Usage	PLO 6: Society & Culture	PLO 7: Environment & Sustainability	PLO 8: Ethics	PLO 9: Individual & Team Work	PLO 10: Communication	PLO 11: Project Mgt. & Finance	PLO 12: Life Long Learning	PLO 13: PSO - 1	PLO 14: PSO - 2	PLO 15: PSO – 3
CLO-1 :	*Develop familiarity with models of innovation and the marketing and technology interface*	*1,2*	*85*	*80*	*H*	*H*	*H*	*M*	*M*	*M*	*M*	*M*	*H*	*M*	*M*	*H*	*H*	*M*	*M*
CLO-2 :	*Understand the importance of new product development to firm performance*	*1,2*	*80*	*75*	*H*	*H*	*H*	*M*	*M*	*M*	*M*	*M*	*M*	*M*	*H*	*H*	*H*	*H*	*H*
CLO-3 :	*Learn methods of generating, evaluating and testing product ideas*	*1,2*	*85*	*80*	*H*	*H*	*H*	*M*	*M*	*M*	*M*	*H*	*M*	*M*	*M*	*M*	*H*	*M*	*H*
CLO-4 :	*Identify relevant components and plan a product launch*	*1,2*	*80*	*75*	*H*	*H*	*H*	*H*	*M*	*H*	*M*	*H*	*H*	*M*	*H*	*H*	*M*	*H*	*M*
CLO-5 :	*Learn methods of evaluating and monitoring the success of a launch*	*1.2*	*85*	*80*	*H*	*M*	*M*	*M*	*M*	*H*	*H*	*H*	*M*	*M*	*M*	*M*	*M*	*M*	*H*

Duration (hour)		Project Selection and Evaluation	New Product Resources	New Product Planning	New Product Development	Product Architecture
		9	9	9	9	9
S-1	SLO-1 SLO-2	*Collection Of Ideas*	*Technological Research*	*Design Of Prototype*	*Journeys In Product Development*	*Establishing the Product architecture*
S-2	SLO-1 SLO-2	*Purpose Of Project*	*Basic concepts and need for Intellectual Property*	*Testing of prototype*	*Product Development Process Tools*	*creation*
S-3	SLO-1 SLO-2	*Selection Criteria*	*Patents*	*Quality Standards*	*Scoping Product Developments*	*clustering*
S-4	SLO-1 SLO-2	*Screening Ideas For New Products*	*Patent Search*	*Marketing Research*	*Technical And Business Concerns*	*geometric layout development*
S-5	SLO-1 SLO-2	*Creative design*	*Patent Laws*	*Introducing New Products*	*Understanding Customer Needs*	*fundamental and incidental interactions*
S-6	SLO-1 SLO-2	*Model Preparation*	*International Code For Patents*	*Integrate process design*	*Establishing Product Function*	*related system level design issues*
S-7	SLO-1	*Testing*	*Intellectual Property Rights (IPR)*	*Managing costs*	*involve customer in development and managing requirements*	*secondary systems*
	SLO-2					
S-8	SLO-1 SLO-2	*Cost evaluation*	*Copyrights*	*Robust design*	*process management and improvement*	*architecture of the chunks*
S-9	SLO-1 SLO-2	*Patent application*	*Geographical Indications*	*Integrating CAE, CAD, CAM tools*	*Plan and establish product specifications*	*creating detailed interface specifications*

Learning Resources	
	1. *Paul trott "Innovation Management and New Product Development" 5th Edition Sep 2011* 2. *Barclay, Z. Dann, P. Holroyd, "New Product development" I, Published by BH Butterworth-Heinemann a division of Reed Educational and professional publishing limited.2000.*
	3. *Marc Annacchino "New Product Development " 1st Edition Sep 2003* 4. *Brain Twiss, "Managing technological innovation", Pitman Publishing Ltd., 1992.*

Learning Assessment											
	Bloom's Level of Thinking	Continuous Learning Assessment (50% weightage)								Final Examination (50% weightage)	
		CLA – 1 (10%)		CLA – 2 (15%)		CLA – 3 (15%)		CLA – 4 (10%)#			
		Theory	Practice	Theory	Practice	Theory	Practice	Theory	Practice	Theory	Practice
Level 1	Remember Understand	*40 %*	-	*30 %*	-	*30 %*	-	*30 %*	-	*30%*	-
Level 2	Apply Analyze	*40 %*	-	*40 %*	-	*40 %*	-	*40 %*	-	*40%*	-
Level 3	Evaluate Create	*20 %*	-	*30 %*	-	*30 %*	-	*30 %*	-	*30%*	-
	Total	100 %		100 %		100 %		100 %		100 %	

CLA – 4 can be from any combination of these: Assignments, Seminars, Tech Talks, Mini-Projects, Case-Studies, Self-Study, MOOCs, Certifications, Conf. Paper etc.,

Course Designers		
Experts from Industry	Experts from Higher Technical Institutions	Internal Experts
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Course Code	18AUO110T	Course Name	AUTOMOTIVE STANDARDS AND REGULATIONS	Course Category	O	Open Elective	L	T	P	C
							3	0	0	3

Pre-requisite Courses	Nil	Co-requisite Courses	Nil	Progressive Courses	Nil
Course Offering Department	Automobile Engineering	Data Book / Codes/Standards	Nil		

Course Learning Rationale (CLR):	*The purpose of learning this course is to:*
CLR-1 :	*Impart knowledge on basics of automobile standards and regulations.*
CLR-2 :	*Know the various safety standards on collision.*
CLR-3 :	*Gain knowledge about various safety standards in automotive electrical systems.*
CLR-4 :	*Understand the regulations used in hybrid and electric vehicles.*
CLR-5 :	*Impart knowledge on regulations used in gaseous fuel vehicles.*

Course Learning Outcomes (CLO):	*At the end of this course, learners will be able to:*	Learning 1: Level of Thinking (Bloom)	2: Expected Proficiency (%)	3: Expected Attainment (%)	PLO 1: Engineering Knowledge	2: Problem Analysis	3: Design & Development	4: Analysis, Design, Research	5: Modern Tool Usage	6: Society & Culture	7: Environment & Sustainability	8: Ethics	9: Individual & Team Work	10: Communication	11: Project Mgt. & Finance	12: Life Long Learning	13: PSO - 1	14: PSO - 2	15: PSO – 3
CLO-1 :	*Gain knowledge about basic automobile standards and regulations.*	1	80	75	M	L	L	L	M	M	M	L	L	L	L	H	H	L	L
CLO-2 :	*Gain knowledge about standards for safety during collision.*	2	75	70	M	L	L	L	M	M	M	L	L	L	L	L	H	M	L
CLO-3 :	*Understand the various standards used for automotive electrical systems.*	2	80	77	M	L	L	L	M	M	M	L	L	L	L	M	H	L	L
CLO-4 :	*Gain knowledge about the regulations used for hybrid and electric vehicles.*	3	75	70	M	L	L	L	M	M	M	L	M	L	L	M	H	M	M
CLO-5 :	*Gain knowledge about the regulations used for gaseous fuel vehicles.*	3	85	80	M	L	L	L	M	M	M	L	L	L	L	M	H	M	L

		General Automotive Standards and Regulations	Collision Safety Standards	Automotive electrical Standards	Electric and Hybrid Vehicle Standards	CNG, LPG Vehicles and Engine Emission Standards
Duration (hour)		09	09	09	09	09
S-1	SLO-1 SLO-2	*Procedure for Type Approval and Certification of Vehicles for Compliance to Central Motor Vehicles Rules.*	*Bumper Fitment on Vehicles – Test Methods.*	*Testing Procedure and Requirements for Headlamp Beam.*	*Battery Operated Vehicles – Requirements for Construction and Functional Safety.*	*Safety and Procedural Requirements for Type Approval of CNG Operated Vehicles.*
S-2	SLO-1 SLO-2	*Speed Limitation Devices and Its Specifications.*	*Safety Belt Assemblies, Safety Belt Anchorages –Specifications.*	*Approval of Front Position Lamps, Rear Position Lamps, Stop Lamps, Direction Indicators, Rear Registration Plate Illuminating Devices and Reversing Lamp.*	*Measurement of Electrical Energy Consumption.*	*Safety and Procedural Requirements for Type Approval of CNG Operated Vehicles.*
S-3	SLO-1 SLO-2	*Arrangement of Foot Controls of Vehicles.*	*Seats, their Anchorages and Head Restraints Specifications, Survival Space for the Protection of the Occupants.*	*Provisions Concerning the Approval of Headlamps Equipped with Gas Discharge Light Sources.*	*Method of Measuring the Range.*	*Safety and Procedural Requirements for Type Approval of LPG Operated Vehicles.*
S-4	SLO-1 SLO-2	*Starting Grade-Ability - Method of Measurement and Requirements.*	*Requirements for Behaviour of Steering Mechanism of a Vehicle in a Head-On Collision.*	*Provisions Concerning the Approval of Light Emitting Diode(LED) Light Sources For use in Approved Lamp Units.*	*Measurement of Net Power andthe Maximum 30 Minute Power and Speed.*	*Safety and Procedural Requirements for Type Approval of LPG Operated Vehicles.*
S-5	SLO-1 SLO-2	*Protective Helmets for Motor Cycle Riders.*	*Procedure for Determining the "H" Point and The Torso Angle in Seating Positions of Motor Vehicles.*	*Lighting, Signalling & Indicating Systems on Motor Vehicles.*	*Electric Power Train - Requirements for Construction and Functional Safety.*	*Code of Practice for use of LPG Fuel in Internal Combustion Engine to Power 4 Wheeled Vehicles.*
S-6	SLO-1 SLO-2	*Protective Helmets and Visors for Motorcycle Riders – Specification.*	*Requirements for the Protection of the Occupants in the Event of an Offset Frontal Collision.*	*Performance Requirements of Lighting and Light-Signalling Devices.*	*Measurement of Electrical Energy Consumption.*	*Code of Practice for use Of LPG Fuel in Internal Combustion Engine to Power 2 & 3 Wheeled Vehicles.*
S-7	SLO-1 SLO-2	*Two Wheeled Vehicles – Location, Identification and Operation of Controls, Tell-Tales and Indicators.*	*Approval of Vehicles with Regards to the Protection of the Occupants in the Event of a Lateral Collision.*	*Testing Standards for Wind Screen Wiping System.*	*Method of Measuring the Range.*	*Code of Practice for use of CNG Fuel in Internal Combustion Engine to Power 4 Wheeled Vehicles.*

S-8	SLO-1 SLO-2	*Procedure for Type Approval and Establishing Conformity of Production for Safety Critical Components.*	*Requirements for the Protection of Pedestrian and Other Vulnerable Road Users in the Event of a Collision with a Motor Vehicle.*	*Horn Installation Requirement.*	*Measurement of Net Power and The Maximum 30 Minute Power and Speed.*	*Code of Practice for use of CNG Fuel in Internal Combustion Engine to Power 2 & 3 Wheeled Vehicles.*
S-9	SLO-1 SLO-2	*NCAP And BNVSAP Ratings, Requirements for School Buses.*	*Requirements for the Protection of Fuel System in The Event of Rear Impact of a Motor Vehicle.*	*Electronic Stability Control Systems.*	*CMVR Type Approval for Hybrid Electric Vehicles, CMVR Type Approval of Vehicles Retrofitted with Hybrid Electric System.*	*Bharath and Euro Emission Norms.*

Learning Resources	1. ARAI publications "\Automotive industry standards", April 30, 2016.	

Learning Assessment											
	Bloom's Level of Thinking	Continuous Learning Assessment (50% weightage)								Final Examination (50% weightage)	
		CLA – 1 (10%)		CLA – 2 (15%)		CLA – 3 (15%)		CLA – 4 (10%)#			
		Theory	Practice	Theory	Practice	Theory	Practice	Theory	Practice	Theory	Practice
Level 1	Remember Understand	*40 %*	-	*30 %*	-	*30 %*	-	*30 %*	-	*30%*	-
Level 2	Apply Analyze	*40 %*	-	*40 %*	-	*40 %*	-	*40 %*	-	*40%*	-
Level 3	Evaluate Create	*20 %*	-	*30 %*	-	*30 %*	-	*30 %*	-	*30%*	-
	Total	100 %		100 %		100 %		100 %		100 %	

CLA – 4 can be from any combination of these: Assignments, Seminars, Tech Talks, Mini-Projects, Case-Studies, Self-Study, MOOCs, Certifications, Conf. Paper etc.,

Course Designers		
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Course Code	18AUO111T	Course Name	AUTOMOTIVE SCIENCES	Course Category	O	Open Elective	L	T	P	C
							3	0	0	3

Pre-requisite Courses	Nil	Co-requisite Courses	Nil	Progressive Courses	Nil
Course Offering Department	Automobile Engineering	Data Book / Codes/Standards	Nil		

Course Learning Rationale (CLR):	*The purpose of learning this course is to:*
CLR-1 :	*Understand the ability and information to follow recent developments about the internal combustion engine technology.*
CLR-2 :	*Describe methods for reduction of exhaust emissions, and their relations to fuel quality and engine performance*
CLR-3 :	*Demonstrate competency in skills related to automotive technology.*

Course Learning Outcomes (CLO):	*At the end of this course, learners will be able to:*	Learning 1: Level of Thinking (Bloom)	Learning 2: Expected Proficiency (%)	Learning 3: Expected Attainment (%)	PLO 1: Engineering Knowledge	PLO 2: Problem Analysis	PLO 3: Design & Development	PLO 4: Analysis, Design, Research	PLO 5: Modern Tool Usage	PLO 6: Society & Culture	PLO 7: Environment & Sustainability	PLO 8: Ethics	PLO 9: Individual & Team Work	PLO 10: Communication	PLO 11: Project Mgt. & Finance	PLO 12: Life Long Learning	PLO 13: PSO - 1	PLO 14: PSO - 2	PLO 15: PSO – 3
CLO-1 :	*Understand the Insights in Internal Combustion Engine*	*1*	*90*	*90*	*H*	*H*	*H*	*M*	*H*	*M*	*H*	*H*	*H*	*L*	*M*	*H*	*H*	*M*	*H*
CLO-2 :	*Summarize the Knowledge in Engine Cycles*	*2*	*90*	*90*	*H*	*H*	*H*	*H*	*M*	*M*	*M*	*M*	*H*	*L*	*H*	*H*	*H*	*L*	*M*
CLO-3 :	*Compare the technology in emissions*	*2*	*90*	*90*	*H*	*M*	*H*	*M*	*H*	*H*	*M*	*H*	*M*	*L*	*H*	*H*	*H*	*H*	*L*
CLO-4 :	*Demonstrate the Relationship in Velocity, Acceleration and Speed*	*2*	*90*	*90*	*H*	*H*	*M*	*H*	*H*	*L*	*L*	*M*	*H*	*L*	*H*	*H*	*H*	*H*	*L*
CLO-5 :	*Explain the technology of Vehicle Characteristics*	*2*	*90*	*90*	*H*	*H*	*H*	*H*	*H*	*M*	*L*	*M*	*H*	*L*	*H*	*H*	*H*	*H*	*M*

Duration (hour)		09	09	09	09	09
S-1	SLO-1	*Internal combustion engines*	*Theoretical engine cycles*	*Fuels and combustion & emissions*	*Velocity and acceleration, speed*	*Vehicle Characteristics*
	SLO-2	*Engine power and Brake power*	*The constant volume cycle (Otto cycle)*	*combustion*	*Speed and velocity Acceleration*	*Load transfer under acceleration*
S-2	SLO-1	*Dynamometers for high-speed engines*	*Thermal efficiency of the theoretical Otto cycle*	*Products of combustion*	*Velocity–time graph Uniform velocity*	*Static reactions*
	SLO-2	*Mean effective pressure*	*Thermal efficiency in terms of compression ratio r*	*Relevant combustion equations*	*Uniform acceleration*	*Vehicle under acceleration*
S-3	SLO-1	*Horsepower PS – the DIN*	*Effect of compression ratio on thermal efficiency*	*Air–fuel ratio Petrol engine combustion*	*Equations of motion and their application to vehicle technology*	*Vehicle acceleration – effect of load transfer*
	SLO-2	*Indicated power Mean effective pressure*	*Relative efficiency*	*Detonation, Pre-ignition*	*Force, mass and acceleration*	*Front wheel drive*
S-4	SLO-1	*Cylinder pressure vs. crank angle*	*Diesel or constant pressure cycle*	*Octane rating*	*Relation between mass and weight*	*Maximum acceleration – rear wheel drive*
	SLO-2	*Mechanical efficiency of an engine*	*Diesel or constant pressure cycle*	*Compression ignition engine combustion chambers*	*Inertia*	*Four wheel drive – fixed*
S-5	SLO-1	*Morse test*	*The dual combustion cycle*	*Diesel fuel-Flash point*	*Motion under gravity*	*Four wheel drive – with third differential*
	SLO-2	*Characteristic curves of engine performance*	*Operation of dual combustion cycle*	*Pour point-Cloud point*	*Angular (circular) motion*	*Four wheel drive – with third differential*
S-6	SLO-1	*Volumetric efficiency*	*Comparison between theoretical and practical engine cycles*	*Exhaust emissions-Factors affecting exhaust emissions*	*Equations of angular motion*	*Accelerating force – tractive effort*
	SLO-2	*Torque vs. engine speed*	*Comparison between theoretical and practical engine cycles*	*Emissions and their causes*	*Equations of angular motion*	*Tractive resistance*
S-7	SLO-1	*Specific fuel consumption vs. engine speed*	*The Stirling engine regenerator*	*Methods of controlling exhaust emissions*	*Relation between angular and linear velocity*	*Power required to propel vehicle*
	SLO-2	*Brake power, torque and sfc compared*	*A double-acting Stirling engine*	*Exhaust gas recirculation*	*Relation between angular and linear velocity*	*Gradeability*
S-8	SLO-1	*Thermal efficiency*	*The gas turbine*	*Catalysts*	*Centripetal acceleration*	*Vehicle power on a gradient*
	SLO-2	*Indicated thermal efficiency*	*The gas turbine*	*Diesel particulate filters*	*Accelerating torque*	*Vehicle on a curved track*
S-9	SLO-1	*Brake thermal efficiency petrol vs. diesel*	*Summary of formulae*	*Liquefied petroleum gas (LPG)*	*Model problem I*	*Overturning speed*
	SLO-2	*Heat energy balance*	*Simple Problems*	*Zero emissions vehicles (ZEVs)*	*Model problem II*	*Skidding speed*

Learning Resources	1. *Allan Bonnick "Automotive Science and Mathematics "Published by Elsevier Ltd First edition 2008* 2. *Willard W. Pulkrabek "Engineering Fundamentals of the Internal Combustion Engine" Pearson; 2 edition (10 June 2003)*	3. *N. K. Giri "Automobile Technology" Khanna Publishers; 2nd edition edition (2002)*

Learning Assessment											
	Bloom's Level of Thinking	Continuous Learning Assessment (50% weightage)								Final Examination (50% weightage)	
		CLA – 1 (10%)		CLA – 2 (15%)		CLA – 3 (15%)		CLA – 4 (10%)#			
		Theory	Practice	Theory	Practice	Theory	Practice	Theory	Practice	Theory	Practice
Level 1	Remember Understand	*40 %*	-	*30 %*	-	*30 %*	-	*30 %*	-	*30%*	-
Level 2	Apply Analyze	*40 %*	-	*40 %*	-	*40 %*	-	*40 %*	-	*40%*	-
Level 3	Evaluate Create	*20 %*	-	*30 %*	-	*30 %*	-	*30 %*	-	*30%*	-
	Total	100 %		100 %		100 %		100 %		100 %	

CLA – 4 can be from any combination of these: Assignments, Seminars, Tech Talks, Mini-Projects, Case-Studies, Self-Study, MOOCs, Certifications, Conf. Paper etc.,

Course Designers		
Experts from Industry	Experts from Higher Technical Institutions	Internal Experts
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Course Code	18AUO112T	Course Name	INTELLIGENT VEHICLE TECHNOLOGY	Course Category	O	Open Elective	L	T	P	C
							3	0	0	3

Pre-requisite Courses	Nil	Co-requisite Courses	Nil	Progressive Courses	Nil
Course Offering Department	Automobile Engineering	Data Book / Codes/Standards	Nil		

Course Learning Rationale (CLR):	*The purpose of learning this course is to:*
CLR-1 :	*Acquire knowledge of about Intelligent vision system*
CLR-2 :	*Know the architecture of Intelligent transportation system*
CLR-3 :	*Impart the techniques of adaptive control*
CLR-4 :	*Know the architecture for autonomous vehicles*
CLR-5 :	*Study the autonomous vehicle cases*

Course Learning Outcomes (CLO):	*At the end of this course, learners will be able to:*	Learning 1	Learning 2	Learning 3	Program Learning Outcomes (PLO) 1	2	3	4	5	6	7	8	9	10	11	12	13	14	15
		Level of Thinking (Bloom)	Expected Proficiency (%)	Expected Attainment (%)	Engineering Knowledge	Problem Analysis	Design & Development	Analysis, Design, Research	Modern Tool Usage	Society & Culture	Environment & Sustainability	Ethics	Individual & Team Work	Communication	Project Mgt. & Finance	Life Long Learning	PSO - 1	PSO - 2	PSO – 3
CLO-1 :	*Understand the intelligent vision system used in automobiles*	*2*	*85*	*75*	*H*	*M*	*H*	*L*	*H*	*M*	*M*	*H*	*H*	*M*	*L*	*H*	*H*	*H*	*H*
CLO-2 :	*Understand the architecture of intelligent transportation system*	*2*	*80*	*75*	*H*	*M*	*H*	*H*	*H*	*M*	*M*	*H*	*H*	*M*	*L*	*M*	*H*	*H*	*H*
CLO-3 :	*Understand adaptive control techniques of an autonomous vehicle*	*2*	*90*	*85*	*H*	*H*	*H*	*H*	*L*	*M*	*M*	*H*	*M*	*M*	*M*	*H*	*H*	*H*	*M*
CLO-4 :	*Understand about the successful autonomous vehicle projects*	*2*	*85*	*80*	*H*	*M*	*H*	*H*	*H*	*H*	*H*	*H*	*H*	*H*	*M*	*H*	*H*	*H*	*H*
CLO-5 :	*Know the case studies of Autonomous vehicle*	*2*	*80*	*75*	*H*	*M*	*M*	*M*	*H*	*H*	*H*	*H*	*H*	*H*	*M*	*H*	*H*	*H*	*H*

		Introduction to Intelligent Vision System	Vehicle Information System and Intelligent Transportation	Adaptive Control Techniques for Intelligent Vehicles	Decisional Architectures for Autonomous Vehicles	Autonomous Vehicle and Case Studies
Duration (hour)		9	9	9	9	9
S-1	SLO-1	*Vision Based Driver Assistance System – Vehicle optical Sensor*	*Intelligent Transportation System (ITS) –*	*Automatic Control Of Highway Traffic And Moving Vehicles*	*Control Architectures*	*DARPA Challenge Case Study*
	SLO-2	*Vision Based Driver Assistance System – Laser Radar*	*Vision for ITS Communications*	*Automatic Control Of Highway Traffic And Moving Vehicles*	*Motion Autonomy*	*DARPA Challenge Case Study*
S-2	SLO-1	*Non Contact ground velocity detecting Sensor*	*Multimedia communication in a car*	*Adaptive Control Of Highway Traffic And Moving Vehicles*	*Deliberative Architectures,*	*ARGO Prototype Vehicle*
	SLO-2	*Road Surface Recognition Sensor*	*Multimedia communication in a car*	*Adaptive Control Of Highway Traffic And Moving Vehicles*	*Deliberative Architectures,*	*ARGO Prototype Vehicle*
S-3	SLO-1	*Vehicle Sensors for Electronic Toll Collection System*	*Current ITS Communication Systems and Services*	*Adaptive Control Overview*	*Reactive Architectures,*	*The Gold System*
	SLO-2	*Vehicle Sensors for Electronic Toll Collection System*	*Current ITS Communication Systems and Services*	*Gain Scheduling*	*Reactive Architectures,*	*The Gold System*
S-4	SLO-1	*Components of a Vision Sensor System*	*Vehicle to Vehicle Communication Systems*	*Model Reference Adaptive Control*	*Hybrid Architecture Overview.*	*The inverse Perspective Mapping*
	SLO-2	*Components of a Vision Sensor System*	*Vehicle to Vehicle Communication Systems*	*Model Reference Adaptive Control*	*Hybrid Architecture Examples*	*Lane Detection*
S-5	SLO-1	*Driver Assistance on Highways –Lane Recognition*	*Road to Vehicle Communication Systems*	*Self-Tuning Adaptive Control System Model*	*Overview Of Sharp Architecture,*	*Obstacle Detection*
	SLO-2	*Driver Assistance on Highways –Lane Recognition*	*Road to Vehicle Communication Systems*	*Self-Tuning Adaptive Control System Model*	*Models Of Vehicles*	*Vehicle Detection*
S-6	SLO-1	*Driver Assistance on Highways –Traffic Sign Recognition*	*Inter Vehicle Communication*	*System Identification Basics,*	*Concepts Of Sensor Based Maneuver,*	*Pedestrian Detection*

	SLO-2	*Driver Assistance on Highways –Traffic Sign Recognition*	*Inter Vehicle Communication*	*Recursive Parameter Estimation,*	*Reactive Trajectory Following, ,*	*Software systems architecture*
S-7	SLO-1	*Driver Assistance in Urban Traffic-Stereo Vision*	*Intra Vehicle Communication*	*Estimator Initialization*	*Parallel Parking*	*Computational Performances*
	SLO-2	*Driver Assistance in Urban Traffic-Stereo Vision*	*Intra Vehicle Communication*	*Design Of Self-Tuning Controllers*	*Platooning*	*ARGO Prototype vehicle Hardware*
S-8	SLO-1	*Driver Assistance in Urban Traffic- Shape base analysis*	*VANETS-Devices*	*Generalized Minimum Variance (GMV) Control*	*Main Approaches To Trajectory Planning,*	*Functionalities- ARGO Prototype vehicle*
	SLO-2	*Driver Assistance in Urban Traffic- Shape base analysis*	*Optical Technologies*	*Pole Placement Control*	*Main Approaches To Trajectory Planning,*	*Data acquisition System,*
S-9	SLO-1	*Driver Assistance in Urban Traffic-Pedestrian Recognition*	*Millimeter Wave technologies*	*Model Predictive Control Overview*	*Non-Holonomic Path Planning.*	*Processing System*
	SLO-2	*Driver Assistance in Urban Traffic-Pedestrian Recognition*	*Millimeter Wave technologies*	*Model Predictive Control Examples*	*Non-Homonymic Path Planning.*	*Control System Overview*

Learning Resources	*1. LjuboVlacic, Michel Parent and Fumio Harashima,“Intelligent Vehicle Technologies”, Butterworth-Heinemann publications, Oxford, 2001-ISBN 0 7506 5093 1* *2. Ronald K Jurgen, “Automotive Electronics Handbook ”, Automotive Electronics Series, SAE, USA, 1998.*	*3. NicuBizon,Lucian D Ascalescu And NaserMahdavitAbatabaei “Autonomous Vehicles*

Learning Assessment											
	Bloom’s Level of Thinking	Continuous Learning Assessment (50% weightage)								Final Examination (50% weightage)	
		CLA – 1 (10%)		CLA – 2 (15%)		CLA – 3 (15%)		CLA – 4 (10%)			
		Theory	Practice	Theory	Practice	Theory	Practice	Theory	Practice	Theory	Practice
Level 1	Remember Understand	*40 %*	-	*30 %*	-	*30 %*	-	*30 %*	-	*30%*	-
Level 2	Apply Analyze	*40 %*	-	*40 %*	-	*40 %*	-	*40 %*	-	*40%*	-
Level 3	Evaluate Create	*20 %*	-	*30 %*	-	*30 %*	-	*30 %*	-	*30%*	-
	Total	100 %		100 %		100 %		100 %		-	

CLA – 4 can be from any combination of these: Assignments, Seminars, Tech Talks, Mini-Projects, Case-Studies, Self-Study, MOOCs, Certifications, Conf. Paper etc.,

Course Designers		
Experts from Industry	Experts from Higher Technical Institutions	Internal Experts
1. Mr.Jegan Amirthalingam, Senior Educator, KPIT a.jegan@kpit.com	*1. Mr. Sam Jebakumar, SRM IST, jebakumj@srmist.edu.in*	*1. Mr. Joshua Paul E , SRMIST*
		2. Mr.Jesu Godwin D, SRMIST

Course Code	18CHO101T	Course Name	SUSTAINABLE ENERGY ENGINEERING	Course Category	O	Open Elective	L	T	P	C
							3	0	0	3

Pre-requisite Courses	Nil	Co-requisite Courses	Nil	Progressive Courses	Nil
Course Offering Department	Chemical Engineering	Data Book / Codes/Standards		Nil	

Course Learning Rationale (CLR):	*The purpose of learning this course is to:*
CLR-1 :	*Familiarize various ways of collecting solar energy and its applications*
CLR-2 :	*Familiarize various ways of utilizing wind energy*
CLR-3 :	*Familiarize various aspects of Biomass energy and utilization*
CLR-4 :	*Understand the current status and future trends in energy*
CLR-5 :	*Appreciate the need for efficient energy storage and distribution*
CLR-6 :	*Understand the various means of utilizing energy for sustainable development*

Course Learning Outcomes (CLO):	At the end of this course, learners will be able to:	Learning 1: Level of Thinking (Bloom)	2: Expected Proficiency (%)	3: Expected Attainment (%)	PLO 1: Engineering Knowledge	2: Problem Analysis	3: Design & Development	4: Analysis, Design, Research	5: Modern Tool Usage	6: Society & Culture	7: Environment & Sustainability	8: Ethics	9: Individual & Team Work	10: Communication	11: Project Mgt. & Finance	12: Life Long Learning	13: PSO - 1	14: PSO - 2	15: PSO –3
CLO-1 :	*Know the different industrial solar equipments for heat and electricity*	*1*	*80*	*75*	*L*	*M*	*H*	*L*			*H*						*H*	*L*	*M*
CLO-2 :	*Know the types of wind mill and their design*	*1*	*80*	*75*	*L*	*M*	*H*	*L*			*H*						*H*	*L*	*M*
CLO-3 :	*Comprehend the uses of energy from biomass and reactor design*	*1*	*80*	*75*	*L*	*M*	*H*	*L*			*H*						*H*	*L*	*M*
CLO-4 :	*Apply the concept of energy transfer to modern processes*	*2*	*70*	*65*	*H*	*H*	*H*	*H*			*H*						*H*	*H*	*H*
CLO-5 :	*Comprehend the various means of energy storage and distribution*	*2*	*75*	*65*	*H*	*H*	*H*	*H*			*H*						*H*	*H*	*H*
CLO-6 :	*Apply the knowledge of sustainable resources for efficient energy utilization and storage*	*2*	*70*	*65*	*H*	*H*	*H*	*H*			*H*						*H*	*H*	*H*

Duration (hour)		9	9	9	9	9
S-1	SLO-1	*Introduction on solar energy*	*Availability of wind*	*Biomass, Biomass resources*	*Current and future state of energy - Introduction*	*Energy storage and distribution - Introduction*
	SLO-2	*Solar angles*	*Special features of wind energy*	*Composition, fuel properties*	*Current and future state of energy - Introduction*	*Energy storage systems*
S-2	SLO-1	*Solar collectors*	*Types of wind mills*	*Biomass conversion technologies*	*Basic thermodynamic functions and applications*	*Mechanical energy storage*
	SLO-2	*Types of collectors*	*The power from the wind*	*Anaerobic digestion*	*Basic thermodynamic functions and applications*	*Mechanical energy storage*
S-3	SLO-1	*Flat plate and dish type*	*Performance of wind mills*	*Direction combustion*	*Calculation of heat of reaction*	*Mechanical energy storage*
	SLO-2	*Types of flat and dish types*	*Modern wind energy generators*	*Pyrolysis*	*Application of Hess law*	*Electrical storage*
S-4	SLO-1	*Solar concentrators*	*Horizontal wind mills*	*Gasification*	*Problems on heat of reaction and Hess law*	*Electrical storage: The lead acid battery*
	SLO-2	*Types of concentrators*	*Vertical wind mills*	*Biogas technology*	*Problems on heat of reaction and Hess law*	*Chemical storage*
S-5	SLO-1	*Solar pumping*	*Wind turbines*	*Bioethanol*	*Other chemical processes for energy transfer*	*Chemical storage*
	SLO-2	*Problems in collectors*	*Design parameters*	*Biodiesel Production*	*Other chemical processes for energy transfer*	*Chemical storage*
S-6	SLO-1	*Solar refrigeration*	*Design principles of wind turbine*	*Community and institutional biogas plants*	*Microwave-assisted reactions*	*Chemical storage*
	SLO-2	*Solar air cooling, Solar furnaces*	*Horizontal and vertical axis types*	*Family biogas plants*	*Microwave-assisted reactions*	*Electromagnetic energy storage*
S-7	SLO-1	*Solar power generation*	*Problems in wind mills*	*Recent Developments in biomass technology*	*Sonochemistry*	*Thermal energy storage (Sensible heat)*
	SLO-2	*Solar drying, stills and cooking*	*Problems in wind mills*	*Energy farming*	*Sonochemistry*	*Thermal energy storage (Sensible heat)*
S-8	SLO-1	*Photo voltaic cell principle*	*Problems in wind mills*	*design consideration*	*Electrochemistry*	*Thermal energy storage (Latent heat)*
	SLO-2	*Photo voltaic cell types*	*Problems in wind mills*	*Problems in digesters*	*Electrochemistry*	*Thermal energy storage (Latent heat)*
S-9	SLO-1	*Photo voltaic cell design*	*Wind power farms*	*Problems in digesters*	*Photochemistry and Photovoltaic Cells*	*Biological storage*
	SLO-2	*Photo voltaic cell advancement*	*Modern wind farms*	*Applications of reactors*	*Photochemistry and Photovoltaic Cells*	*Biological storage*

Learning Resources	1. *Anne E. Marteel-Parrish and Martin A. Abraham, "Green Chemistry and Engineering - A pathway to sustainability", John Wiley & Sons, 2014.* 2. *Rai G.D., "Non Conventional Energy Sources", Khanna Publishers, New Delhi, 1999.*	3. *Bansal N.K, Manfred Kleen Man and Michael Meliss, "Renewable energy sources of conversion technology" TMH Publication.* 4. *Kothari. P., Singal, K. C. and Rakesh, "Renewable Energy Sources and Emerging Technologies", Ranjan PHI Pvt. Ltd., New Delhi, 2008*

Learning Assessment												
	Bloom's Level of Thinking	Continuous Learning Assessment (50% weightage)								Final Examination (50% weightage)	
		CLA – 1 (10%)		CLA – 2 (15%)		CLA – 3 (15%)		CLA – 4 (10%)#			
		Theory	Practice	Theory	Practice	Theory	Practice	Theory	Practice	Theory	Practice
Level 1	Remember Understand	*40 %*	-	*30 %*	-	*30 %*	-	*30 %*	-	*30%*	-
Level 2	Apply Analyze	*40 %*	-	*40 %*	-	*40 %*	-	*40 %*	-	*40%*	-
Level 3	Evaluate Create	*20 %*	-	*30 %*	-	*30 %*	-	*30 %*	-	*30%*	-
	Total	100 %		100 %		100 %		100 %		100 %	

CLA – 4 can be from any combination of these: Assignments, Seminars, Tech Talks, Mini-Projects, Case-Studies, Self-Study, MOOCs, Certifications, Conf. Paper etc.,

Course Designers		
Experts from Industry	Experts from Higher Technical Institutions	Internal Experts
1. Mr. A. Subramaniam, PESCO Beam Environmental Solutions Pvt. Ltd.,	*1. Dr. Lima Rose Miranda, Anna University, email: limamiranda2007@gmail.com*	*1 Dr. K. Deepa SRM Inst. of Science & Technology, deepak1@srmist.edu.in*
2. Mr. S. T. Kalaimani, CPCL, Chennai	*2. Dr. T. R. Sundararaman, Rajalakshmi Engineering College*	*2 Mr. V. Ganesh SRM Inst. of Science & Technology, ganesv@srmist.edu.in*

Course Code	18CHO102T	Course Name	PETROLEUM ENGINEERING	Course Category	O	OPEN ELECTIVE	L	T	P	C
							3	0	0	3

Pre-requisite Courses	NIL	Co-requisite Courses	NIL	Progressive Courses	NIL
Course Offering Department	Chemical Engineering	Data Book / Codes/Standards	NIL		

Course Learning Rationale (CLR):	*The purpose of learning this course is to:*
CLR-1 :	*Understand the formation and evaluation of crude oil, overview of petroleum refining processes, Distillation*
CLR-2 :	*Understand the Evaluation and testing, properties, Petroleum refining processes*
CLR-3 :	*Understand the Thermal and catalytic cracking, treatment techniques*
CLR-4 :	*Understand the production of fuels, lubricating oil, storage and transportation*
CLR-5 :	*Understand the production of olefin gases, intermediates compounds and important petrochemicals*
CLR-6:	*Understand the overview of petroleum refinery products*

		Learning			Program Learning Outcomes (PLO)														
		1	2	3	1	2	3	4	5	6	7	8	9	10	11	12	13	14	15
Course Learning Outcomes (CLO):	*At the end of this course, learners will be able to:*	Level of Thinking (loom)	Expected Proficiency %)	Expected Attainment (%)	Engineering Knowledge	Problem Analysis	Design & Development	Analysis, Design, Research	Modern Tool Usage	Society & Culture	Environment & Sustainability	Ethics	Individual & Team Work	Communication	Project Mgt. & Finance	Life Long Learning	PSO - 1	PSO - 2	PSO –3
CLO-1 :	*Comprehend the potential growth of petrochemical industries, distillation characteristics*	*1*	*75*	*70*	*L*		*L*										*H*	*H*	
CLO-2 :	*Comprehend the thermal properties of petroleum fractions*	*1*	*75*	*70*	*M*		*M*										*H*	*H*	*M*
CLO-3 :	*Comprehend the conversion of petroleum, hydrodesulphurization*	*1*	*80*	*75*	*H*		*M*										*H*	*H*	
CLO-4 :	*Comprehend the fuel, storage and transportation -characteristics*	*1*	*80*	*75*	*M*		*M*				*L*						*H*	*H*	*M*
CLO-5 :	*Comprehend the flow sheets of important petrochemicals*	*1*	*80*	*75*	*M*		*H*										*H*	*H*	
CLO-6:	*Comprehend the salient features of petroleum engineering*	*1*	*80*	*70*	*H*		*H*				*L*						*H*	*H*	*M*

Duration (hour)		9	9	9	9	9
S-1	SLO-1	*Overview of petrochemical*	*Distillation condition*	*Octane number*	*Thermal cracking*	*Overview of Refinery Products*
	SLO-2	*Industrial Growth in India, Economics, Feedstock Selection for Petrochemicals*	*Distillation products*	*Cetane number, Diesel index, their determination and importance*	*Thermal cracking in vapor, liquid and mixed phase*	*Refinery Products*
S-2	SLO-1	*Formation*	*Petroleum refining processes*	*Catalytic cracking*	*Production of aviation gasoline*	*Importance and growth potential of petrochemical in India*
	SLO-2	*Formation theories*	*Petroleum Products*	*Houdry fixed bed*	*Properties*	*Petrochemical types*
S-3	SLO-1	*Migration of crude*	*Evaluation of Crude Oil*	*Fluidized bed*	*Motor fuel, kerosene, fuel*	*Reforming and cracking: Cracking of Naphtha*
	SLO-2	*Accumulation of petroleum*	*Testing of Petroleum Products*	*Catalytic bed*	*Diesel oil, tractor fuel and jet*	*Production of C2 and C3 Compounds*
S-4	SLO-1	*Types of crude*	*General processing, topping*	*Reforming process*	*Lubricating oil manufacture*	*Production of intermediate chemicals: Acrylonitrile,*
	SLO-2	*Crude classification*	*vacuum distillations*	*Alkylation process*	*Petroleum waxes and asphalts*	*ethylene oxide*
S-5	SLO-1	*Formation and Evaluation of Crude Oil*	*Physical properties*	*Conversion of petroleum gases into motor fuel with alkylation*	*Storage of petroleum products*	*Higher olefins*
	SLO-2	*General processing of crude*	*Thermal properties*	*Flow diagram*	*Types of storage*	*Benzene*
S-6	SLO-1	*Atmospheric distillation of crude*	*Properties of petroleum fractions*	*Polymerization*	*Tanks*	*Toluene*
	SLO-2	*Flow diagram*	*Thermal properties*	*Hydrogenation and dehydrogenation*	*Bullets*	*Xylene*
S-7	SLO-1	*Distillation condition*	*Flash point, fire point*	*Treatment techniques*	*Special types of spheres*	*Polymerization process*
	SLO-2	*Distillation products*	*Viscosity factor*	*Removal of Sulphur Compounds*	*Transportation of petroleum products, road, rail*	*Plastics*
S-8	SLO-1	*Vacuum distillations*	*Petroleum refining processes*	*Dewaxing*	*Sea and pipeline*	*Ethenic polymers*
	SLO-2	*Flow diagram*		*Clay Treatment and Hydrofining*	*Types of transportation*	*Polyvinyl chloride*
S-9	SLO-1	*Primary process*	*Refining flow diagram*	*Desulphurization,*	*Safety norms*	*Synthetic fibers- polyesters- polyesters ribbon*
	SLO-2	*Secondary process*		*Solvent Treatment Processes*	*Importance of pipeline transportation.*	*Polyethylene Terephthalate*

Learning Resources	1. BhaskaraRao. B.K, "A Text on Petroleum Chemicals", 4thEdn.,Khanna Publishers, New Delhi, 2007 2. Nelson.W.L, "Petroleum Refinery Engineering", McGraw Hill Publishing Company Limited, 1985.	3. GopalaRao M. and Marshall Sittig. "Dryden's Outlines of Chemical Technology", 3rd Edn.,East-West Press, New Delhi, 1997.

Learning Assessment											
	Bloom's Level of Thinking	Continuous Learning Assessment (50% weightage)								Final Examination (50% weightage)	
		CLA – 1 (10%)		CLA – 2 (15%)		CLA – 3 (15%)		CLA – 4 (10%)#			
		Theory	Practice	Theory	Practice	Theory	Practice	Theory	Practice	Theory	Practice
Level 1	Remember Understand	*40 %*	-	*30 %*	-	*30 %*	-	*30 %*	-	*30%*	-
Level 2	Apply Analyze	*40 %*	-	*40 %*	-	*40 %*	-	*40 %*	-	*40%*	-
Level 3	Evaluate Create	*20 %*	-	*30 %*	-	*30 %*	-	*30 %*	-	*30%*	-
	Total	100 %		100 %		100 %		100 %		100 %	

CA – 4 can be from any combination of these: Assignments, Seminars, Tech Talks, Mini-Projects, Case-Studies, Self-Study, MOOCs, Certifications, Conf. Paper etc.,

Course Designers		
Experts from Industry	Experts from Higher Technical Institutions	Internal Experts
1. Mr. A. Subramaniam, PESCO Beam Environmental Solutions Pvt. Ltd.,	*1. Dr. Lima Rose Miranda, Anna University, email: limamiranda2007@gmail.com*	*1 Dr. K. Anbalagan, SRM Inst. of Science & Technology, anbalagan.k@ktr.srmuniv.ac.in*
2. Mr. S. T. Kalaimani, CPCL, Chennai	*2. Dr. T. R. Sundararaman, Rajalakshmi Engineering College*	*2 Dr. M.Magesh kumar SRM Inst. of Science & Technology, mageshkumar.m@ktr.srmuniv.ac.in*

Course Code	18CHO103T	Course Name	INTRODUCTION TO CHEMICAL ENGINEERING	Course Category	O	OPEN ELECTIVE	L	T	P	C
							3	0	0	3

Pre-requisite Courses	Nil	Co-requisite Courses	Nil	Progressive Courses	Nil
Course Offering Department	Chemical Engineering	Data Book / Codes/Standards	Nil		

Course Learning Rationale (CLR):	*The purpose of learning this course is to:*
CLR-1 :	*Understand the basics of process calculation*
CLR-2 :	*Be exposed to the fundamentals of Mechanical Operations*
CLR-3 :	*Understand the fundamentals of fluid flow phenomena*
CLR-4 :	*Be exposed to the principles of heat transfer*
CLR-5 :	*Acquire the knowledge on the basics of mass transfer*
CLR-6 :	*Be exposed to the basic principles of chemical engineering*

Course Learning Outcomes (CLO):	*At the end of this course, learners will be able to:*	Learning 1: Level of Thinking (Bloom)	Learning 2: Expected Proficiency (%)	Learning 3: Expected Attainment (%)	PLO 1: Engineering Knowledge	PLO 2: Problem Analysis	PLO 3: Design & Development	PLO 4: Analysis, Design, Research	PLO 5: Modern Tool Usage	PLO 6: Society & Culture	PLO 7: Environment & Sustainability	PLO 8: Ethics	PLO 9: Individual & Team Work	PLO 10: Communication	PLO 11: Project Mgt. & Finance	PLO 12: Life Long Learning	PLO 13: PSO - 1	PLO 14: PSO - 2	PLO 15: PSO –3
CLO-1 :	*Learn the basics of stoichiometry and mass balance*	2	80	70	H	H											H	L	
CLO-2 :	*Familiarized with mechanical operations involved in material handling*	2	80	70		H	H	L									H	H	L
CLO-3 :	*Understand the concept of fluid and its flow*	2	70	65		H	H	L									H	H	
CLO-4 :	*Gain Knowledge on heat transfer principles*	2	80	70	H	H	H	L									H	H	
CLO-5 :	*Comprehend the basics of mass transfer*	2	70	65	H	H		L									M	L	
CLO-6 :	*Analyze the concepts in chemical engineering*	2	75	65	H	H	H	M									H	M	M

Duration (hour)		9	9	9	9	9
S-1	SLO-1	*Units and dimensions, the mole unit*	*Size reduction*	*Nature of fluids: Type of fluids and flow:*	*Introduction to Heat Transfer*	*Introduction to Mass Transfer operations*
	SLO-2	*mole fraction (or percent) and mass fraction (or percent)*	*Size reduction*	*Nature of fluids: Type of fluids and flow:*	*Various modes of Heat transfer*	*Diffusion, Types, Fick's I law of Diffusion.*
S-2	SLO-1	*analyses of a mixture, concentrations*	*Size analysis*	*incompressible and compressible, potential flow, Laminar and turbulent flow*	*Fourier's law of heat conduction and Thermal conductivity*	*Steady – state molecular diffusion in fluids at rest and in laminar flow: molecular diffusion in gases.*
	SLO-2	*basis of calculations*	*Size analysis*	*incompressible and compressible, potential flow, Laminar and turbulent flow*	*Newton's law of cooling, Natural and forced*	*Molecular diffusion in gases: steady state diffusion of A through non diffusing B*
S-3	SLO-1	*Problem solving on Units and dimensions*	*Screen efficiency*	*Hydrostatic equilibrium and manometers*	*Steady-state conduction compound resistances in series- slab and cylinder.*	*Gas phase equimolal counter diffusion. Diffusion in Multicomponent gas mixtures*
	SLO-2	*Problem solving on Concentrations*	*Screen efficiency*	*Hydrostatic equilibrium and manometers*	*Steady-state conduction compound resistances in series- slab and cylinder.*	*Gas phase equimolal counter diffusion. Diffusion in Multicomponent gas mixtures*
S-4	SLO-1	*predicting P-V-T properties of gases using ideal gas law & Van der Waals equation*	*Filtration and its types – pressure and vacuum filtration*	*Newtonian and Non-Newtonian fluids: Newton's-law of viscosity*	*Steady-state conduction compound resistances in series- slab and cylinder.*	*Molecular diffusion in liquids: steady state diffusion of A through non diffusing B*
	SLO-2	*Calculation of density*	*Filtration and its types – pressure and vacuum filtration*	*Newtonian and Non-Newtonian fluids: Newton's-law of viscosity*	*Steady-state conduction compound resistances in series- slab and cylinder.*	*Molecular diffusion in liquids: steady state diffusion of A through non diffusing B*
S-5	SLO-1	*Basics of chemical equation and stoichiometry*	*Filters and its classification*	*Reynolds number and transition from laminar to turbulent flow*	*Problem solving on heat transfer rate*	*Liquid phase equimolal counter diffusion*
	SLO-2	*limiting reactant, excess reactant, conversion, selectivity and yield*	*Filters and its classification*	*Reynolds number and transition from laminar to turbulent flow*	*Problem solving on heat transfer rate*	*Liquid phase equimolal counter diffusion*
S-6	SLO-1	*Problem solving on Density calculations*	*Basics of Settling and sedimentation*	*Boundary layer concept*	*heat transfer coefficient and Overall heat transfer coefficient*	*Effect of temperature and pressure on diffusivity.*
	SLO-2	*Problem solving on Stoichiometry*	*Basics of Settling and sedimentation*	*Boundary layer concept*	*heat transfer coefficient and Overall heat transfer coefficient*	*Principles of drying, driers and freeze drying*

S-7	SLO-1	*Basic concepts involved in material balance calculations*	*Principles of agitation, Types of agitators*	*Friction factors*	*Problem solving on heat transfer coefficient*	*Various methods of distillation and extraction.*
	SLO-2	*Basic concepts of recycle, bypass and purge streams*	*Principles of agitation, Types of agitators*	*Friction factors*	*Problem solving on heat transfer coefficient*	*Various methods of distillation and extraction.*
S-8	SLO-1	*Problem solving on Material Balance - Mixing*	*Flow patterns: prevention of swirling- draft tubes*	*Drag & Lift forces, Terminal settling velocity*	*Heat transfer to fluids without phase change: Boiling and Condensation*	*Basic concept of leaching, adsorption,*
	SLO-2	*Problem solving on Material Balance - Mixing*	*Flow patterns: prevention of swirling- draft tubes*	*Drag & Lift forces, Terminal settling velocity*	*Heat transfer to fluids without phase change: Boiling and Condensation*	*Basic concept of leaching, adsorption,*
S-9	SLO-1	*Problem solving on Material Balance - Drying*	*Blending and Mixing- Mixers: types*	*Introduction to various types of flow metering devices*	*Basic concepts of radiation, examples and application*	*absorption and membrane separation process*
	SLO-2	*Problem solving on Material Balance - Drying*	*Blending and Mixing- Mixers: types*	*Introduction to various types of flow metering devices*	*Basic concepts of radiation, examples and application*	*absorption and membrane separation process*

Learning Resources	1. *David M. Himmelblau, "Basic Principles and Calculations in Chemical Engineering", 6th Edn., Prentice-Hall of India, New Delhi, 1998.* 2. *Anup K Swain, Hemalata Patra, Roy. G.K, "Mechanical operations", Tata -McGraw Hill, 2010.* 3. *Noel de Nevers, "Fluid Mechanics for Chemical Engineers", 3rd Edn., McGraw Hill International Editions, 2011*	4. *Binay K Dutta, "Heat Transfer: Principles and Applications", PHI Learning Private Limited, Delhi,2010* 5. *Christie John Geankoplis, "Transport Processes and Separation Process Principles (Includes Unit Operations)", 4th Edn., Pearson India Education Services Pvt. Ltd., 2015.*

SLO – Session Learning Outcome

Learning Assessment											
	Bloom's Level of Thinking	Continuous Learning Assessment (50% weightage)								Final Examination (50% weightage)	
		CLA – 1 (10%)		CLA – 2 (15%)		CLA – 3 (15%)		CLA – 4 (10%)#			
		Theory	Practice	Theory	Practice	Theory	Practice	Theory	Practice	Theory	Practice
Level 1	Remember Understand	*40 %*	-	*30 %*	-	*30 %*	-	*30 %*	-	*30%*	-
Level 2	Apply Analyze	*40 %*	-	*40 %*	-	*40 %*	-	*40 %*	-	*40%*	-
Level 3	Evaluate Create	*20 %*	-	*30 %*	-	*30 %*	-	*30 %*	-	*30%*	-
	Total	100 %		100 %		100 %		100 %		100 %	

CLA – 4 can be from any combination of these: Assignments, Seminars, Tech Talks, Mini-Projects, Case-Studies, Self-Study, MOOCs, Certifications, Conf. Paper etc.,

Course Designers		
Experts from Industry	Experts from Higher Technical Institutions	Internal Experts
1. Mr. A. Subramaniam, PESCO Beam Environmental Solutions Pvt. Ltd.,	*1. Dr. Lima Rose Miranda, Anna University,* *email: limamiranda2007@gmail.com*	*1 Dr. S. Sam David* *SRM Inst. of Science & Technology, samdavis@srmist.edu.in*
2. Mr. S. T. Kalaimani, CPCL, Chennai	*2. Dr. T. R. Sundararaman, Rajalakshmi Engineering College*	*2 Mr. V. Ganesh* *SRM Inst. of Science & Technology, ganesv@srmist.edu.in*

Course Code	18CHO104T	Course Name	PROCESS PLANT SAFETY	Course Category	O	Open Elective	L	T	P	C
							3	0	0	3

Pre-requisite Courses	NIL	Co-requisite Courses	NIL	Progressive Courses	NIL
Course Offering Department	Chemical Engineering	Data Book / Codes/Standards	Nil		

Course Learning Rationale (CLR):	*The purpose of learning this course is to:*
CLR-1 :	*Familiarize the basics of Industrial safety management*
CLR-2 :	*Acquire knowledge on chemical plant safety*
CLR-3 :	*Impart knowledge on Industrial accidents, prevention and fire protection systems*
CLR-4 :	*Acquire knowledge on Hazard identification techniques*
CLR-5 :	*Expose industrial hygiene and Occupational health hazards, Safety legislation in chemical industries*
CLR-6 :	*Learning safety management , chemical plant safety, techniques of hazard identification, Industrial Hygiene, occupational Hazards and safety legislation in chemical industries*

Course Learning Outcomes (CLO):	*At the end of this course, learners will be able to:*	Learning 1: Level of Thinking (Bloom)	Learning 2: Expected Proficiency (%)	Learning 3: Expected Attainment (%)	PLO 1: Engineering Knowledge	2: Problem Analysis	3: Design & Development	4: Analysis, Design, Research	5: Modern Tool Usage	6: Society & Culture	7: Environment & Sustainability	8: Ethics	9: Individual & Team Work	10: Communication	11: Project Mgt. & Finance	12: Life Long Learning	13: PSO - 1	14: PSO - 2	15: PSO –3
CLO-1 :	*Know the basics of Industrial Safety Management.*	2	80	70	L	M	M			L	M		H	H		H	H	M	M
CLO-2 :	*Understand the various aspects of Chemical plant safety*	3	80	75	M	H				M	H	M	H	H		M	H	M	M
CLO-3 :	*Understand the various aspects of Industrial accidents and Fire safety*	3	80	75	L	M	M	M		H	H	M	H	H		M	H	M	M
CLO-4 :	*Able to use Hazard identification techniques for the prevention of industrial accidents*	3	85	80	M	M		M	M	M	H						H	M	M
CLO-5 :	*Know the Various aspect of industrial hygiene and Occupational Health hazards, Safety legislation in chemical industries*	3	80	75	L		M	M		L	H		H				H	L	L
CLO-6 :	*Will be able to prevent and control the accidents in chemical Industries by applying the acquired knowledge from Course Learning Rationale*	1	75	70	M	H	M	M	M	M	H	M	H	H		H	H	H	M

Duration (hour)		9	9	9	9	9
S1	SLO-1	*Importance of Safety consciousness in Indian Chemical Industries*	*Chemical process Industries - Siting and Layout of a Chemical plant*	*Definitions, accident causation theories, Classification, Causes, Costs , Principles of Accident prevention*	*Hazard analysis - Preliminary Hazard Analysis (PHA)*	*Concepts - Industrial and Occupational health hazards, Housekeeping, human factors and error, stress at work*
S2	SLO-1	*Development of Industrial Health and Safety*	*Classification of hazardous chemicals*	*Industrial accidents – Bhopal Gas tragedy, Chernobyl – case study*	*Detailed hazard analysis - FMEA*	*Role of trade unions in Industrial safety and health*
S3	SLO-1	*Development of Industrial Health and Safety - OSHA*	*Transportation of hazardous chemicals*	*Accident prevention technique - Plant and Chemical job safety analysis*	*Fault Tree Analysis*	*Personnel protective equipments –head protection, eye and face protection*
S4	SLO-1	*Safety Organization –Polices-Culture*	*Storage and handling of hazardous chemicals*	*Safety performance measurement tools - FR. SR, (FSI)*	*Hazard and operability (HAZOP) study*	*Personnel protective equipments –hand and foot protection*
S5	SLO-1	*Safety Organization – Planning- Promotion*	*Chemical reaction hazards and their control*	*Safety performance measurement tools- SafeT-Score, Accident rate per 1000 workers*	*Hazard and operability (HAZOP) study*	*Personnel protective equipments –body protection and respirators*
S6	SLO-1	*Safety Organization – Inspection –Rules*	*High pressure - High temperature operations – Case studies*	*Disabling injury index, Accident Compensation Statutes Disabling injury index, Accident Compensation Statutes*	*Human Error Analysis*	*Safety legislation in India, Factories act 1948*
S7	SLO-1	*Safety Organization –Responsibility – Supervision*	*Emergency preparation: On-site and Offsite*	*Accident Investigation reporting and Analysis*	*Risk Analysis*	*Indian boilers act and regulations, Indian electricity act and rules*
S8	SLO-1	*Effective Safety Education and Training*	*Safe guarding of Machines – Ergonomics*	*Conditions -Fire triangle- Classification of fires*	*Risk assessment*	*Indian explosives act and rules, Mines act, Petroleum act and rules*
S9	SLO-1	*Communication at various levels of production and operation, Safety slogans*	*Safe guarding of Machines – Ergonomics*	*Common causes of industrial fires, Fire protection systems- prevention*	*Dow (Index) Fire and Explosion Index*	*Environmental protection act.*

Learning Resources	1. *Sharma. A M "Safety and Health in Industry" -A Hand book, BS Publications , 2009* 2. *Fulekar. M.H, "Industrial Hygiene and Chemical Safety", I.K International Publishing house Pvt Ltd., 2006.* 3. *Fawcett .H.H, and Wood .W.S, Safety and Accident Prevention in Chemical Operations, John Wiley & sons, U.S.A.,1965*	4. *Willie Hammer &Dennis Price, Occupational safety management and Engineering, Prentice Hall, 2001* 5. *William Handley, Industrial safety hand book, McGraw- Hill, 1969 6. Daniel. A, Crowl& Joseph. F Louvar Chemical Process safety: fundamentals with applications, Prentice Hall international series*

SLO – Session Learning Outcome

Learning Assessment											
	Bloom's Level of Thinking	Continuous Learning Assessment (50% weightage)								Final Examination (50% weightage)	
		CLA – 1 (10%)		CLA – 2 (15%)		CLA – 3 (15%)		CLA – 4 (10%)#			
		Theory	Practice	Theory	Practice	Theory	Practice	Theory	Practice	Theory	Practice
Level 1	Remember Understand	*40 %*	-	*30 %*	-	*30 %*	-	*30 %*	-	*30%*	-
Level 2	Apply Analyze	*40 %*	-	*40 %*	-	*40 %*	-	*40 %*	-	*40%*	-
Level 3	Evaluate Create	*20 %*	-	*30 %*	-	*30 %*	-	*30 %*	-	*30%*	-
	Total	100 %		100 %		100 %		100 %		100 %	

CA – 4 can be from any combination of these: Assignments, Seminars, Tech Talks, Mini-Projects, Case-Studies, Self-Study, MOOCs, Certifications, Conf. Paper etc.,

Course Designers		
Experts from Industry	Experts from Higher Technical Institutions	Internal Experts
1. *Mr. A. Subramaniam, PESCO Beam Environmental Solutions Pvt. Ltd.,*	1. *Dr. Lima Rose Miranda, Anna University, email: limamiranda2007@gmail.com*	*Dr.B.Karunanithi* *SRM Institute of Science and Technology* *karunanb@srmist.edu.in*
2. *Mr. S. T. Kalaimani, CPCL, Chennai*	2. *Dr. T. R. Sundararaman, Rajalakshmi Engineering College*	*Ms.D.Nanditha* *SRM Institute of Science and Technology* *nandithd@srmist.edu.in*

Course Code	18CHO105T	Course Name	POLLUTION ABATEMENT	Course Category	O	OPEN ELECTIVE	L	T	P	C
							3	0	0	3

Pre-requisite Courses	NIL	Co-requisite Courses	NIL	Progressive Courses	NIL
Course Offering Department	Chemical Engineering	Data Book / Codes/Standards		Nil	

Course Learning Rationale (CLR):	*The purpose of learning this course is to:*
CLR-1 :	*know about the industrial activities and fates of industrial contaminants*
CLR-2 :	*know about the environmental regulations*
CLR-3 :	*know about the air pollution control methods*
CLR-4 :	*know about the principles of water treatment*
CLR-5 :	*know about the air pollution control methods*
CLR-6:	*know about the sources and treatment options for environmental issues*

Course Learning Outcomes (CLO):	*At the end of this course, learners will be able to:*	Learning 1: Level of Thinking (Bloom)	2: Expected Proficiency (%)	3: Expected Attainment (%)	Program Learning Outcomes (PLO) 1: Engineering Knowledge	2: Problem Analysis	3: Design & Development	4: Analysis, Design, Research	5: Modern Tool Usage	6: Society & Culture	7: Environment & Sustainability	8: Ethics	9: Individual & Team Work	10: Communication	11: Project Mgt. & Finance	12: Life Long Learning	13: PSO1	14: PSO2	15: PSO3
CLO-1 :	*Identify the major industries that creates pollutants and how it affects the environment*	*1*	*85*	*75*		*L*		*L*		*H*	*H*		*M*			*H*	*H*	*L*	*L*
CLO-2 :	*Implement the rules and regulations in specific industries*	*1*	*75*	*70*		*H*		*H*	*L*		*H*	*M*	*M*				*H*	*L*	*L*
CLO-3 :	*Identify the sources of air pollution and able to control the air pollution*	*1*	*85*	*75*	*M*	*M*	*H*	*M*			*L*					*H*	*M*	*H*	*H*
CLO-4 :	*Identify different water treatment methods used in industry and able to implement the methods wherever necessary*	*1*	*85*	*75*	*H*	*H*	*M*	*M*			*M*	*M*	*L*			*H*	*M*	*H*	*H*
CLO-5 :	*Identify the sources of air pollution and able to control the air pollution*	*1*	*85*	*75*	*H*	*H*	*M*	*M*			*M*	*M*	*L*			*H*	*M*	*H*	*H*
CLO-6 :	*Identify the pollution nature and able to bring the solution*	*1*	*75*	*70*	*H*	*H*	*M*	*M*			*M*	*M*	*L*			*H*	*M*	*H*	*M*

Duration (hour)		9	9	9	9	9
S-1	SLO-1	*introduction*	*environmental regulations prevention vs control of industrial pollution.*	*air pollution control methods introduction to particulate emission control*	*principles of water treatment primary, secondary and tertiary treatments*	*solid waste and disposal methods sources and types of solid waste*
	SLO-2	*introduction*	*prevention vs control of industrial pollution*	*gravitational settling chambers*	*principles of water treatment secondary treatments*	*sources and types of solid waste*
S-2	SLO-1	*industrial activity and environment*	*prevention vs control of industrial pollution*	*cyclone separators,*	*principles of water treatment secondary treatments*	*processing methods, disposal- principle, practices and methods,*
	SLO-2	*industrial activity and environment*	*prevention vs control of industrial pollution*	*electrostatic precipitators*	*principles of water treatment secondary treatments*	*processing methods, disposal- principle, practices and methods,*
S-3	SLO-1	*industrial activity and environment*	*prevention vs control of industrial pollution*	*Volatile organic compounds control*	*principles of water treatment tertiary treatments*	*processing methods, disposal- principle, practices and methods,*
	SLO-2	*industrial activity and environment*	*prevention vs control of industrial pollution*	*Volatile organic compounds control*	*principles of water treatment tertiary treatments*	*processing methods, disposal- principle, practices and methods,*
S-4	SLO-1	*fates of industrial contaminants*	*environment policies and regulations to encourage pollution prevention*	*Volatile organic compounds control*	*principles of water treatment tertiary treatments*	*energy from solid waste, waste management hierarchy,*
	SLO-2	*fates of industrial contaminants*	*environment policies and regulations to encourage pollution prevention*	*control of sulphur dioxide*	*principles of water treatment tertiary treatments*	*energy from solid waste, waste management hierarchy,*
S-5	SLO-1	*case studies on industrial contaminants*	*environment policies and regulations to encourage pollution prevention*	*control of sulphur dioxide*	*advanced waste water treatments*	*energy from solid waste, waste management hierarchy,*
	SLO-2	*case studies on industrial contaminants*	*environment policies and regulations to encourage pollution prevention*	*control of sulphur dioxide*	*advanced waste water treatments*	*energy from solid waste, waste management hierarchy,*
S-6	SLO-1	*industrialization and sustainable development*	*environment friendly chemical processes*	*control of oxides of nitrogen*	*advanced waste water treatments*	*energy from solid waste, waste management hierarchy,*
	SLO-2	*industrialization and sustainable development*	*environment friendly chemical processes*	*control of oxides of nitrogen*	*advanced waste water treatments*	*energy from solid waste, waste management hierarchy,*
S-7	SLO-1	*sustainability strategies*	*environment friendly chemical processes*	*control of carbon monoxide and hydrocarbons*	*advanced waste water treatments*	*energy from solid waste, waste management hierarchy,*

	SLO-2	*sustainability strategies*	*environment friendly chemical processes*	*control of carbon monoxide and hydrocarbons*	*advanced waste water treatments*	*energy from solid waste, waste management hierarchy,*
S-8	SLO-1	*barriers to sustainability*	*regulations for clean environment and implication for industries*	*noise pollution measurements and its control*	*recovery of metals from process effluents*	*energy from solid waste, waste management hierarchy,*
	SLO-2	*Barriers to sustainability*	*Regulations for clean environment and implication for industries*	*Noise pollution measurements and its control*	*Recovery of metals from process effluents*	*energy from solid waste, waste management hierarchy,*
S-9	SLO-1	*Pollution prevention in achieving sustainability*	*Regulations for clean environment and implication for industries*	*Noise pollution measurements and its control*	*Recovery of metals from process effluents*	*hazardous waste, biomedical waste, and nuclear waste.*
	SLO-2	*Pollution prevention in achieving sustainability*	*Regulations for clean environment and implication for industries*	*Noise pollution measurements and its control*	*Recovery of metals from process effluents*	*hazardous waste, biomedical waste, and nuclear waste.*

Learning Resources	1. *Bishop.P, "Pollution Prevention: Fundamentals and Practice", McGraw Hill International Edn., McGraw Hill Book Co., Singapore, 2000* 2. *Freeman.H.M, "Industrial Pollution Prevention Hand Book", McGraw Hill, 1995* 3. *James. G. Mann and Liu.Y.A, "Industrial Water Reuse and Waste Water Minimization", McGraw Hill, 1999*	4. *Rose.G.R.D, "Air pollution and Industry", Van Nostrand Reinhold Co., NewYork 1972* 5. *Pandey.G.N and Carney.G.C, "Environmental Engineering", Tata McGraw Hill, New Delhi,1989* 6. *Kapoor.B.S, "Environmental Engineering", 3rd Edn., Khanna publishers,1997*

SLO – Session Learning Outcome

Learning Assessment											
	Bloom's Level of Thinking	Continuous Learning Assessment (50% weightage)								Final Examination (50% weightage)	
		CLA – 1 (10%)		CLA – 2 (15%)		CLA – 3 (15%)		CLA – 4 (10%)#			
		Theory	Practice	Theory	Practice	Theory	Practice	Theory	Practice	Theory	Practice
Level 1	Remember Understand	*40 %*	-	*30 %*	-	*30 %*	-	*30 %*	-	*30%*	-
Level 2	Apply Analyze	*40 %*	-	*40 %*	-	*40 %*	-	*40 %*	-	*40%*	-
Level 3	Evaluate Create	*20 %*	-	*30 %*	-	*30 %*	-	*30 %*	-	*30%*	-
	Total	100 %		100 %		100 %		100 %		100 %	

CA –4 can be from any combination of these: Assignments, Seminars, Tech Talks, Mini-Projects, Case-Studies, Self-Study, MOOCs, Certifications, Conf. Paper etc.,

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2. Mr. S. T. Kalaimani, CPCL, Chennai	*2. Dr. T. R. Sundararaman, Rajalakshmi Engineering College*	*2 Dr. S.Vishali SRM Inst. of Science & Technology, vishalis@srmist.edu.in*

Course Code	18CHO106T	Course Name	INTRODUCTION TO PROTEOMICS	Course Category	O	OPEN ELECTIVE	L	T	P	C
							3	0	0	3

Pre-requisite Courses	NIL	Co-requisite Courses	NIL	Progressive Courses	NIL
Course Offering Department	Chemical Engineering	Data Book / Codes/Standards		Nil	

Course Learning Rationale (CLR):	*The purpose of learning this course is to:*
CLR-1 :	*Introduce protein structure and function*
CLR-2 :	*Understand the methodologies utilized for protein isolation*
CLR-3 :	*Understand the analytical methodologies available for protein identification*
CLR-4 :	*Have an insight into methods available for the identification of proteins in a high-through-put manner*
CLR-5 :	*Apply a scientific approach to proteomics investigation using bioinformatics tools*
CLR-6 :	*Introduce various combination of sample preparation and analytical methodologies for proteomics investigation*

Course Learning Outcomes (CLO):	At the end of this course, learners will be able to:	Learning 1: Level of Thinking (Bloom)	Learning 2: Expected Proficiency (%)	Learning 3: Expected Attainment (%)	PLO 1: Engineering Knowledge	PLO 2: Problem Analysis	PLO 3: Design & Development	PLO 4: Analysis, Design, Research	PLO 5: Modern Tool Usage	PLO 6: Society & Culture	PLO 7: Environment & Sustainability	PLO 8: Ethics	PLO 9: Individual & Team Work	PLO 10: Communication	PLO 11: Project Mgt. & Finance	PLO 12: Life Long Learning	PLO 13: PSO - 1	PLO 14: PSO - 2	PLO 15: PSO –3
CLO-1 :	*Understand the significance of protein structure and function from a physiological context*	*2*	*80*	*70*	*L*	*M*	*M*	*M*	*L*							*M*	*H*	*M*	*M*
CLO-2 :	*Design a sequence of methodologies for desired protein isolation from complex matrices*	*3*	*80*	*75*	*L*	*M*	*M*	*M*	*M*							*M*	*H*	*M*	*M*
CLO-3 :	*Design one or more analytical methodologies in series or parallel for protein identification*	*3*	*80*	*75*	*L*	*M*	*M*	*M*	*H*							*M*	*H*	*M*	*M*
CLO-4 :	*Conceive high-throughput screening methodology for identification of proteins in complex mixtures*	*3*	*85*	*80*	*L*	*M*	*M*	*M*	*H*	*L*	*L*					*M*	*H*	*M*	*M*
CLO-5 :	*Utilize proteomics methodologies aided by bioinformatics tools for protein characterization*	*3*	*80*	*75*	*L*	*M*	*H*	*H*	*H*	*L*	*L*	*L*	*M*	*M*		*H*	*H*	*H*	*H*
CLO-6 :	*Design a sample preparation and analytical methodology scheme for a proteomics investigation*	*1*	*75*	*70*	*M*	*H*	*H*	*H*	*H*	*L*	*L*	*L*	*H*	*H*		*H*	*H*	*H*	*H*

Duration (hour)		9	9	9	9	9
S1	SLO-1	*An Overview of Proteomics*	*Strategies for Protein Identification*	*MS- principles*	*Protein structures*	*Protein Chips and Functional Proteomics*
S2	SLO-1	*Need, scope and challenges of proteomics*	*Strategies for Protein Identification*	*MS- principles*	*Techniques for solving protein structures*	*Protein Chips and Functional Proteomics*
S3	SLO-1	*Strategies for Protein separation*	*Strategies for Protein Identification*	*Instrumentation and applications in proteomics*	*Techniques for solving protein structures*	*Protein Chips and Functional Proteomics*
S4	SLO-1	*2D gel electrophoresis- principle and applications*	*Protein Identification with antibodies*	*Instrumentation and applications in proteomics*	*Techniques for solving protein structures*	*Applications of Proteomics in disease diagnosis*
S5	SLO-1	*2D gel electrophoresis- principle and applications*	*Protein Identification with antibodies*	*Strategies for Protein Quantization*	*Protein interactions- principles and methods to study them*	*Applications of Proteomics in disease diagnosis*
S6	SLO-1	*Liquid chromatography- principle and applications*	*Protein Identification with antibodies*	*Quantitative proteomics with standard 2D gels Multiplexed proteomics*	*Protein interactions- principles and methods to study them*	*Applications of Proteomics in disease diagnosis*
S7	SLO-1	*Liquid chromatography- principle and applications*	*Protein sequence determination by chemical degradation*	*Quantitative proteomics with standard 2D gels Multiplexed proteomics*	*Protein interactions- principles and methods to study them*	*Drug development and plant biotechnology*
S8	SLO-1	*Multidimensional liquid chromatography*	*Protein sequence determination by chemical degradation*	*Quantitative with mass spectrometry*	*Protein Modification in Proteomics.*	*Drug development and plant biotechnology*
S9	SLO-1	*Multidimensional liquid chromatography*	*Protein sequence determination by chemical degradation*	*Quantitative with mass spectrometry*	*Protein Modification in Proteomics.*	*Drug development and plant biotechnology*

Learning Resources	1. *R. M. Twyman, Principles of Proteomics (Advanced Text Series), Bios Scientific, 2004* 2. *David W Mount, Bioinformatics- Sequence and genome analysis, Cold Spring Harbor Laboratory Press, second edition, 2004.*	3. *S. R. Pennington, M. J. Dunn, Proteomics: from Protein Sequence to Function, Springer publications, first edition, 2001.* 4. *Timothy Palzkill, Proteomics, Springer, 2002.*

Learning Assessment											
	Bloom's Level of Thinking	Continuous Learning Assessment (50% weightage)								Final Examination (50% weightage)	
		CLA – 1 (10%)		CLA – 2 (15%)		CLA – 3 (15%)		CLA – 4 (10%)#			
		Theory	Practice	Theory	Practice	Theory	Practice	Theory	Practice	Theory	Practice
Level 1	Remember Understand	*40 %*	-	*30 %*	-	*30 %*	-	*30 %*	-	*30%*	-
Level 2	Apply Analyze	*40 %*	-	*40 %*	-	*40 %*	-	*40 %*	-	*40%*	-
Level 3	Evaluate Create	*20 %*	-	*30 %*	-	*30 %*	-	*30 %*	-	*30%*	-
	Total	100 %		100 %		100 %		100 %		100 %	

CA – 4 can be from any combination of these: Assignments, Seminars, Tech Talks, Mini-Projects, Case-Studies, Self-Study, MOOCs, Certifications, Conf. Paper etc.,

Course Designers		
Experts from Industry	Experts from Higher Technical Institutions	Internal Experts
1. Mr. A. Subramaniam, PESCO Beam Environmental Solutions Pvt. Ltd.,	*1. Dr. Lima Rose Miranda, Anna University, email: limamiranda2007@gmail.com*	*Dr. M.P. Rajesh* *SRM Institute of Science and Technology* *rajeshm@srmist.edu.in*
2. Mr. S. T. Kalaimani, CPCL, Chennai	*2. Dr. T. R. Sundararaman, Rajalakshmi Engineering College*	

Course Code	18CEO301T	Course Name	ADVANCED DESIGN OF RCC	Course Category	O	Open Elective Courses	L	T	P	C
							2	1	0	3

Pre-requisite Courses	18CEC207T	Co-requisite Courses	Nil	Progressive Courses	Nil
Course Offering Department	Civil Engineering	Data Book / Codes/Standards	IS 456-2000, SP 16 Charts, IS 3370 Part1,2,3,4, IS 1343-2012, IRC 3-1983, IRC:83-2018 (Part II)		

Course Learning Rationale (CLR):	*The purpose of learning this course is to:*
CLR-1 :	*Analyse the retaining wall with the effect of active and passive pressure*
CLR-2 :	*Design of Flat Slab using Direct Design Method as per IS456-2000*
CLR-3 :	*Utilize the concept the of yield line theory*
CLR-4 :	*Design Water Tanks using Working Stress Method*
CLR-5 :	*Utilize concepts of ILD to analyse the RCC bridge for simple spans*
CLR-6 :	*Analyse prestressed concrete sections for flexure*

Course Learning Outcomes (CLO):	*At the end of this course, learners will be able to:*	Learning 1: Level of Thinking (Bloom)	Learning 2: Expected Proficiency (%)	Learning 3: Expected Attainment (%)	PLO 1: Engineering Knowledge	PLO 2: Problem Analysis	PLO 3: Design & Development	PLO 4: Analysis, Design, Research	PLO 5: Modern Tool Usage	PLO 6: Society & Culture	PLO 7: Environment & Sustainability	PLO 8: Ethics	PLO 9: Individual & Team Work	PLO 10: Communication	PLO 11: Project Mgt. & Finance	PLO 12: Life Long Learning	PLO 13: PSO - 1	PLO 14: PSO - 2	PLO 15: PSO - 3
CLO-1 :	*Identify the effect of active and passive pressure influencing the behavior in design of retaining walls*	3	80	75	H	H	-	-	-	-	-	-	-	-	-	-	H	-	H
CLO-2 :	*Analyse the behavior of Flat slab in flexure and punching shear*	3	85	75	H	H	-	-	-	-	-	-	-	-	-	-	H	-	H
CLO-3 :	*Apply yield line theory to the design of slabs*	3	75	75	H	H	-	H	-	-	-	-	-	-	-	-	H	-	H
CLO-4 :	*Analyse the behavior of underground and elevated water tanks*	3	90	80	H	H	-	-	-	-	-	-	-	-	-	-	H	-	M
CLO-5 :	*Analyseand design of RCC Bridge and Culvert using IRC loadings*	3	85	75	H	H	-	-	-	-	-	-	-	-	-	-	H	-	M
CLO-6 :	*Apply the strength and load balancing concept to the design of beams in flexure*	3	80	75	H	H	-	H	-	-	-	-	-	-	-	-	H	-	H

Duration (hour)		9	9	9	9	9
S-1	SLO-1	*RETAINING WALLS Introduction to Retaining Walls*	*FLAT SLABS Introduction to Flat Slab*	*RCC WATER TANKS Introduction to Water Retaining Structures*	*DESIGN OF BRIDGES Types of bridges and culverts*	*PRESTRESSED CONCRETE STRUCTURES Basic concepts*
	SLO-2	*Design of Retaining Walls, Proportioning of the size of the wall*	*Advantages of Flat Slab*	*Design of Rectangular and Circular Water Tanks*	*Simply supported girder bridges, Balanced cantilever and their behavior*	*Principle of prestressing methods and materials required*
S-2	SLO-1	*Design for Overturning moment*	*Design of Flat slab, Proportioning*	*Design Problems – Circular slabs subjected to direct tension*	*Design Problems*	*Stress and Strength concept and Load balancing concept*
	SLO-2	*Design for Sliding and provision for shear key*	*Design for Bending*	*Design Problems – Contd.,*	*Introduction to IRC Loading, impact loading, Codal Provisions for design*	*Design Problems*
S-3	SLO-1	*Tutorials*	*Tutorials*	*Tutorials*	*Tutorials*	*Tutorials*
	SLO-2	*Tutorials*	*Tutorials*	*Tutorials*	*Tutorials*	*Tutorials*
S-4	SLO-1	*Design of Toe and Heel Slab of Retaining Wall*	*Thickness of flat slab based on punching shear*	*Design Problems*	*Design of slab culvert for Class AA, 70R, Class A*	*Analysis of sections subjected to flexure*
	SLO-2	*Design of Stem of Retaining Wall*	*Design Problems*	*Design of Underground Water Tanks*	*Design Problems – Design of slabs based on IRC Codes*	*Design Problems – Beams subjected to eccentric prestressing*
S-5	SLO-1	*Introduction to Counterfort Retaining Walls*	*INTRODUCTION TO YIELD LINE THEORY*	*Design Problems – Design of Rectangular Water tanks (L/B >2)*	*Design Problems – Contd.,*	*Design Problems – Contd.,*
	SLO-2	*Design of Counterfort Retaining Walls, Proportioning of the size of the wall and Counterfort*	*Design of Square and Rectangular Slabs*	*Design Problems*	*Design Problems*	*Losses of prestress using Simple cable profile*
S-6	SLO-1	*Tutorials*	*Tutorials - Design of Square slabs for simply supported condition*	*Tutorials - Design of Rectangular Water tanks (L/B < 2)*	*Tutorials*	*Tutorials – Losses due to elastic deformation of concrete*
	SLO-2	*Tutorials*	*Tutorials – Contd.,*	*Tutorials*	*Tutorials*	*Tutorials – Contd.,*

S-7	SLO-1	*Design for Overturning moment*	*Design of Square slabs for fixed support condition*	*Design of overhead water tank and Intze type tanks*	*Loads on T-beam girder bridges using Courbans theory*	*Design of beams subjected to losses in shrinkage in concrete*
	SLO-2	*Design for Sliding and provision for shear key*	*Check for bending and shear*	*Design Problems*	*Design Problems*	*Design Problems – Contd.,*
S-8	SLO-1	*Design of Toe and Heel Slab of Counterfort Retaining Wall*	*Design of Circular and Triangular Slabs*	*Design of Staging with columns and beams, Shaft and conventional types*	*Drawing ILD diagram for simple spans and calculation of design Bending moment, shear force for class AA and class A loading*	*Introduction to design of beams*
	SLO-2	*Design of Stem of Counterfort Retaining Wall*	*Design of Circular and Triangular Slabs*	*Design Problems*	*Design Problems*	*Design of beams based on IS 1343.*
S-9	SLO-1	*Tutorials*	*Tutorials - Design of triangular slabs for different edge conditions*	*Tutorials*	*Tutorials*	*Tutorials*
	SLO-2	*Tutorials*	*Tutorials – Contd.,*	*Tutorials*	*Tutorials*	*Tutorials*

Learning Resources	1. *Krishnaraju.N, Pranesh.R.N, Reinforced Concrete Design, New Age International Publication, 2003.* 2. *Ramamrutham.S, Design of Reinforced Concrete Structures, DhanpatRai Publishing Company., 2015.* 3. *Johnson Victor D, Essentials of Bridge Engineering, 4th ed, Oxford & IBH Publishing Company, 2007.* 4. *UnnikrishnaPillai.S, DevdasMenon, Reinforced Concrete Design, 5thed., Tata McGraw, 2003.*	5. *Subramanian.N, Design of Reinforced Concrete Structures, Oxford University Press, 2013* 6. *Krishnaraju.N, Prestressed Concrete, Tata McGraw-Hill Education, 2008* 7. *NPTEL Course: Reinforced Concrete Road Bridges.https://onlinecourses-archive.nptel.ac.in/noc17_ce24/preview* 8. *NPTEL Course: Prestressed Concrete Structures https://nptel.ac.in/courses/105106117*

Learning Assessment

	Bloom's Level of Thinking	Continuous Learning Assessment (50% weightage)								Final Examination (50% weightage)	
		CLA – 1 (10%)		CLA – 2 (15%)		CLA – 3 (15%)		CLA – 4 (10%)#			
		Theory	Practice	Theory	Practice	Theory	Practice	Theory	Practice	Theory	Practice
Level 1	Remember Understand	*40 %*	-	*30 %*	-	*30 %*	-	*30 %*	-	*30%*	-
Level 2	Apply Analyze	*40 %*	-	*40 %*	-	*40 %*	-	*40 %*	-	*40%*	-
Level 3	Evaluate Create	*20 %*	-	*30 %*	-	*30 %*	-	*30 %*	-	*30%*	-
	Total	100 %		100 %		100 %		100 %		100 %	

CLA – 4 can be from any combination of these: Assignments, Seminars, Tech Talks, Mini-Projects, Case-Studies, Self-Study, MOOCs, Certifications, Conf. Paper etc.,

Course Designers

Experts from Industry	Experts from Higher Technical Institutions	Internal Experts
1. Er. G.Hariharanath, GA Consultants, Chennai, gac1996@hotmail.com	*1. Dr. R. Santhakumar, Professor, Centre for Rural Department, NITTTR*	*Prof. G. Augustine ManirajPandian, SRMIST*
2. Er. AGV. Desigan, Design Group Engineering Consultancy Pvt Ltd. Chennai, desigan.agv@gmail.com	*2. Dr. P. Jayabalan, NIT, Trichy, pjeya@nitt.edu*	*Dr.P.R.Kannan Rajkumar, SRMIST*

Course Code	18CEO302J	Course Name	MODERN CIVIL ENGINEERING ECONOMICS	Course Category	O	Open Elective Course	L	T	P	C
							2	0	2	3

Pre-requisite Courses	Nil	Co-requisite Courses	Nil	Progressive Courses	Nil
Course Offering Department	Civil Engineering	Data Book / Codes/Standards	Nil		

Course Learning Rationale (CLR):	*The purpose of learning this course is to:*
CLR-1 :	*Understand the basic principles of economies*
CLR-2 :	*Realize the type of firm and market structure*
CLR-3 :	*Understand the concept of Indian economy*
CLR-4 :	*Apply the concept of estimation*
CLR-5 :	*Realize the types of construction specification*
CLR-6 :	*Analyze rate analysis*

Course Learning Outcomes (CLO):	*At the end of this course, learners will be able to:*	Learning 1: Level of Thinking (Bloom)	2: Expected Proficiency (%)	3: Expected Attainment (%)	PLO 1: Engineering Knowledge	2: Problem Analysis	3: Design & Development	4: Analysis, Design, Research	5: Modern Tool Usage	6: Society & Culture	7: Environment & Sustainability	8: Ethics	9: Individual & Team Work	10: Communication	11: Project Mgt. & Finance	12: Life Long Learning	13: PSO - 1	14: PSO - 2	15: PSO – 3
CLO-1 :	*Identify the various economic policies*	3	85	75	H	H	-	-	-	H	-	-	-	-	-	-	H	-	-
CLO-2 :	*Identify the forms of market structure and organization*	2	85	75	H	H	-	-	-	H	-	-	-	-	-	-	H	-	-
CLO-3 :	*Apply the concepts of time value of money*	2	85	75	H	H	-	-	-	-	-	-	-	-	H	-	H	-	-
CLO-4 :	*Determine the different types of estimation*	2	85	75	H	H	-	M	-	-	-	-	-	-	-	-	H	-	-
CLO-5 :	*Develop the specification for different types of buildings*	3	85	75	H	H	-	M	-	-	-	-	H	-	-	-	H	-	-
CLO-6 :	*Identify the factors affecting rate analysis*	3	85	75	H	H	-	M	-	-	-	-	H	-	-	-	H	-	-

Duration (hour)		9	9	9	9	9
S-1	SLO-1	*Basic Principles and Methodology of Economics.*	*Forms of organizations*	*ROI Problem*	*Present and future worth of cash flows*	*Rate analysis-Importance*
	SLO-2	*Demand/supply*	*Cost & Cost Control –Techniques*	*Payback Period*		*Rate analysis-necessity*
S-2	SLO-1	*Government Policies and Application*	*Types of Costs*	*Payback Period Problem*	*Structure of productive activity*	*Factors affecting rate analysis*
	SLO-2	*Basic Macro-economic Concepts*	*Lifecycle costs*	*Bid price*	*Urbanization*	*Equipment productivity*
S-3	SLO-1 SLO-2	*Drawings to read and understand - Autocad*	*Earthwork estimation (Foundation)*	*Estimation of finishes (Interior and Exterior)*	*Estimation of MEP works*	*Rate analysis – Concrete works*
S-4	SLO-1 SLO-2	*Drawings to read and understand - Autocad*	*Earthwork estimation (Foundation)*	*Estimation of finishes (Interior and Exterior)*	*Estimation of MEP works*	*Rate analysis – Concrete works*
S-5	SLO-1	*GDP/GNP/NI/Disposable income*	*Break even Analysis*	*Evaluation of bids*	*Indian economy - plans*	*Labour productivity*
	SLO-2	*Public sector economics –welfare*			*Post reform Growth*	*Factors affecting productivity*
S-6	SLO-1	*Public sector economics – externalities, labour market*	*Budgets*	*RA Bills*	*Specifications-Types, requirements and importance*	*Measurements for various items*
	SLO-2	*Components of Monetary and Financial System*	*Capital Budgeting*		*detailed specifications for buildings*	*Introduction to the process of Estimation*
S-7	SLO-1 SLO-2	*Quantity estimation basics - Excel*	*Estimation of concrete works (Sub and super structure)*	*Estimation of bridges*	*Reinforcement calculations*	*Rate analysis – Masonry works*
S-8	SLO-1 SLO-2	*Earthwork estimation (Embankments & Trenches)*	*Estimation of masonry works*	*Estimation of culverts*	*BIM Quantity Takeoff*	*Rate analysis - Plastering*
S-9	SLO-1	*Central bank –monetary aggregates, Commercial banks & their functions*	*Application of Linear Programming*	*Final bills*	*Detailed specifications for roads, Detailed specifications for minor bridges*	*IS standards for quantity estimation, IS standards for quantity estimation - recommendations*
	SLO-2	*Capital and Debt Markets, Elements of Business/Managerial Economics*	*Investment Analysis – NPV Problem*	*Depreciation and Time value of money*	*Detailed specifications for industrial structures, Rate analysis-Purpose*	*Drawings – Architectural, Drawings – Structural and MEP*

Learning Resources	1. *Mankiw Gregory N. (2002), Principles of Economics, Thompson Asia* 2. *V. Mote, S. Paul, G. Gupta(2004), Managerial Economics, Tata McGraw Hill* 3. *Misra, S.K. and Puri (2009), Indian Economy, Himalaya* 4. *Pareek Saroj (2003), Textbook of Business Economics, Sunrise Publishers* 5. *Typical PWD Rate Analysis documents.*	6. *Dutta, B.N., Estimating and Costing in Civil Engineering (Theory & Practice), UBS Publishers, 2016* 7. *Dutta, B.N., Estimating and Costing in Civil Engineering (Theory & Practice), UBS Publishers, 2016* 8. *Introduction to Accounting and Finance for Civil Engineers – NPTEL Online course*

Learning Assessment											
	Bloom's Level of Thinking	Continuous Learning Assessment (50% weightage)								Final Examination (50% weightage)	
		CLA – 1 (10%)		CLA – 2 (15%)		CLA – 3 (15%)		CLA – 4 (10%)#			
		Theory	Practice	Theory	Practice	Theory	Practice	Theory	Practice	Theory	Practice
Level 1	Remember Understand	*20 %*	*20 %*	*15 %*	*15 %*	*15 %*	*15 %*	*15 %*	*15 %*	*15 %*	*15 %*
Level 2	Apply Analyze	*20 %*	*20 %*	*20 %*	*20 %*	*20 %*	*20 %*	*20 %*	*20 %*	*20 %*	*20 %*
Level 3	Evaluate Create	*10 %*	*10 %*	*15 %*	*15 %*	*15 %*	*15 %*	*15 %*	*15 %*	*15 %*	*15 %*
	Total	100 %		100 %		100 %		100 %		100 %	

CLA – 4 can be from any combination of these: Assignments, Seminars, Tech Talks, Mini-Projects, Case-Studies, Self-Study, MOOCs, Certifications, and Conf. Paper etc.

Course Designers		
Experts from Industry	Experts from Higher Technical Institutions	Internal Experts
Mr. Rajeev Srinivasan, Senior Planning, NASS Contacting, Rajeev.srinivasan@nasscontracting.com	*Dr. A .R. Krishnaraja, Associate professor, Kongu Engineering college, krajacivil@kongu.ac.in*	*Mr.M.B.Sridhar, Asst. Prof., SRMIST*
Mr. N. Arivu Sudar, Fosroc India, n.arivusudar@gmail.com	*Dr. J. Saravanan, Associate Professor, Annamalai University, ausjs5070@gmail.com*	*Mr.S.Gopinath, Asst. Prof., SRMIST*

Course Code	18CEO303J	Course Name	MODERN TOOLS IN ENGINEERING SURVEYING	Course Category	O	Open Elective Course	L	T	P	C
							2	0	2	3

Pre-requisite Courses	18CEC204T	Co-requisite Courses	Nil	Progressive Courses	Nil
Course Offering Department	CIVIL ENGINEERING	Data Book / Codes/Standards	Nil		

Course Learning Rationale (CLR):	*The purpose of learning this course is to:*
CLR-1 :	*Determine the Horizontal and vertical control*
CLR-2 :	*Know the Hydrographic surveying*
CLR-3 :	*Understand Advance surveying instruments*
CLR-4 :	*Know Global positioning System and segments*
CLR-5 :	*Introduce photogrammetry to civil engineering*
CLR-6 :	*Introduction of remote sensing to civil engineering*

Course Learning Outcomes (CLO):	*At the end of this course, learners will be able to:*	Learning 1: Level of Thinking (Bloom)	2: Expected Proficiency (%)	3: Expected Attainment (%)	PLO 1: Engineering Knowledge	2: Problem Analysis	3: Design & Development	4: Analysis, Design, Research	5: Modern Tool Usage	6: Society & Culture	7: Environment & Sustainability	8: Ethics	9: Individual & Team Work	10: Communication	11: Project Mgt. & Finance	12: Life Long Learning	13: PSO - 1	14: PSO - 2	15: PSO – 3
CLO-1 :	*know the basics, importance, and methods of Triangulation and Trilateration*	2	85	80	H	-	-	-	-	-	M	-	L	-	-	H	H	-	-
CLO-2 :	*Study the various Hydrographic Surveying Techniques.*	2	85	75	H	-	-	-	-	-	M	-	L	-	-	H	H	-	-
CLO-3 :	*Acquire knowledge about EDM and Total Station*	2	80	75	H	-	-	-	-	-	H	-	L	-	-	H	H	-	-
CLO-4 :	*Survey Using GPS.*	2	85	80	H	-	-	-	-	-	H	-	L	-	-	H	H	-	-
CLO-5 :	*Study the Concept of Aerial Photo Interpretation.*	2	85	75	H	H	H	M	H	-	H	-	M	-	-	H	H	-	-
CLO-6 :	*learn the importance and different aspects of remote sensing*	2	80	75	H	H	H	H	H	-	H	-	M	-	-	H	H	-	-

Duration (hour)		09	09	09	09	09
S-1	SLO-1	*TRIANGULATION AND TRILATERATION*	*HYDROGRAPHIC SURVEYING*	*EDM, TOTAL STATION, GPS SURVEYING*	*PHOTOGRAMMETRY SURVEYING*	*REMOTE SENSING*
	SLO-2	*Horizontal Vertical control - methods Triangulation – Primary Secondary and Tertiary Triangulation*	*Methods of Hydrographic Surveying Establishment of Horizontal control Tide Gauges-*	*Infrared EDM & Microwave system- Measuring DDM-ODM- EDM Electro-optical system- Measuring& Working Principle,*	*Introduction - Photogrammetry in Civil engineering History of Photogrammetry ,*	*Introduction , Historical Background Components of Remote sensing*
S-2	SLO-1	*Base line –Figure and Layout of base lines*	*Recording and non recording Type, Staff, float and weight gauge, Self registering Tide Gauge*	*Sources of error in EDM ,Total station-Types*	*Terminology in Photogrammetry- Photo theodolite,*	*Electromagnetic Radiation (EMR) Ideal remote sensing system*
	SLO-2	*Base line extension- By Prolongation By Double Sigjhting Method*	*Equipments of Sounding-Shore signal and buoys*	*Measuring and working principle,*	*Terrestrial and Aerial photographs - vertical and oblique photograph*	*Wave length and Frequency of Different bands*
S-3	SLO-1	*Tacheometric Surveying--Constants of Tacheometer*	*Setting out simple circular curve --Single Theodolite Method*	*Total Station Surveying - Measurements of Distances and angles,*	*Total Station Surveying - Measurements of Traversing,*	*Identification of aerial photographs*
	SLO-2	*Tacheometric Surveying--Constants of Tacheometer*	*Setting out simple circular curve --Single Theodolite Method*	*Total Station Surveying - Measurements of Distances and angles,*	*Total Station Surveying - Measurements of Traversing,*	*Identification of aerial photographs*
S-4	SLO-1	*Tacheometric Surveying--Stadia Tacheometry*	*Setting out simple circular curve --Double Theodolite Method*	*Total Station Surveying- Measurements of, Slope*	*GPS Surveying –Measurement of Coordinates*	*Aerial Photo Interpretation Using Photo Interpretation Keys*
	SLO-2	*Tacheometric Surveying--Stadia Tacheometry*	*Setting out simple circular curve --Double Theodolite Method*	*Total Station Surveying- Measurements of, Slope*	*GPS Surveying –Measurement of Coordinates*	*Aerial Photo Interpretation Using Photo Interpretation Keys*
S-5	SLO-1	*Baseline measurement- instruments and accessories Wheelers baseline apparatus*	*Sounding Equipment, Angle measuring instruments Location of Sounding-*	*Coordinate system-Classification, GPS - Fundamentals*	*Scale of an aerial photograph Types of scales*	*Interactions with atmosphere & Earth features*
	SLO-2	*Jardein's Method & Hunter's short base Method*	*Observation from the shore , boat, both shore and boat*	*Space ,Control & User Segments of GPS*	*Overlapping of Aerial Photographs,*	*Platform, Sensors Definition, Types Airborne Platforms*

S6	SLO-1	*Correction Determination of intervisibility of triangulation stations*	*Location by stretched wire across a river*	*Errors in GPS Surveying*	*Measurement of Scale, Flight Planning,*	*Geostationary and Sunsynchronuous Orbits*
	SLO-2	*Axial Signal Correction-Eye and Object Correction*	*Plotting of Sounding - Mechanical method ,*	*GPS Surveying Methods*	*Photo interpretation keys*	*Active and passive remote sensing*
S-7	SLO-1	*Tacheometric Surveying--Tangential Tacheometer*	*Setting out simple circular curve --Single Theodolite Method*	*Total Station Surveying- Measurements of distances &Height*	*Use of Stereoscope for 3-D Viewing*	*Tracing of Landuse and land cover from image*
	SLO-2	*Tacheometric Surveying--Tangential Tacheometer*	*Setting out simple circular curve --Single Theodolite Method*	*Total Station Surveying- Measurements of distances &Height*	*Use of Stereoscope for 3-D Viewing*	*Tracing of Landuse and land cover from image*
S-8	SLO-1	*Tacheometric Surveying--Subtense bar method*	*Contouring*	*Total Station Surveying - Measurements of Traversing,*	*Height determination from a Stereo pair using the Parallax bar*	*Tracing of Landuse and land cover from image*
	SLO-2	*Tacheometric Surveying--Subtense bar method*	*Contouring*	*Total Station Surveying - Measurements of Traversing,*	*Height determination from a Stereo pair using the Parallax bar*	*Tracing of Landuse and land cover from image*
S-9	SLO-1	*Satellite Station Reduction to Centre*	*Graphical Method ,Analytical Method Stream Gauge-Area velocity Method*	*Kinematic Surveying*	*Stereoscopy-Stereoscope and Stereo-photographs*	*Spectral –Radiometric &Temporal resolution Microwave remote sensing*
	SLO-2	*Signals –Luminous and Non-luminous Signals Towers*	*Velocity Measurement using Floats &Current meter Weir method, Chemical Method*	*Static Surveying*	*Photo interpretation keys, Applications of aerial Photos*	*Scanners - Radiometer - RADAR, Applications of Remote Sensing*

Learning Resources	*1. Kanetkar .T.P, "Surveying and Levelling" Vols. I and II, United Book Corporation, Pune, 1994.* *2. Surveying and leveling Part I"I, Late T P Kanetkar and Prof. S V Kulkarni, Poona VidyagrihaPrakashan,* *3. Punmia .B.C, "Surveying, Vols". I and II, Laxmi Publications,1999.*	*https://nptel.ac.in/noc/individual_course.php?id=noc18-ce37* *https://swayam.gov.in/nd1_noc19_ce39* *https://swayam.gov.in/nd1_noc19_ce34* *https://nptel.ac.in/noc/individual_course.php?id=noc18-ce35 (Part I and II)*

Learning Assessment

	Bloom's Level of Thinking	Continuous Learning Assessment (50% weightage)								Final Examination (50% weightage)	
		CLA – 1 (10%)		CLA – 2 (15%)		CLA – 3 (15%)		CLA – 4 (10%)#			
		Theory	Practice	Theory	Practice	Theory	Practice	Theory	Practice	Theory	Practice
Level 1	Remember Understand	*15%*	*15%*	*15%*	*15%*	*20%*	*20%*	*20%*	*20%*	*15%*	*15%*
Level 2	Apply Analyze	*20%*	*20%*	*20%*	*20%*	*20%*	*20%*	*20%*	*20%*	*20%*	*20%*
Level 3	Evaluate Create	*15%*	*15%*	*15%*	*15%*	*10%*	*10%*	*10%*	*10%*	*15%*	*15%*
	Total	100 %		100 %		100 %		100 %		100 %	

CLA – 4 can be from any combination of these: Assignments, Seminars, Tech Talks, Mini-Projects, Case-Studies, Self-Study, MOOCs, Certifications, Conf. Paper etc.,

Course Designers

Experts from Industry	Experts from Higher Technical Institutions	Internal Experts
1. Mr G Hariharanath, Chief Executive ,GA consultants,gac1996@hotmail.com	*Dr. E S M. Suresh, NITTR,esmsuresh@gmail.com*	*Dr. Sachikanta Nanda, SRMIST*
2. Er. AGV. Desigan, Design Group Engineering Consultancy Pvt Ltd. Chennai, desigan.agv@gmail.com	*Dr. Srinivasa Raju, IRS, Anna University, raju_irs@yahoo.com*	*Dr. R. Annadurai, SRMIST*

Course Code	18CEO304T	Course Name	EMERGING TRENDS IN STEEL DESIGN	Course Category	E	Open Elective Course	L	T	P	C
							2	1	0	3

Pre-requisite Courses	Nil	Co-requisite Courses	Nil	Progressive Courses	Nil
Course Offering Department	Civil Engineering	Data Book / Codes/Standards		IS : 800-2007, Steel Tables(Revised), IS : 875-Part 1,2 & 3	

Course Learning Rationale (CLR):	The purpose of learning this course is to:
CLR-1 :	*Identify the characteristics of steel connection types and different configurations*
CLR-2 :	*Identifying structural steel connections and appropriate design*
CLR-3 :	*Identify and solve beam-column design, plate and gantry girder*
CLR-4 :	*Solve the basic column base problems and to design the base plates*
CLR-5 :	*Analyze the basic concepts roof types and to design connections for different roof models*
CLR-6 :	*Identify pre-engineered building components, classification of towers and loading combinations*

		Learning			Program Learning Outcomes (PLO)														
		1	2	3	1	2	3	4	5	6	7	8	9	10	11	12	13	14	15
Course Learning Outcomes (CLO):	At the end of this course, learners will be able to:	Level of Thinking (Bloom)	Expected Proficiency (%)	Expected Attainment (%)	Engineering Knowledge	Problem Analysis	Design & Development	Analysis, Design, Research	Modern Tool Usage	Society & Culture	Environment & Sustainability	Ethics	Individual & Team Work	Communication	Project Mgt. & Finance	Life Long Learning	PSO - 1	PSO - 2	PSO – 3
CLO-1 :	*Accrue the knowledge of steel connections, beam-column joints and plates*	2	85	75	H	M	M	L	-	-	-	-	L	-	-	M	L	-	-
CLO-2 :	*Analyze and Design eccentric and moment resistant connections*	2	85	75	H	H	M	M	-	-	-	-	L	-	-	M	L	-	-
CLO-3 :	*Analyze and Design beam-columns, plate girder and gantry girder*	2	85	75	H	H	M	M	-	-	-	-	-	-	-	M	-	-	-
CLO-4 :	*Accrue the knowledge on Design of column bases and eccentrically loaded base plate*	2	85	75	H	H	M	M	-	-	-	-	L	-	-	M	L	-	-
CLO-5 :	*Analyze and design roof truss and connections of industrial structures*	2	85	75	H	H	M	M	-	-	-	-	-	-	-	M	-	-	-
CLO-6 :	*Accrue comprehensive knowledge in Understanding design principle of pre-engineered buildings and towers*	2	85	75	H	H	M	M	-	-	-	-	L	-	-	M	L	-	-

Duration (hour)		9	9	9	9	9
S-1	SLO-1	*Introduction to Steel Design*	*Introduction to Beam-Column*	*Introduction to column bases*	*Structural frames and functions of components*	*Components of pre-engineered buildings*
	SLO-2	*Brief notes on emerging trends in structural steel design*	*Beam-Column configuration*	*Introduction to footing*	*Types of roof trusses for different spans*	*Structural behavior of pre-engineered buildings*
S-2	SLO-1	*Connection types*	*Behaviour of short beam-columns*	*Types of footings*	*Estimation of dead loads, live loads, wind loads*	*Pre-engineered buildings – Design aspects*
	SLO-2	*Connection configuration*	*Behaviour of long beam-columns*	*Design of Slabs*	*Load combinations*	*Pre-engineered buildings – Design aspects*
S-3	SLO-1	*Simple connections*	*Numerical problems on beam-column*	*Design of Slabs – Numerical problems*	*Analysis of roof truss - Principles*	*Connection design - Concept*
	SLO-2	*Simple connection configuration*	*Numerical problems on beam-column*	*Design of Slabs – Numerical problems*	*Analysis of roof truss*	*Connection design*
S-4	SLO-1 SLO-2	*Tutorial 1: Connections*	*Tutorial 3: Beam-Column design*	*Tutorial 5: Column bases, footings and slabs*	*Tutorial 7: Roof truss and load*	*Tutorial 9: Pre-engineered buildings components and connections*
S-5	SLO-1	*Semi-rigid connections*	*Interaction Formula*	*Design of gusseted plate*	*Design of roof truss - Concept*	*Introduction to Plate grider*
	SLO-2	*Semi-rigid connection configurations*	*Principles of Beam-Column*	*Numerical problems on gusseted plate*	*Design of roof truss*	*Components of a plate girder*
S-6	SLO-1	*Rigid Connections*	*Design approach to beam-column*	*Numerical problems on gusseted plate*	*Numerical problems on roof truss design*	*Various sections adopted for plate girders*
	SLO-2	*Rigid connection configurations*	*Design consideration*	*Design of base plate and connections*	*Numerical problems on roof truss design*	*Variations in girder section*
S-7	SLO-1	*Numerical problems on Simple configuration*	*Boundary constraints and restraints*	*Design of base plate and connections – Numerical problems*	*Design of Purlins - Concept*	*Design concept of plate girder*

	SLO-2	*Numerical problems on Simple configuration*	*Introduction to gantry girder*	*Design of base plate and connections – Numerical problems*	*Design of purlins*	*Design of plate girder*
S-8	SLO-1	*Tutorial 2: Connection numerical problems and applications*	*Tutorial 4: Gantry girder*	*Tutorial 6:Plates and connections*	*Tutorial 8: Roof truss and Purlins*	*Tutorial 10: Plate girder*
	SLO-2					
S-9	SLO-1	*Numerical problems on Semi-rigid and rigid configuration*	*Gantry girder - Principles*	*Design applications of gusseted plates*	*Numerical problems on purlins*	*Plate girder - Principles*
	SLO-2	*Numerical problems on Semi-rigid and rigid configuration*	*Gantry girder – Design Concepts*	*Design applications of base plate*	*Numerical problems on purlins*	*Plate girder – Design Concepts*

Learning Resources	1. *Subramanian.N, "Design of Steel Structures-Limit State Method", Oxford University Press, New Delhi, 2016* 2. *Duggal .S.K, "Limit State Design of Steel Structures", Tata McGraw Hill Publishing Company, New Delhi, 2010.*	3. *Ramamrutham .S., "Design of Steel Structures", DhanpatRai Pub., 2013* 4. *Vazirani .V.N, "Design and Analysis of Steel Structures", Khanna Publishes, 2003* 5. *Ramachandra .S, VirendraGhelot, "Limit State Design of Steel of Structures", Scientific Publishers, New Delhi,2012.*

Learning Assessment

	Bloom's Level of Thinking	Continuous Learning Assessment (50% weightage)								Final Examination (50% weightage)	
		CLA – 1 (10%)		CLA – 2 (15%)		CLA – 3 (15%)		CLA – 4 (10%)			
		Theory	Practice	Theory	Practice	Theory	Practice	Theory	Practice	Theory	Practice
Level 1	Remember Understand	*20%*	-	*15%*	-	*15%*	-	*15%*	-	*15%*	-
Level 2	Apply Analyze	*20%*	-	*20%*	-	*20%*	-	*20%*	-	*20%*	-
Level 3	Evaluate Create	*10%*	-	*15%*	-	*15%*	-	*15%*	-	*15%*	-
	Total	100 %		100 %		100 %		100 %		100%	

CLA – 4 can be from any combination of these: Assignments, Seminars, Tech Talks, Mini-Projects, Case-Studies, Self-Study, MOOCs, Certifications, and Conf. Paper etc.

Course Designers		
Experts from Industry	Experts from Higher Technical Institutions	Internal Experts
1. Er. G.Hariharanath, GA Consultants, Chennai, gac1996@hotmail.com	*1. Dr. R. Santhakumar, Professor, Centre for Rulal Department, NITTTR*	*1. Dr. S. SenthilSelvan, SRMIST*
2. Er. AGV. Desigan, Design Group Engineering Consultancy Pvt Ltd. Chennai, desigan.agv@gmail.com	*2. Dr. P. Jayabalan, NIT, Trichy, pjeya@nitt.edu*	*2. Dr.K.S. Satyanarayanan, SRMIST*

Course Code	18CEO401T	Course Name	ADVANCED PRESTRESSED CONCRETE STRUCTURES	Course Category	O	Open Elective Course	L	T	P	C
							3	0	0	3

Pre-requisite Courses	Nil	Co-requisite Courses	Nil	Progressive Courses	Nil
Course Offering Department	Civil Engineering	Data Book / Codes/Standards	IS 1343: 2012		

Course Learning Rationale (CLR):	*The purpose of learning this course is to:*
CLR-1 :	*Know and utilize the concepts of prestress concrete to analyse prestress concrete sections*
CLR-2 :	*Understand about the importance of short and long term deflections and transfer of prestressing by bond*
CLR-3 :	*Understand about composite section under flexure and shear*
CLR-4 :	*Know about the process of design of pipes, piles and pavements*
CLR-5 :	*Understand to analyzefolded plates and shell*
CLR-6 :	*Make them familiar on continuous beam and concordant cable*

Course Learning Outcomes (CLO):	*At the end of this course, learners will be able to:*	Learning 1: Level of Thinking (Bloom)	2: Expected Proficiency (%)	3: Expected Attainment (%)	PLO 1: Engineering Knowledge	2: Problem Analysis	3: Design & Development	4: Analysis, Design, Research	5: Modern Tool Usage	6: Society & Culture	7: Environment & Sustainability	8: Ethics	9: Individual & Team Work	10: Communication	11: Project Mgt. & Finance	12: Life Long Learning	13: PSO - 1	14: PSO - 2	15: PSO - 3
CLO-1 :	*Analyze the prestress concrete sections using different concepts*	*3*	*80*	*75*	*H*	*H*	-	-	-	-	-	-	-	-	-	-	*H*	-	*H*
CLO-2 :	*Determine short and long term deflections and bond stress in prestressed concrete members*	*3*	*85*	*75*	*H*	*H*	-	-	-	-	-	-	-	-	-	-	*H*	-	*H*
CLO-3 :	*Determinethe flexural and shear strength of prestressed composite section*	*3*	*75*	*75*	*H*	*H*	-	*H*	-	-	-	-	-	-	-	-	*H*	-	*H*
CLO-4 :	*Design the cylinder and non-cylinder pipe, piles and pavements*	*3*	*90*	*80*	*H*	*H*	-	-	-	-	-	-	-	-	-	-	*H*	-	*H*
CLO-5 :	*Design folded plates and shell*	*3*	*85*	*75*	*H*	*H*	-	-	-	-	-	-	-	-	-	-	*H*	-	*H*
CLO-6 :	*Analyze primary, secondary and resultant moments on continuous beam and identify the concordant cable*	*3*	*80*	*75*	*H*	*H*	-	-	-	-	-	-	-	-	-	-	*H*	-	*H*

Duration (hour)		9	9	9	9	9
S-1	SLO-1	*PRESTRESSED CONCRETE Introduction - Basic concept – Principle of prestressing – Materials.*	*DEFLECTIONS Reasons to control deflections – Factors influencing deflections – short term deflection – uncracked section - Mohr's theorems*	*COMPOSITE CONSTRUCTION Introduction – composite action - advantages – types of composite construction.*	*DESIGN OF PIPES Design of non-cylinder pipes – losses of prestress.*	*FOLDED PLATES Introduction - types of folded plates –slab action – plate action – Names of methods for analysis.*
	SLO-2	*Forms of steel – systems of prestressing*		*Methods of construction – propped – unpropped construction.*		
S-2	SLO-1	*Types of prestressing – uses of prestressed concrete.*	*Deflection due to different cable profiles*	*Analysis of stresses*	*Example*	*Design example*
	SLO-2	*Materials – concrete strength limitation – requirements of steel for prestressed concrete.*	*Example*	*Example*		
S-3	SLO-1	*Analysis – basic assumptions.*	*Example*	*Examples*	*Example*	*Design example*
	SLO-2	*Concentric and eccentric tendons – resultant stresses – at transfer – at service. Concepts of prestressing – rectangle – symmetrical I-section only.*				
S-4	SLO-1	*Stress concept*	*Prediction of long term deflections - Example*	*Flexural strength of composite section.*	*Design of cylinder pipes Design of shear reinforcement*	*SHELL Introduction –advantages – methods of prestressing – design.*
	SLO-2			*Example*		
S-5	SLO-1	*Stress concept – examples*	*Examples*	*Example*	*Example*	*Design example*
	SLO-2					
S-6	SLO-1	*Stress concept - examples*	*Examples*	*Example*	*DESIGN OF PILES*	*Design example*
	SLO-2					

					Advantages – driving stresses – service load stresses - reinforcements.	
S-7	SLO-1 SLO-2	*Strength concept - examples*	*BOND* *Transmission of prestressing force - transmission length.*	*Shear strength of composite section.*	*Example*	*CONTINUOUS BEAMS* *Advantages – effects of prestressing - primary moment – secondary moment – resultant moment – pressure line.*
S-8	SLO-1 SLO-2	*Load balancing concept – cable profile – reaction – equivalent loads.*	*Example*	*Example*	*DESIGN OF PAVEMENTS* *General features – design of prestress in pavements.*	*Use of theorem of three moments - example*
S-9	SLO-1 SLO-2	*Load balancing concept – examples.*	*Bond stress – example.*	*Example*	*Example*	*Concordant cable profile – examples.*

Learning Resources	1. *Krishnaraju .R, "Prestressed Concrete", Tata McGraw-Hill Education, Edition: 2018, NewDelhi.* 2. *Pandit .G.S, Gupta .S.P, "Prestressed Concrete", CBS Publishers & Distributors, 2008* 3. *S. Ramamrutham, "Prestressed Concrete", DhanpatRai Publishing Company, Fifth Edition, Reprint 2016* 4. *Lin T.Y, Design of, "Prestressed Concrete Structures", Asia Publishing House, Bombay 1995.*	5. *IS: 1343-2012 "IS Code of Practice for Prestressed Concrete", BIS, New Delhi, 2012.* 6. *NPTEL Course: Prestressed Concrete Structures: https://nptel.ac.in/courses/105106117/*

Learning Assessment											
	Bloom's Level of Thinking	Continuous Learning Assessment (50% weightage)								Final Examination (50% weightage)	
		CLA – 1 (10%)		CLA – 2 (15%)		CLA – 3 (15%)		CLA – 4 (10%)#			
		Theory	Practice	Theory	Practice	Theory	Practice	Theory	Practice	Theory	Practice
Level 1	Remember Understand	40 %	-	30 %	-	30 %	-	30 %	-	30%	-
Level 2	Apply Analyze	40 %	-	40 %	-	40 %	-	40 %	-	40%	-
Level 3	Evaluate Create	20 %	-	30 %	-	30 %	-	30 %	-	30%	-
	Total	100 %		100 %		100 %		100 %		100 %	

CLA – 4 can be from any combination of these: Assignments, Seminars, Tech Talks, Mini-Projects, Case-Studies, Self-Study, MOOCs, Certifications, and Conf. Paper etc.

Course Designers		
Experts from Industry	Experts from Higher Technical Institutions	Internal Experts
1. Er. G.Hariharanath, GA Consultants, Chennai, gac1996@hotmail.com	*1. Dr. R. Santhakumar, Professor, Centre for Rulal Department, NITTTR*	*1. Dr. K. Gunasekaran, SRMIST*
2. Er. AGV. Desigan, Design Group Engineering Consultancy Pvt Ltd. Chennai, desigan.agv@gmail.com	*2. Dr. P. Jayabalan, NIT, Trichy, pjeya@nitt.edu*	*2. Dr. P. R. Kannan Rajkumar, SRMIST*

Course Code	18CEO402T	Course Name	BRIDGE ENGINEERING	Course Category	O	Open Elective Course	L	T	P	C
							3	0	0	3

Pre-requisite Courses	18CEC207T	Co-requisite Courses	Nil	Progressive Courses	Nil
Course Offering Department	Civil Engineering	Data Book / Codes/Standards	IS 456 : 2000, IRC 3-1983, IRC 112:2011, IRC 22: 2015, IRC:83-2018 (Part II)		

Course Learning Rationale (CLR):	*The purpose of learning this course is to:*
CLR-1 :	*Comprehend the principles of bridge engineering*
CLR-2 :	*Acquire knowledge on the various types of IRC (Indian Road Congress) loads*
CLR-3 :	*Understand and evaluate the internal forces due to moving loads*
CLR-4 :	*Get familiarized with the design principles of different types of RCC bridges*
CLR-5 :	*Understand the principles of design of bridge substructure*
CLR-6 :	*Determine the forces in elastomeric bearings.*

Course Learning Outcomes (CLO):	*At the end of this course, learners will be able to:*	Learning 1 Level of Thinking (Bloom)	Learning 2 Expected Proficiency (%)	Learning 3 Expected Attainment (%)	PLO 1 Engineering Knowledge	PLO 2 Problem Analysis	PLO 3 Design & Development	PLO 4 Analysis, Design, Research	PLO 5 Modern Tool Usage	PLO 6 Society & Culture	PLO 7 Environment & Sustainability	PLO 8 Ethics	PLO 9 Individual & Team Work	PLO 10 Communication	PLO 11 Project Mgt. & Finance	PLO 12 Life Long Learning	PLO 13 PSO - 1	PLO 14 PSO - 2	PLO 15 PSO - 3
CLO-1 :	*Choose the most appropriate type of bridge for the given conditions*	3	75	60	H	H	-	H	-	-	L	-	-	-	-	L	H	-	-
CLO-2 :	*Calculate the functional dimensions of a bridge across a waterway*	3	75	60	H	H	-	H	-	-	-	-	-	-	-	L	H	-	-
CLO-3 :	*Design slab type and girder type RCC bridges*	3	90	85	H	H	L	H	-	-	-	-	-	-	-	L	H	-	-
CLO-4 :	*Calculate the design forces on substructure*	3	85	80	H	H	L	H	-	-	-	-	-	-	-	L	H	-	-
CLO-5 :	*Design abutments and bridge foundations*	3	75	70	H	H	L	H	-	-	-	-	-	-	-	L	H	-	-
CLO-6 :	*Design Elastomeric bearings*	3	75	60	H	H	L	H	-	-	-	-	-	-	-	L	H	-	-

Duration (hour)		9	9	9	9	9
S-1	SLO-1	*FUNDAMENTALS OF BRIDGE ENGINEERING & IRC LOADS* *Hydraulic factors influencing bridge design*	*DESIGN OF RCC SLAB BRIDGES* *Span limitations*	*DESIGN OF RCC T BEAM BRIDGES* *Span limitations*	*DESIGN OF BRIDGE SUBSTRUCTURE* *Abutment – types*	*DESIGN OF BEARINGS* *Definition of bearings*
	SLO-2	*Calculation of linear waterway*	*Analysis of simply supported slab due to concentrated loads – introduction*	*Configuration – spacing of T beams , end overhang*	*Forces affecting the stability of abutments*	*Forces on bearing*
S-2	SLO-1	*Effect of bridge on river regime*	*Effective width method for slab supported on opposite edges only*	*Introduction to Pigeauds method - deck slab supported on T beams*	*Problem solving to determine the stability of abutments*	*Types of bearings*
	SLO-2	*Economic span of bridge*	*Span-wise dispersion*	*Dispersed dimensions of wheel over the slab*	*Piers – types of piers*	*Basis for selection of bearings*
S-3	SLO-1	*Calculation of scour depth*	*Width-wise dispersion*	*Computation of bending moment using the curves for centrally placed wheel load*	*Loads on piers*	*Types of elastomeric bearings*
	SLO-2	*Design loads – IRC Class AA Class A*	*Analysis for bending*	*Design principles for longitudinal T beam girder – Courbon's theory*	*Analysis of piers*	*Behavior of elastomeric bearings under loads*
S-4	SLO-1	*Design loads – IRC Class A and B*	*Analysis for shear*	*Understanding the various terms in the formula and its application*	*Problem solving – preliminary dimensions*	*Dimensions of elastomeric bearings as per IRC: 82*
	SLO-2	*Impact effect*	*Design of slab bridge – computation of dead loads*	*Design of T beam bridge – preliminary dimensions – Class AA trackedload*	*Determination final stresses in the piers*	*Vertical stiffness – shape factor*
S-5	SLO-1	*Longitudinal forces*	*Positioning of IRC Class AA loads – tracked*	*Design of cantilever span*	*Bridge foundations – types*	*Thickness of bearing*
	SLO-2	*Centrifugal forces*	*Analysis for maximum bending moment & Shear force*	*Determination of maximum bending moment in the interior span of the deck slab – Pigeaud's method*	*Well foundations – types*	*Stresses on elastomeric bearings*
S-6	SLO-1	*Types of bridges – suitability of different types of bridges for various spans - slab bridges*	*Positioning of IRC Class AA loads – wheeled*	*Design of deck slab using limit state method*	*Components of well foundations*	*Slip in bearing*

	SLO-2	*Girder bridges*	*Analysis for maximum bending moment & Shear force*	*Analysis of longitudinal girder – dead loads bending and shear*	*Design of well foundations – working stress method*	*Shear deformation in bearing*
S-7	SLO-1	*Continuous bridges – precautions from settlement considerations*	*Positioning of IRC Class A loads*	*Moving loads – bending*	*Pile foundations – pile groups*	*Stability of bearing*
	SLO-2	*Balanced double cantilever bridges*	*Analysis for maximum bending moment & Shear force*	*Moving loads – shear*	*Design principles of pile foundation*	*Uplift at the bearing*
S-8	SLO-1	*Arch bridges*	*Design using Limit state method - for bending moment*	*Computing the design bending and shear forces*	*Design forces*	*Influence of steel plates in the bearing*
	SLO-2	*Fundamentals of analysis using moving loads*	*Design for shear*	*Design of girder using limit state method – bending*	*Design using working stress method*	*Design of bearing – input loads*
S-9	SLO-1	*Determination of absolute maximum reaction*	*Detailing of reinforcement*	*Design for shear*	*Structural detailing*	*Design of bearing for stresses*
	SLO-2	*Determination of absolute maximum shear and bending moment due to moving loads*	*Sketching the cross section to show structural details*	*Detailing with sketches*	*Sketching the cross section to show structural details*	*Check for deformation*

Learning Resources	1. *Johnson Victor .D, "Essentials Of Bridge Engineering", Oxford University Press, Sixth edition, 2018* 2. *Jagadeesh.T.R, Jayaram .M.A, "Design Of Bridge Structures", Prentice – Hall of India Pvt. Ltd., 2009.* 3. *Krishna Raju .N, "Design of Bridges", Oxford & IBH Publishing Company Pvt. Ltd., Fifth edition, 2018* 4. *IRC:3-1983, Dimensions & Weights of Road Design Vehicles (First Revision), IRC, 1983.* 5. *IRC:5-2015, Standard Specifications and Code of Practice for Road Bridges, Section I – General Features of Design (Eighth Revision), IRC, 2015.* 6. *IRC:6-2017, Standard Specifications and Code of Practice for Road Bridges, Section-II Loads and Load Combinations (Seventh Revision), IRC, 2017*	7. *IRC:22-2015, Standard Specifications and Code of Practice for Road Bridges, section VI – Composite Construction (Limit States Design) (Third Revision), IRC, 2015.* 8. *IRC:45-1972, Recommendations for Estimating the Resistance of Soil Below the Maximum Scour Level in the Design of Well Foundations of Bridges, IRC, 1972.* 9. *IRC:78-2014, Standard Specifications and Code of Practice for Road Bridges, Section VII-Foundations and Substructures (Revised Edition), IRC, 1974.* 10. *IRC:83-2018, (Part II), Standard Specifications and Code of Practice for Road Bridges, Section IX – Bearings (Elastomeric Bearings), Part II (Second Revision), IRC, 2018.* 11. *IRC:112-2011, Code of Practice for Concrete Road Bridges, IRC, 2011.*

Learning Assessment

	Bloom's Level of Thinking	Continuous Learning Assessment (50% weightage)								Final Examination (50% weightage)	
		CLA – 1 (10%)		CLA – 2 (15%)		CLA – 3 (15%)		CLA – 4 (10%)#			
		Theory	Practice	Theory	Practice	Theory	Practice	Theory	Practice	Theory	Practice
Level 1	Remember Understand	*40 %*	-	*40 %*	-	*40 %*	-	*10 %*	-	*40%*	-
Level 2	Apply Analyze	*40 %*	-	*40 %*	-	*40 %*	-	*85 %*	-	*55%*	-
Level 3	Evaluate Create	*20 %*	-	*20 %*	-	*20 %*	-	*5 %*	-	*5%*	-
	Total	100 %		100 %		100 %		100 %		100 %	

CLA – 4 can be from any combination of these: Assignments, Seminars, Tech Talks, Mini-Projects, Case-Studies, Self-Study, MOOCs, Certifications, Conf. Paper etc.,

Course Designers

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2. Er. (Mrs.) Mekala Ponmalar Gurubaran, National Highways, Tamilnadu, gmekalaponmalar@yahoo.com	*2. Dr. P. Jayabalan, NIT, Trichy, pjeya@nitt.edu*	*2. Dr. K. S.Satyanarayanan, SRMIST*

Course Code	18CEO404J	Course Name	FUNDAMENTALS OF COMPUTING	Course Category	O	Open Elective Course	L	T	P	C
							2	0	2	3

Pre-requisite Courses	Nil	Co-requisite Courses	Nil	Progressive Courses	Nil
Course Offering Department	Civil Engineering	Data Book / Codes/Standards	Nil		

Course Learning Rationale (CLR):	*The purpose of learning this course is to:*	Learning			Program Learning Outcomes (PLO)														
		1	2	3	1	2	3	4	5	6	7	8	9	10	11	12	13	14	15
CLR-1 :	*Learning of basics of computer programming using C, Java, Python*																		
CLR-2 :	*Description of basic syntax of C, Java, Python programming*																		
CLR-3 :	*Description of Data types, variables and key words*																		
CLR-4 :	*Illustrate the use of reserved words, operators*																		
CLR-5 :	*Understand the need of using statements, Loops in programming*																		
CLR-6 :	*Knowing about numbers, decisions*																		
Course Learning Outcomes (CLO):	*At the end of this course, learners will be able to:*	Level of Thinking (Bloom)	Expected Proficiency (%)	Expected Attainment (%)	Engineering Knowledge	Problem Analysis	Design & Development	Analysis, Design, Research	Modern Tool Usage	Society & Culture	Environment & Sustainability	Ethics	Individual & Team Work	Communication	Project Mgt. & Finance	Life Long Learning	PSO - 1	PSO - 2	PSO – 3
CLO-1 :	*Understanding of C, Java, Python languages*	*2*	*85*	*80*	*H*	*H*	-	-	-	-	-	-	-	-	-	-	*H*	-	-
CLO-2 :	*Writing simple programs by using C, Java, Python programming languages*	*3*	*85*	*75*	*H*	*H*	-	-	-	-	-	-	-	-	-	-	*H*	-	-
CLO-3 :	*Programming by using data types, variables and key words*	*3*	*85*	*75*	*H*	*H*	-	-	-	-	-	-	-	-	-	-	*H*	-	-
CLO-4 :	*Express proficiency in using of reserved words and operators*	*2*	*85*	*80*	*H*	*H*	-	-	-	-	-	-	-	-	-	-	*H*	-	-
CLO-5 :	*Identify the operations is using statements, loops in programming*	*2*	*80*	*75*	*H*	*H*	-	-	-	-	-	-	-	-	-	-	*H*	-	-
CLO-6 :	*Expertise in making decisions and in using numbers for operation*	*3*	*85*	*75*	*H*	*H*	-	-	-	-	-	-	-	-	-	-	*H*	-	-

Duration (hour)		9	9	9	9	9
S-1	SLO-1	*Overview*	*Data types*	*C programming reserved words*	*If..else statement*	*Loops in Python* *Loops in C?*
	SLO-2	*Introduction to computer program*	*C and Java Data types*	*Java programming reserved words*	*If… else…if statement (if..elseif..else)*	*Numbers*
S-2	SLO-1	*Introduction to computer programming*	*Python Data types*	*Python programming reserved words*	*The switch statement*	*Math operation on Numbers*
	SLO-2	*Uses of computer programs (Advantages of Computer Programs)*	*Variables*	*Operators*	*Decisions in Java, Python (Decisions in C, Java, Python)*	*Numbers in Java, Python*
S-3	SLO-1	*Lab Session 1: Understanding of Computer Hardware and programming environment of C, Java and python Languages.*	*Lab Session 3: Initialization of data types in C, Java and Python .*	*Lab Session 5: Demonstrate the use of reserve words in C, Java, and Python*	*Lab Session 7: Develop a program using Decision statement.*	*Lab Session 9: Develop a program to solve computational problems using Math Operators.*
	SLO-2					
S-4	SLO-1					
	SLO-2					
S-5	SLO-1	*Algorithm*	*Creating variables*	*Arithmetic operators*	*Loops*	*Characters*
	SLO-2	*Basics of Programming*	*Store values in variables*	*Relational operators*	*The while loop*	*Escape sequences*
S-6	SLO-1	*Text editor, Compiler*	*Access stored values in variables*	*Logical operators*	*The do..while loop*	*Characters in Java* *Characters in C?*
	SLO-2	*Interpreter, Online Compilation*	*Variables in Java (Variables in C, Java Family and Python)*	*Operators in Java (Operators in C, Java)*	*The break statement*	*Characters in Java*
S-7	SLO-1	*Lab Session 2: Understanding the concept of Algorithm, Flowchart, Naming the program files, Storing, Compilation, Execution and Debugging.*	*Lab Session 4: Initialization of variables in C, Java and Python .*	*Lab Session 6: Understand and Develop a program to solve simple computational problems using arithmetic operators, relational and logical operators.*	*Lab Session 8: Develop a program using loop statement.*	*Lab Session 10: Understanding of Escape and Character sequences*
	SLO-2					
S-8	SLO-1					
	SLO-2					
S-9	SLO-1	*Basic Syntax of C and Java programming*	*Variabes in Python*	*Operators in Pyhon*	*The continue statement*	*Characters in Python*
	SLO-2	*Simple programs in C*	*Key words*	*Decision statements*	*Loops in Java*	*Characters in Python*

Learning Resources	1. *Programming in C by E. Balagurusamy, Mcgraw hill publications (India), New Delhi* 2. *Programming in Java by E. Balagurusamy , McGrawHill Publications(India), New Delhi* 3. *Programming in Python by E. Balagurusamy , McGrawHill Publications (India), New Delhi*	4. *Wesley J Chun, "Core Python Applications Programming", 3rd Edition, Pearson Education India, 2015. ISBN-13: 978-9332555365* 5. *https://nptel.ac.in/noc/individual_course.php?id=noc18-cs33* 6. *https://nptel.ac.in/courses/106105191/* 7. *https://nptel.ac.in/courses/117106113/34*

Learning Assessment											
	Bloom's Level of Thinking	Continuous Learning Assessment (50% weightage)								Final Examination (50% weightage)	
		CLA – 1 (10%)		CLA – 2 (15%)		CLA – 3 (15%)		CLA – 4 (10%)#			
		Theory	Practice	Theory	Practice	Theory	Practice	Theory	Practice	Theory	Practice
Level 1	Remember Understand	*20 %*	*20 %*	*15 %*	*15 %*	*15 %*	*15 %*	*15 %*	*15 %*	*15 %*	*15 %*
Level 2	Apply Analyze	*20 %*	*20 %*	*20 %*	*20 %*	*20 %*	*20 %*	*20 %*	*20 %*	*20 %*	*20 %*
Level 3	Evaluate Create	*10 %*	*10 %*	*15 %*	*15 %*	*15 %*	*15 %*	*15 %*	*15 %*	*15 %*	*15 %*
	Total	100 %		100 %		100 %		100 %		100 %	

CLA – 4 can be from any combination of these: Assignments, Seminars, Tech Talks, Mini-Projects, Case-Studies, Self-Study, MOOCs, Certifications, Conf. Paper etc.,

Course Designers		
Experts from Industry	Experts from Higher Technical Institutions	Internal Experts
1. Er. S. Dhanabal, General Manager, NLY, Neyveli, dhans1960@yahoo.co.in	*1. Dr. R. Santhakumar, Professor, Centre for Rulal Department, NITTTR*	*Mr. Shaik Niyazuddin Guntakal, SRMIST*
2. Er. AGV. Desigan, Design Group Engineering Consultancy Pvt Ltd. Chennai, desigan.agv@gmail.com	*2. Dr. P. Jayabalan, NIT, Trichy, pjeya@nitt.edu*	*Mr. C. Arun, SRMIST*

Course Code	18CSO101T	Course Name	IT INFRASTRUCTURE MANAGEMENT	Course Category	O	Open Elective	L	T	P	C
							3	0	0	3

Pre-requisite Courses	Nil	Co-requisite Courses	Nil	Progressive Courses	Nil
Course Offering Department	Computer Science& Engg.	Data Book / Codes/Standards	Nil		

Course Learning Rationale (CLR):	The purpose of learning this course is to:
CLR-1 :	*Understand the design factors and challenges in IT Infrastructure Management*
CLR-2 :	*Understand service delivery and associated processes*
CLR-3 :	*Understand storage and security management related to IT Infrastructure*
CLR-4 :	*Understand performance and tuning processes and associated case studies*
CLR-5 :	*Understand the suitable for combinations in information technology, business administration and electronic*

Course Learning Outcomes (CLO):	At the end of this course, learners will be able to:	Learning 1 Level of Thinking (Bloom)	2 Expected Proficiency (%)	3 Expected Attainment (%)	Program Learning Outcomes (PLO) 1 Engineering Knowledge	2 Problem Analysis	3 Design & Development	4 Analysis, Design, Research	5 Modern Tool Usage	6 Society & Culture	7 Environment & Sustainability	8 Ethics	9 Individual & Team Work	10 Communication	11 Project Mgt. & Finance	12 Life Long Learning	13 PSO - 1	14 PSO - 2	15 PSO – 3
CLO-1 :	*Be able to describe the business value and processes of ICT services in an organization and apply that knowledge and skill with initiative to a workplace scenario*	2	80	85	L	-	L	H	L	-	-	-	H	H	M	L	-	-	-
CLO-2 :	*Be able to investigate, critically analyze and evaluate the impact of new and current ICT services to an organization*	2	75	80	M	-	-	H	H	-	-	-	L	L	L	H	-	-	-
CLO-3 :	*Be able to describe how effective IT Infrastructure Management requires strategic planning with alignment from both the IT and business perspectives in an organization*	2	85	80	M	L	M	H	L	-	-	-	M	H	H	H	-	-	-
CLO-4 :	*Be able to demonstrate the technical and communications skills that contribute to the operation of ICT services in an organization*	2	80	75	M	L	L	L	-	-	-	-	H	H	M	L	-	-	-
CLO-5 :	*Be able to reflect critically on the role of an enterprise architect in an organization*	2	75	85	L	-	L	L	-	-	-	-	L	L	H	L	-	-	-
CLO-6 :	*Be able to synthesize the theoretical, technical and management issues that deliver ICT services to an organization*	2	80	85	H	-	L	L	L	-	-	-	L	L	H	L	-	-	-

Duration (hour)		9	9	9	9	9
S-1	SLO-1	*Introduction – IT Infrastructure*	*Service Delivery And Support Process - Intro*	*Storage And Security Management - Intro*	*Performance And Tuning Process*	*Case Studies*
	SLO-2	*Challenges in IT Infrastructure Management*		*Backup and Storage, Archive & Retrieve*		
S-2	SLO-1	*Design Factors for IT Organizations*	*Service Level Management*	*Space Management*	*Introduction on tuning process*	*Asset Network Corporation case*
	SLO-2	*Design Factors for IT Infrastructures*				
S-3	SLO-1	*Determining customer's Requirements,*	*Financial Management*	*Hierarchical space management*	*Difference between Performance and Tuning processes and other Infrastructure processes*	*Radio Shack case*
	SLO-2	*Identifying System Components to manage*				
S-4	SLO-1	*Identifying System Components to*	*IT Service Continuity Management*	*Database & Application protection*	*Definitions*	*Business Process Outsourcing (BPO)*
	SLO-2	*manage*				*Infrastructure Planning and Management*
S-5	SLO-1	*Exist Processes, Data, applications,*	*Capacity Management*	*Disaster Recovery*	*Preferred characteristics*	*e-Commerce Business*
	SLO-2			*Bare Machine Recovery (BMR)*		*Infrastructure Planning and Management*
S-6	SLO-1	*Tools and their integration*	*Configuration Management*	*Data Retention*	*Performance and tuning applied to major resource environments*	*Enron case*
	SLO-2					
S-7	SLO-1	*IT Systems and Service*	*Service desk, Incident management*	*Computer Security*	*Assessing an Infrastructure's*	*Tycocase*
	SLO-2	*Management Process*		*Identity Management*	*performance and tuning process*	

S-8	SLO-1	Information systems Design Process	Availability management,	Access control system	Measuring and streamlining the P and T process	Worldcom case
	SLO-2					
S-9	SLO-1	IT Infrastructure Library	Release Management	Intrusion Detection	Performance tuning recommendations for data and event management	Analyze an information infrastructure – case study
	SLO-2					

Learning Resources	1. *Rich Schiesser, " IT Systems Management", 2nd edition, 2010, Pearson Education, ISBN: 978-0137025060* 2. *P.Gupta,"ITInfrastructureandItsManagement"2ndReprint,2010,TataMcGrawHill,ISBN: 978-0070699793* 3. *SjaakLaan,"ITInfrastructureArchitecture:InfrastructureBuildingBlocksandConcepts",2011, Lulu Press Inc, ISBN978-1-4478-8128-5.*	4. *LeonardJessup,JosephValacich,"InformationSystemToday:ManagingDigitalWorld",3rdEdition, 2007, Prentice Hall, ISBN:0-13-233506-9.* 5. *Hausman,Cook,"ITArchitectureforDummies",2011,WileyPublishing,Hoboken,NJ www.wiley.com ISBN:978-0-470-55423-4* 6. *RichardJ.Reese,"ITArchitectureinAction",2008,XlibrisPublishing,ISBN:978-1-4363-0505-1*

Learning Assessment											
	Bloom's Level of Thinking	Continuous Learning Assessment (50%								Final Examination (50% weightage)	
		CLA – 1 (10%)		CLA – 2 (15%)		CLA – 3 (15%)		CLA – 4 (10%)#			
		Theory	Practice	Theory	Practice	Theory	Practice	Theory	Practice	Theory	Practice
Level 1	Remember Understand	*40 %*	-	*30 %*	-	*30 %*	-	*30 %*	-	*30%*	-
Level 2	Apply Analyze	*40 %*	-	*40 %*	-	*40 %*	-	*40 %*	-	*40%*	-
Level 3	Evaluate Create	*20 %*	-	*30 %*	-	*30 %*	-	*30 %*	-	*30%*	-
	Total	100 %		100 %		100 %		100 %		100 %	

CLA – 4 can be from any combination of these: Assignments, Seminars, Tech Talks, Mini-Projects, Case-Studies, Self-Study, MOOCs, Certifications, Conf. Paper etc.,

Course Designers		
Experts from Industry	Experts from Higher Technical Institutions	Internal Experts
1. Mr. Mohamed Yaseen MS, Technical Business Analyst, CBA - Sydney, Australia, yasucseau@gmail.com	*1. Dr.J.Baskar Babujee, Associate Professor, Madras Institute of Technology,Chennai. baskarjee@annauniv.edu*	*1. Dr. C.N.S.Vinoth Kumar, SRMIST*
2. Mr.P.AnandaNatarajan,Senior Associate Consultant, Infosys, Chennai., anand_adnan@yahoo.com		*2. Dr. MB.Mukesh Krishnan, SRMIST*

Course Code	18CSO102T	Course Name	MOBILE APPLICATION DEVELOPMENT	Course Category	O	Open Elective	L	T	P	C
							3	0	0	3

Pre-requisite Courses	Nil	Co-requisite Courses	Nil	Progressive Courses	Nil
Course Offering Department	Computer Science &Engg	Data Book / Codes/Standards	Nil		

Course Learning Rationale (CLR):	*The purpose of learning this course is to:*
CLR-1 :	*Understand the basics of Android devices andPlatform.*
CLR-2 :	*Acquire knowledge on basic building blocks ofAndroid programming required for Appdevelopment.*
CLR-3 :	*Understand persistence Data storage mechanismin Android*
CLR-4 :	*Understand advanced application concepts likenetworking, Animations and Google Maps services etc.*
CLR-5 :	*Develop and publish Android applications in toAndroid Market*

Course Learning Outcomes (CLO):	*At the end of this course, learners will be able to:*	Learning 1: Level of Thinking (Bloom)	Learning 2: Expected Proficiency (%)	Learning 3: Expected Attainment (%)	PLO 1: Engineering Knowledge	2: Problem Analysis	3: Design & Development	4: Analysis, Design, Research	5: Modern Tool Usage	6: Society & Culture	7: Environment & Sustainability	8: Ethics	9: Individual & Team Work	10: Communication	11: Project Mgt. & Finance	12: Life Long Learning	13: PSO - 1	14: PSO - 2	15: PSO – 3
CLO-1 :	*Acquire the knowledge on Android devices and Platform*	2	80	85	L	-	-	-	H	-	-	-	-	-	-	-	-	-	-
CLO-2 :	*Acquire knowledge on basic building blocks ofAndroid programming required for Appdevelopment.*	2	75	80	L	-	H	-	-	-	-	-	-	-	-	-	-	-	-
CLO-3 :	*Apply the knowledge of persistence Data storage mechanismin Android*	2	85	80	-	-	H	-	-	-	-	-	-	-	-	-	-	-	-
CLO-4 :	*Apply the knowledge in advanced application concepts likenetworking, Animations and Google Maps services etc.*	2	80	75	L	-	H	-	H	-	-	-	-	-	-	-	-	-	-
CLO-5 :	*Design and apply the knowledge to publish Android applications in toAndroid Market*	2	75	85	H	-	-	H	-	-	-	-	-	-	-	-	-	-	-

Duration (hour)		9	9	7	10	10
S-1	SLO-1	*Introduction: Introduction to mobile application development, trends.*	*GUI for Android: Introduction to activities life-cycle*	*Introduction to Different Data persistence schemes*	*Services :introduction to services– localservice,*	*Introduction to Location based services*
	SLO-2					
S-2	SLO-1	*introduction to various platforms,*	*Android v7 supportlibrary form API21 for lower versionsupport*	*Shared preferences*	*remote service and binding theservice,.*	*Google maps V2 services using Google API.*
	SLO-2					
S-3	SLO-1	*introduction to smart phones*	*Intent :intent object*	*File Handling se*	*the communication between serviceand activity, Intent Service*	*Animations and Graphics: Property Animation .*
	SLO-2					
S-4	SLO-1	*Android platform: Android platform,features and architecture,*	*intent filters ,addingcategories*	*Managing data using SQLite databa*	*MultiThreading: Handlers*	*View Animations, DrawableAnimations*
	SLO-2					
S-5	SLO-1	*versions ,comparison added features in each versions.*	*linking activities, user interfacedesign components*	*Content providers:*	*,AsyncTask*	*Media and Camera API: Working withvideo and audio inputs*
	SLO-2					
S-6	SLO-1	*ART(Android Runtime),ADB(AndroidDebug Bridge).*	*Views and View Groups: Basic views,picker views, adapter views, Menu, App Baretc, basics of screen design; differentlayouts.*	*user content provider*	*android network programming:HttpUrlConnection*	*Camera API*
	SLO-2					
S-7	SLO-1	*Development environment/IDE: Android studio and its working environment*	*App widgets.Lollipop Materialdesign: new themes, new widgets,Cardlayouts. RecyclerView*	*Android in build content providers*	*Connecting to REST-based and SOAP based Web services*	*Sensor programming: Motion sensors*
	SLO-2					
S-8	SLO-1	*gradle build system, emulator setup*	*Fragments: Introduction to activities,*		*Broad castreceivers:LocalBroadcastManager,Dynamic broadcast receiver*	*Position sensors, Environmental sensors.*
	SLO-2					
S-9	SLO-1	*Application anatomy: Applicationframework basics: resources layout, values,asset XML representation*	*activities life-cycle.*		*System Broadcast. PendingIntent, Notifications*	*Publishing Android Apps: Guide lines.*
	SLO-2					

		and generatedR.Javafile ,Android manifest file. Creating asimple application.				
S-10					*Telephony Manager:Sending SMS andmaking calls.*	*policies and process of uploading Apps toGoogle play*

Learning Resources	1. *Dawn Griffiths, David Griffiths,"Head First: Android Development" ,OReilly2015,ISBN:9781449362188.* 2. *Greg Milette,Adam Stroud,"PROFESSIONALAndroid™ Sensor Programming", John Wiley and Sons, Inc2012,ISBN/978111265055,9781280678943,978111227459*	3. *PaulDeital, Harvey Deital, AlexanderWald, "Android6 for Programmers, App Drivenapproach",2015, Prentice Hall ,ISBN:9780134289366.* 4. *http://developer.android.com/training/index.htmlas on Date21.4.2016*

Learning Assessment

	Bloom's Level of Thinking	Continuous Learning Assessment (50% weightage)								Final Examination (50% weightage)	
		CLA – 1 (10%)		CLA – 2 (15%)		CLA – 3 (15%)		CLA – 4 (10%)#			
		Theory	Practice	Theory	Practice	Theory	Practice	Theory	Practice	Theory	Practice
Level 1	Remember Understand	*40 %*	-	*30 %*	-	*30 %*	-	*30 %*	-	*30%*	-
Level 2	Apply Analyze	*40 %*	-	*40 %*	-	*40 %*	-	*40 %*	-	*40%*	-
Level 3	Evaluate Create	*20 %*	-	*30 %*	-	*30 %*	-	*30 %*	-	*30%*	-
	Total	100 %		100 %		100 %		100 %		100 %	

CLA – 4 can be from any combination of these: Assignments, Seminars, Tech Talks, Mini-Projects, Case-Studies, Self-Study, MOOCs, Certifications, Conf. Paper etc.,

Course Designers		
Experts from Industry	Experts from Higher Technical Institutions	Internal Experts
	1. Dr. KHANNA NEHEMIAH , Professor, Ramanujan Computing, Anna University	*1. Dr.M.UMA*
		2. Dr.Ganesh Kumar, SRMIST
		3.Mr.K.Naveen

Course Code	18CSO103T	Course Name	SYSTEM MODELING AND SIMULATION	Course Category	O	Open Elective	L	T	P	C
							3	0	0	3

Pre-requisite Courses	Nil	Co-requisite Courses	Nil	Progressive Courses	Nil
Course Offering Department	Computer Science and Engineering	Data Book / Codes/Standards	Nil		

Course Learning Rationale (CLR):	*The purpose of learning this course is to:*
CLR-1 :	*Select a suitable modeling method according to problem area and assignment, and justify their choice.*
CLR-2 :	*Formulate models of a system to describe the system on different levels of abstraction and from different viewpoints.*
CLR-3 :	*Learn and apply the continuous system simulation*
CLR-4 :	*Learn theory and probability concepts in simulation*
CLR-5 :	*Learn the simulation languages and tools*

Course Learning Outcomes (CLO):	*At the end of this course, learners will be able to:*	Learning 1	2	3	Program Learning Outcomes (PLO) 1	2	3	4	5	6	7	8	9	10	11	12	13	14	15
		Level of Thinking (Bloom)	Expected Proficiency (%)	Expected Attainment (%)	Engineering Knowledge	Problem Analysis	Design & Development	Analysis, Design, Research	Modern Tool Usage	Society & Culture	Environment & Sustainability	Ethics	Individual & Team Work	Communication	Project Mgt. & Finance	Life Long Learning	PSO - 1	PSO - 2	PSO – 3
CLO-1 :	*Implement the appropriate modeling method for the given problem*	*2*	*80*	*85*	*H*	-	-	-	-	-	-	-	-	-	-	-	-	-	-
CLO-2 :	*Explain the system abstraction in different levels*	*2*	*75*	*80*	*H*	*H*	-	-	-	-	-	-	-	-	-	-	-	-	-
CLO-3 :	*Apply the models under continuous system simulation*	*2*	*85*	*80*	*H*	-	-	-	-	-	-	-	-	-	-	-	-	-	-
CLO-4 :	*Analyze the probability concepts for simulating a system*	*2*	*80*	*75*	*H*	*H*	-	-	-	-	-	-	-	-	-	-	-	-	-
CLO-5 :	*Apply tools to like GPSS and SIMSCRIPT to check model properties of a system*	*2*	*75*	*85*	*H*	-	-	*H*	-	-	-	-	-	-	-	-	-	-	-

Duration (hour)		9	9	9	9	9
S-1	SLO-1	*Introduction to system modelling*	*Continuous System Simulation - Introduction*	*Probability Theory*	*Queueing Theory - Introduction*	*General description of GPSS and SIMSCRIPT*
S-2	SLO-1	*Modeling principles and concepts*	*Numerical solution of differential equations*	*Probability CONCEPTS IN SIMULATION -*	*Arrival Pattern distributions*	*programming in GPSS*
S-3	SLO-1	*Continuous systems and Discrete systems*	*Analog computers*	*Monte Carlo techniques*	*servicing times, queuing disciplines*	*Application of GPSS on specific problem*
S-4	SLO-1	*Modeling, types of models,subsystems*	*Hybrid computers*	*Application of Monte Carlo techniques*	*measure of queues*	*Simulation Programming Techniques*
S-5	SLO-1	*corporate model, system study..*	*continuous system simulation languages CSMP*	*Stochastic variables*	*mathematical solutions to queuing problems*	*Data Structures*
S-6	SLO-1	*System Simulation: Techniques,*	*system dynamic growth models,*	*probability functions*	*Discrete system simulation: Events*	*Implementation of activities*
S-7	SLO-1	*comparison of simulation and analytical methods*	*logistic curves*	*Random Number Generation algorithms*	*Generation of arrival pattern*	*Events and queues, event scanning*
S-8	SLO-1	*types of simulation, distributed log models*	*Illustration of Continuous System Simulation*	*Illustration of Probability concepts*	*Simulation programming tasks*	*Simulation algorithms in GPSS and SIMSCRIPT*
S-9	SLO-1	*cobweb models*	*Case Study*	*Case Study*	*Analysis of simulation output*	*Case Study*

Learning Resources	
	1. Geoffery Gordon, " System Simulation" , PHI, 2nd edition *2. Jerry Banks , John S.Carson ,Barry Nelson, David M.Nicol, "Discrete – Event System Simulation", PHI, 3rd edition* *3. Karian. Z.A., Dvdewicz .E.Z, "Modern Statistical Systems and GPSS Simulation",Freeman, 1991*

Learning Assessment											
	Bloom's Level of Thinking	Continuous Learning Assessment (50% weightage)								Final Examination (50% weightage)	
		CLA – 1 (10%)		CLA – 2 (15%)		CLA – 3 (15%)		CLA – 4 (10%)#			
		Theory	Practice	Theory	Practice	Theory	Practice	Theory	Practice	Theory	Practice
Level 1	Remember Understand	*40 %*	-	*30 %*	-	*30 %*	-	*30 %*	-	*30%*	-
Level 2	Apply Analyze	*40 %*	-	*40 %*	-	*40 %*	-	*40 %*	-	*40%*	-
Level 3	Evaluate Create	*20 %*	-	*30 %*	-	*30 %*	-	*30 %*	-	*30%*	-
	Total	100 %		100 %		100 %		100 %		100 %	

CLA – 4 can be from any combination of these: Assignments, Seminars, Tech Talks, Mini-Projects, Case-Studies, Self-Study, MOOCs, Certifications, Conf. Paper etc.,

Course Designers		
Experts from Industry	Experts from Higher Technical Institutions	Internal Experts
		1. Prof.S.S.Sridhar, SRMIST
		2. Mr. C.Arun, SRMIST

Course Code	18CSO104T	Course Name	FREE AND OPEN SOURCE SOFTWARES	Course Category	O	Open Elective	L	T	P	C
							3	0	0	3

Pre-requisite Courses	Nil	Co-requisite Courses	Nil	Progressive Courses	Nil
Course Offering Department	Computer Science and Engineering	Data Book / Codes/Standards	Nil		

Course Learning Rationale (CLR):	*The purpose of learning this course is to:*	Learning 1	2	3	PLO 1	2	3	4	5	6	7	8	9	10	11	12	13	14	15
CLR-1 :	*Be exposed to the context and operation of free and open source software (FOSS) communities and associated software projects.*																		
CLR-2 :	*Be familiar with participating in a FOSS project*																		
CLR-3 :	*Learn scripting language like Python or Perl, Ruby*																		
CLR-4 :	*Learn some important FOSS tools and techniques*																		
Course Learning Outcomes (CLO):	*At the end of this course, learners will be able to:*	Level of Thinking (Bloom)	Expected Proficiency (%)	Expected Attainment (%)	Engineering Knowledge	Problem Analysis	Design & Development	Analysis, Design, Research	Modern Tool Usage	Society & Culture	Environment & Sustainability	Ethics	Individual & Team Work	Communication	Project Mgt. & Finance	Life Long Learning	PSO - 1	PSO - 2	PSO – 3
CLO-1 :	*Install and run open-source operating systems.*	*3*	*80*	*70*	*L*	*H*	-	*H*	*L*	-	-	-	*L*	*L*	-	*H*	-	-	-
CLO-2 :	*Gather information about Free and Open Source Software projects from software releases and from sites on the internet.*	*3*	*85*	*75*	*M*	*H*	*L*	*M*	*L*	-	-	-	*M*	*L*	-	*H*	-	-	-
CLO-3 :	*Build and modify one or more Free and Open Source Software packages.*	*3*	*75*	*70*	*M*	*H*	*M*	*H*	*L*	-	-	-	*M*	*L*	-	*H*	-	-	-
CLO-4 :	*Contribute software to and interact with Free and Open Source Software development projects.*	*3*	*85*	*80*	*M*	*H*	*M*	*H*	*L*	-	-	-	*M*	*L*	-	*H*	-	-	-
CLO-5 :	*Identify and apply various linux commands*	*3*	*85*	*75*	*H*	*H*	*M*	*H*	*L*	-	-	-	*M*	*L*	-	*H*	-	-	-

Duration (hour)		9	9	9	9	9
S-1	SLO-1	*Introduction-*	*Linux Installation and Hardware Configuration*	*Unix file system, Unix files, i-nodes and structure and file system relatedcomm ands*	*Usage of design Tools like Argo UML or equivalent*	*Open Source Software Development*
	SLO-2	*Open Source, Free Software, Free Software vs. Open Source software*				
S-2	SLO-1	*FOSS examples*	*Boot Process-The Linux Loader (LILO)*	*Shell Programming, Shell as command processor, Shell vari ables*	*Version Control Systems like Git or equivalent*	*Case Study – Libreoffice -Samba*
	SLO-2	*FOSS Characteristics*	*The Grand Unified Boot loader (GRUB)*			
S-3	SLO-1	*FOSS History, Examples*	*Dual-Booting Linux and other Operating System*	*Creating command substitution, Scripts*	*Bug Tracking Systems*	
	SLO-2	*FOSS Copyright*	*Boot-Time Kernel Options*			
S-4	SLO-1	*Guidelines for effectively working with FOSS community*	*Basic Linux Commands*	*Creating commands for Functions, Conditionals*	*Package Management Systems*	
	SLO-2					
S-5	SLO-1	*Benefits of Community based Software Development*	*Linux Commands for operations - redirection, pipes, filters, job control, changing ownership/permission of files/directories*	*Creating commands for loops*	*Introduction to Programming language using Python*	
	SLO-2					
S-6	SLO-1	*Requirements for being open, free software, open source software*	*Advanced Linux Commands like curl, wget, ftp, ssh and grep*	*Customizing environment*	*Basic commands, variables, Decision Making, Lists, Modules, strings, looping,*	*Case Studies : Apache, BSD, Linux, Mozilla (Firefox), Wikipedia, Joomla, GCC,*
	SLO-2					

S-7	SLO-1	*Four degrees of freedom*	*X Windows System Configuration*	*Shell scripting for system configurations*	*conditional statements, classes, Exceptions packages*	*Open Office*
	SLO-1					
S-8	SLO-1	*FOSS Licensing Models*	*System Administration*	*Shell scripting with functions and conditions*		
	SLO-2	*FOSS Licenses – GPL- AGPL- LGPL – FDL*	*Backup and Restore Procedures*			
S-9	SLO-1	*Implications*	*Strategies for keeping a Secure Server*	*Shell scripting with looping*		
	SLO-2					

Learning Resources	1. *EllenSiever,StephenFiggins,RobertLove,ArnoldRobbins,"LinuxinaNutshell",Sixth Edition, OReilly Media, 2009.* 2. *LinuxProgrammingBiblebyJohnGoerzen,IDGBooks,NewDelhi,2000.* 3. *Your Unix - The Ultimate Guide by Sumitabha Das, TMH,2000*	4. *PerlProgrammingbookathttp://www.perl.org/books/beginning-perl/.* 5. *Rubyprogrammingbookathttp://ruby-doc.com/docs/ProgrammingRuby/.* 6. *Samba: URL :http://www.samba.org/.*

Learning Assessment											
	Bloom's Level of Thinking	Continuous Learning Assessment (50% weightage)								Final Examination (50% weightage)	
		CLA – 1 (10%)		CLA – 2 (15%)		CLA – 3 (15%)		CLA – 4 (10%)#			
		Theory	Practice	Theory	Practice	Theory	Practice	Theory	Practice	Theory	Practice
Level 1	Remember Understand	*40 %*		*30 %*		*30 %*		*30 %*		*30 %*	
Level 2	Apply Analyze	*40 %*		*40 %*		*40 %*		*40 %*		*40 %*	
Level 3	Evaluate Create	*20 %*		*30 %*		*30 %*		*30 %*		*30 %*	
	Total	100 %		100 %		100 %		100 %		-	

CLA – 4 can be from any combination of these: Assignments, Seminars, Tech Talks, Mini-Projects, Case-Studies, Self-Study, MOOCs, Certifications, Conf. Paper etc.

Course Designers		
Experts from Industry	Experts from Higher Technical Institutions	Internal Experts
1.BijoymonSoman Sr. Test Analyst UST Global, Philadelphia,PA, USA	*1. Dr.Arun kumar M N Assistant Professor, Federal Institute of Science and Technology, Angamaly, Kerala*	*1. Mrs Aswathy K Cherian, SRMIST*
		2.Mrs. Nimala , SRMIST

Course Code	18CSO105T	Course Name	ANDROID DEVELOPMENT	Course Category	O	Open Elective	L	T	P	C
							3	0	0	3

Pre-requisite Courses	Nil	Co-requisite Courses	Nil	Progressive Courses	Nil
Course Offering Department	Computer Science and Engineering	Data Book / Codes/Standards	Nil		

Course Learning Rationale (CLR):	*The purpose of learning this course is to:*
CLR-1 :	*Understand the basics of Android devices and Platform.*
CLR-2 :	*Acquire knowledge on basic building blocks of Android programming required for Application development*
CLR-3 :	*Gain knowledge to user interfaces used in android applications*
CLR-4 :	*Acquire knowledge on advanced application concepts like networking, Animations and Google Maps services etc*
CLR-5 :	*Develop and publish Android applications in to Android Market*
CLR-6 :	*Understand the knowledge of JSON and MQTT*

Course Learning Outcomes (CLO):	*At the end of this course, learners will be able to:*	Learning 1: Level of Thinking (Bloom)	2: Expected Proficiency (%)	3: Expected Attainment (%)	PLO 1: Engineering Knowledge	2: Problem Analysis	3: Design & Development	4: Analysis, Design, Research	5: Modern Tool Usage	6: Society & Culture	7: Environment & Sustainability	8: Ethics	9: Individual & Team Work	10: Communication	11: Project Mgt. & Finance	12: Life Long Learning	13: PSO - 1	14: PSO - 2	15: PSO – 3
CLO-1 :	*To exposed to technology and business trends impacting Android Platform*	2	80	85	H	-	L	-	-	-	-	-	-	-	-	-	-	-	-
CLO-2 :	*Be competent with the characterization and architecture of mobile applications*	2	75	80	L	H	H	-	-	-	-	-	-	-	-	-	-	-	-
CLO-3 :	*To understanding enterprise scale requirements of mobile applications*	2	85	80	H	-	H	L	-	-	-	-	-	-	-	-	-	-	-
CLO-4 :	*To designing and developing mobile applications using one application development framework*	2	80	75	L	L	H	-	-	-	-	-	-	-	M	-	-	-	-
CLO-5 :	*To understand how to handle and share android data*	2	75	85	L	-	H	H	L	-	-	-	-	-	-	-	-	-	-
CLO-6 :	*To develop an android services and to publish android application for use*	2	80	85	H	-	H	-	-	-	-	-	-	-	M	-	-	-	-

Duration (hour)		9	9	9	9	9
S-1	SLO-1	*Creating a new Android Project*	*Hosting a UI Fragment*	*Action Bar and Options Menus*	*Loopers, Handlers, and HandlerThread*	*Introduction to JSON*
	SLO-2	*Defining the Project and SDK setting*	*Creating a UI Fragment*	*Enabling Ancestral Navigation*	*Creating a search interface*	*JSON and Android*
S-2	SLO-1	*Creating an Android Virtual Device (AVD) in Android Studio*	*Adding a UI Fragment to the FragmentManager*	*An Alternative Menu Item*	*Hardware search button*	*Designing JSON and JSON Operation*
	SLO-2	*Android Virtual Device (AVD) in Android Studio*	*The FragmentManager and the fragment lifecycle*	*Saving and Loading Local Files*	*Creating an IntentService*	*Server reachability and Connection & Splash App*
S-3	SLO-1	*Configuring the Android Studio AVD Emulator*	*Creating User Interfaces with Layouts and Widgets*	*Context Menu Resource*	*Delayed Execution with AlarmManager*	*Lazy Loading Images*
	SLO-2	*The Emulator Environment and Toolbar Options*	*XML Layout Attributes*	*Floating Context Menu*	*Broadcast Intents*	*Lazy loading Libraries*
S-4	SLO-1	*Extended Control options*	*the Graphical Layout Tool*	*Contextual Action Mode*	*Waking Up on Boot*	*Lazy loading Archirtecture*
	SLO-2	*Drag and Drop Support*	*Creating a ListFragment*	*Camera I: Viewfinder*	*Filtering Foreground Notifications*	*Handling Image Assets*
S-5	SLO-1	*Configuring Fingerprint Emulation*	*Hosting a Fragment*	*Using the Camera API*	*Receivers and Long-running Tasks*	*Remote Crash Logs and App*
	SLO-2	*Android Studio Apps on a Physical Android Device*	*ListFragment, ListView and ArrayAdapter*	*Camera II: Taking Pictures and Handling Images*	*Browsing The Web & WebView*	*Push Messaging Services*
S-6	SLO-1	*Enabling ADB on Android based Devices*	*Fragment Arguments*	*Updating the Model Layer*	*Custom Views and Touch Events*	*Firebase Cloud Messaging*
	SLO-2	*Android Studio Editor*	*ViewPager*	*Updating CrimeFragment's View*	*Creating BoxDrawingView*	*Open Source Push Messaging with MQTT*

S-7	SLO-1	*Splitting the Editor Window, Code Completion, Statement*	*Dialogs*	*Implicit Intents*	*Handling Touch Events*	*MQTT App and Project*
	SLO-2	*Parameter Information, Parameter Name Hints,*	*Audio Playback Using MediaPlayer*	*Two-Pane Master-Detail Interfaces*	*Tracking the Device's Location*	*Message Brokers*
S-8	SLO-1	*Code Generation*	*Retained Fragments*	*Adding Layout Flexibility*	*Locations and the LocationManager*	*MQTT Broker setup for AWS*
	SLO-2	*Code Folding*	*Rotation and Retained Fragments*	*Activity: Fragment Boss*	*Receiving Broadcast Location Updates*	*Sending Messages with MQTT Web Clients*
S-9	SLO-1	*Quick Documentation Lookup*	*Rotation Handling and onSaveInstanceState(Bundle)*	*Styles And Includes*	*Updating the UI with Location Data*	*Firebase Cloud Messaging*
	SLO-2	*Code Reformatting*	*Localization*	*Cleaning Up with Styles*	*Testing Locations on Real and Virtual Devices*	*MQTT Push Messaging*

Learning Resources	1. *Neil Smyth, Kotlin / Android Studio 3.0 Development Essentials - Android 8 Edition, Payload Media, Inc.2017* 2. *BillPhillipsandBrianHardy,AndroidProgramming:TheBigNerdRanchGuide,BigNerdRanch,Inc. 2013*	3. *MarkWickham,PracticalAndroid:14CompleteProjectsonAdvancedTechniquesandApproaches, Apress,2018* 4. *DavidGriffiths,HeadFirst:AndroidDevelopment,OReilly2015,ISBN:9781449362188*

Learning Assessment

	Bloom's Level of Thinking	Continuous Learning Assessment (50%								Final Examination (50% weightage)	
		CLA – 1 (10%)		CLA – 2 (15%)		CLA – 3 (15%)		CLA – 4 (10%)#			
		Theory	Practice	Theory	Practice	Theory	Practice	Theory	Practice	Theory	Practice
Level 1	Remember Understand	*40 %*	-	*30 %*	-	*30 %*	-	*30 %*	-	*30%*	-
Level 2	Apply Analyze	*40 %*	-	*40 %*	-	*40 %*	-	*40 %*	-	*40%*	-
Level 3	Evaluate Create	*20 %*	-	*30 %*	-	*30 %*	-	*30 %*	-	*30%*	-
	Total	100 %		100 %		100 %		100 %		100 %	

CLA – 4 can be from any combination of these: Assignments, Seminars, Tech Talks, Mini-Projects, Case-Studies, Self-Study, MOOCs, Certifications, Conf. Paper etc.,

Course Designers

Experts from Industry	Experts from Higher Technical Institutions	Internal Experts
1. *DineshBabuT,DevelopmentManager,HPIndia.dinesh.thavamani@hp.com*		1. *Mr.S.Pradeep,SRMIST*
2. *SurajSundaram,AssociateITConsultant,TCSCanada.suraj.s@tcs.com*		2. *Mr. C. Arun,SRMIST*

Course Code	18CSO106T	Course Name	DATA ANALYSIS IN R	Course Category	O	Open Elective	L	T	P	C
							3	0	0	3

Pre-requisite Courses	Nil	Co-requisite Courses	Nil	Progressive Courses	Nil
Course Offering Department	Computer Science and Engineering	Data Book / Codes/Standards	Nil		

Course Learning Rationale (CLR):	*The purpose of learning this course is to:*
CLR-1 :	*Understand and write programs in R*
CLR-2 :	*Gain knowledge on the working of statistical data in R*
CLR-3 :	*Gain knowledge on Linear regression and maniputlation in R*
CLR-4 :	*Acquire knowledge on classification and clustering in R*
CLR-5 :	*Acquire knowledge on Linear Model selection and regulaization and working it in R*
CLR-6 :	*Introduce the Tree baed methods and working it in R*

		Learning			Program Learning Outcomes (PLO)														
		1	2	3	1	2	3	4	5	6	7	8	9	10	11	12	13	14	15
Course Learning Outcomes (CLO):	*At the end of this course, learners will be able to:*	Level of Thinking (Bloom)	Expected Proficiency (%)	Expected Attainment (%)	Engineering Knowledge	Problem Analysis	Design & Development	Analysis, Design, Research	Modern Tool Usage	Society & Culture	Environment & Sustainability	Ethics	Individual & Team Work	Communication	Project Mgt. & Finance	Life Long Learning	PSO - 1	PSO - 2	PSO – 3
CLO-1 :	*Acquire the knowledge on data analysis in R*	*2*	*80*	*85*	*H*	-	-	-	*H*	-	-	-	-	-	-	-	-	-	-
CLO-2 :	*Acquire the ability to find meaning pattern using R*	*2*	*75*	*80*	*H*	*H*	-	-	-	-	-	-	-	-	-	-	-	-	-
CLO-3 :	*Acquire the ability to find graphically interpret data in R*	*2*	*75*	*80*	*H*	*H*	-	-	-	-	-	-	-	-	-	-	-	-	-
CLO-4 :	*Apply the knowledge for implementing anlaytical alogirthms*	*2*	*80*	*75*	*H*		-	-	-	-	-	-	-	-	-	-	-	-	-
CLO-5 :	*Handle large scale analytics projects from various domains*	*2*	*75*	*85*	*H*	*H*	-	*H*	-	-	-	-	-	-	-	-	-	-	-
CLO-6 :	*Develop intelligent decision support systems*	*2*	*75*	*80*	*H*	-	-	*H*	-	-	-	-	-	-	-	-	-	-	-

Duration (hour)		9	9	9	9	9
S-1	SLO-1	*Data in data analytics*	*Simple Linear Regression*	*An Overview of Classification*	*Cross-Validation The Validation Set Approach*	*The Basics of Decision Trees-Regression Trees*
	SLO-2	*NOIR classification*	*Estimating the coefficients*	*Logistic Regression - The Logistic Model*	*Leave-One-Out Cross-Validation*	*Classification Trees*
S-2	SLO-1	*Introduction to R*	*Assessing the Accuracy of the Coeﬃcient Estimates*	*Estimating the Regression Coeﬃcients*	*k-Fold Cross-Validation*	*Trees Versus Linear Models*
	SLO-2	*Data types*	*Assessing the Accuracy of the Model*	*Making Predictions*	*Bias-Variance Trade-Oﬀ for k-Fold Cross-Validation*	*Advantages and Disadvantages of Trees*
S-3	SLO-1	*Control structures*	*Libraries for Simple Linear Regression in R*	*Multiple Logistic Regression*	*The Validation Set Approach in R*	*Bagging -Random Forests*
	SLO-2	*Control structures - Using the console*	*Programming in simple linear regression in R*	*Logistic Regression for >2 Response Classes*	*Leave-One-Out Cross-Validation in R*	*Boosting*
S-4	SLO-1	*Objects in R - Numbers, Attributes*	*Multiple Linear Regression - Estimating the Regression Coeﬃcients*	*Linear Discriminant Analysis - Using Bayes' Theorem for Classification*	*k-Fold Cross-Validation .in R*	*Fitting Classification Trees in R*
	SLO-2	*Vectors - create vectors*	*Multiple Linear Regression in R*	*Linear Discriminant Analysis for p = 1*	*The Bootstrap in R*	*Fitting Regression Trees in R*
S-5	SLO-1	*Using [] brackets*	*Extensions of the Linear Model*	*Linear Discriminant Analysis for p>1*	*Linear Model Selection and Regularization-Subset Selection*	*Bagging and Random Forests in R*
	SLO-2	*Vectorized operations*	*Potential Problems*	*Quadratic Discriminant Analysis*	*Stepwise Selection Choosing the Optimal Model*	*Boosting in R*
S-6	SLO-1	*Matrix -building a matrix, Naming dimensions, Colnames and Rownames*	*The Marketing Plan*	*Logistic Regression, LDA,*	*Shrinkage Methods Ridge Regression*	*Principal Components Analysis - What Are Principal Components?*
	SLO-2	*Matrix operations, Visualizing with Matplot()*	*Comparison of Linear Regression with K-Nearest Neighbors*	*QDA, and KNN in R - T*	*The Lasso Selecting the Tuning Parameter*	*More on PCA*

S-7	SLO-1	*Data frame*	*Qualitative Predictors*	*Example using Stock Market Data*	*Dimension Reduction Methods Principal Components RegressionP*	*Principal Components Analysis in R*
	SLO-2	*List*	*Extensions of the Linear Model*	*Logistic Regression in R*	*artial Least Squares*	*More on PCA - Other Uses for Principal Components*
S-8	SLO-1	*Functions*	*Interaction Terms in R*	*Linear Discriminant Analysis in R*	*Best Subset Selection in R*	*Clustering Methods- K-Means*
	SLO-2	*Indexing data*	*Non-linear Transformations of the Predictors in R*	*Quadratic Discriminant Analysis in R*	*Forward and Backward Stepwise Selection in R*	*Hierarchical Clustering*
S-9	SLO-1	*Reading data*	*Qualitative Predictors in R*	*K-Nearest Neighbors in R*	*Choosing Among Models Using the Validation Set Approach and Cross-Validation in R*	*K-Means Clustering in R*
	SLO-2	*Writing data*	*Writing Functions for linear regression in R*	*An Application to Caravan Insurance Data in R*	*Ridge Regression and the Lasso in R*	*Hierarchical Clustering in R*

Learning Resources	1. *G James, D. Witten, T Hastie, and R. Tibshirani, An Introduction to Statistical Learning: with Applications in R, Springer, 2013* 2. *Chambers, John, Software for Data Analysis Programming with R, Springer, 2008* 3. *Trevor Hastie Robert Tibshirani Jerome Friedman,The Elements of Statistical Learning, Data Mining, Inference, and Prediction (2nd Edn.), Springer, 2014*	4. *Mark Gardener,Beginning R: The Statistical Programming Language, Wiley, 2013* 5. *Upadhyaya and A. Upadhyaya, Material Science and Engineering, Anshan Publications, 2007*

Learning Assessment											
	Bloom's Level of Thinking	Continuous Learning Assessment (50%								Final Examination (50% weightage)	
		CLA – 1 (10%)		CLA – 2 (15%)		CLA – 3 (15%)		CLA – 4 (10%)#			
		Theory	Practice	Theory	Practice	Theory	Practice	Theory	Practice	Theory	Practice
Level 1	Remember Understand	*40 %*	-	*30 %*	-	*30 %*	-	*30 %*	-	*30%*	-
Level 2	Apply Analyze	*40 %*	-	*40 %*	-	*40 %*	-	*40 %*	-	*40%*	-
Level 3	Evaluate Create	*20 %*	-	*30 %*	-	*30 %*	-	*30 %*	-	*30%*	-
	Total	100 %		100 %		100 %		100 %		100 %	

CLA – 4 can be from any combination of these: Assignments, Seminars, Tech Talks, Mini-Projects, Case-Studies, Self-Study, MOOCs, Certifications, Conf. Paper etc.,

Course Designers		
Experts from Industry	Experts from Higher Technical Institutions	Internal Experts
1. Venkatesh K. Pappakrishnan, Ph.D. *Data scientist | Physicist, Santa Clara, California*	*1. Dr. J. Prakash, MIT, Chennai, prakaiit@rediffmail.com*	*1. Dr.V.Kavitha, SRMIST*
2. Prakash V, *Technical Lead at Bridgeline Digital Inc* *Greater Boston Area*	*2.Dr. Latha Karthigaa, PhD ,* *Innovation Research Assistant,* *The University of Auckland*	*2. Dr.Alice Nithya, SRMIST*

Course Code	18CSO107T	Course Name	IOS DEVELOPMENT	Course Category	O	Open Elective	L	T	P	C
							3	0	0	3

Pre-requisite Courses	Nil	Co-requisite Courses	Nil	Progressive Courses	Nil
Course Offering Department	CSE	Data Book / Codes/Standards	Nil		

Couse Learning Rationale (CLR):	*The purpose of learning this course is to:*	Learning			Program Learning Outcomes (PLO)														
		1	2	3	1	2	3	4	5	6	7	8	9	10	11	12	13	14	15
CLR-1 :	*Understand the basics of ios device and platform*																		
CLR-2 :	*Understand the basic building blocks of ios programming required for App development*																		
CLR-3 :	*Understand Data storage mechanism in ios*																		
CLR-4 :	*Understand advanced application concepts like animations, webservices,etc*																		
CLR-5 :	*Develop and publish ios application in to ios market*																		
CLR-6 :	*understanding enterprise scale requirements of mobile application*																		
Course Learning Outcomes (CLO):	*At the end of this course, learners will be able to:*	Level of Thinking (Bloom)	Expected Proficiency (%)	Expected Attainment (%)	Engineering Knowledge	Problem Analysis	Design & Development	Analysis, Design, Research	Modern Tool Usage	Society & Culture	Environment & Sustainability	Ethics	Individual & Team Work	Communication	Project Mgt. & Finance	Life Long Learning	PSO - 1	PSO - 2	PSO – 3
CLO-1 :	*Acquire the knowledge of ios device and platform*	2	80	85	H	-	-	-	-	-	-	-	-	-	-	-	-	-	-
CLO-2 :	*Acquire the knowledge on ios programming for App Development*	2	75	80	H	H	-	-	-	-	-	-	-	-	-	-	-	-	-
CLO-3 :	*Apply the concepts used for data storage in ios*	2	85	80	H	-	-	-	-	-	-	-	-	-	-	-	-	-	-
CLO-4 :	*Apply the animation and webservice concepts in the App*	2	80	75	H	H	-	-	-	-	-	-	-	-	-	-	-	-	-
CLO-5 :	*Understand the basic idea to publish ios application into ios market*	2	75	85	H	-	-	H	-	-	-	-	-	-	-	-	-	-	-
CLO-6 :	*Understand the needs of enterprise to develop App*	2	80	85	H	-	-	-	-	-	-	-	-	-	-	-	-	-	-

Duration (hour)		9	9	9	9	9
S-1	SLO-1	*Top Mobile OS in Market*	*The Swift Language-Types*	*Programmatic views-anchors,Margins*	*Stack Views*	*Webservices*
	SLO-2	*Difference between IOS and Android*	*Literals and subscripting, Initializers, Properties, Instance methods*	*Programmatic controls*	*Nested stack views*	
S-2	SLO-1	*IOS Architecture*	*Optionals,Subscripting dictionaries, Loops and String Interpolation*	*Localization*	*Segues*	*JSON Data*
	SLO-2		*Enumerations*			
S-3	SLO-1	*History of IOS*	*Views-Basics*	*Internalization*	*UINavigation Controller*	*Collection views*
	SLO-2		*Frames, Customizing the labels*		*Dismissing the keyboard*	
S-4	SLO-1	*Requirements*	*The auto Layout System*	*Controlling Animations*	*Even handling basics*	*Extensions*
	SLO-2		*Adding Constraints*	*Completion,constraints*		
S-5	SLO-1	*Versions*	*Text Input- Editing,Keyboard attributes*	*Timing functions*	*Camera*	*Image caching*
	SLO-2					
S-6	SLO-1	*Framework -MVC Design Pattern*	*Dismissing the keyboard*	*Debugging*	*Saving,Loading and Application States*	*Core Data*
	SLO-2		*Number formatters*			
S-7	SLO-1	*Application Life Cycle*	*Delegation*	*UITableView and Controller*	*Loading files, Error handling*	*Fetch requests and predicates*
	SLO-2		*Conforming to a protocol*			
S-8	SLO-1	*Features*	*View controllers*	*Editing UITableview*	*Size class*	*Core Data Relationships*
	SLO-2		*UITabBarController*			
S-9	SLO-1	*A simple IOS Application*	*Appearing and accessing views*	*Subclassing UITableViewcell*	*Touch Events and UIResponder*	*Accessibility*
	SLO-2					

Learning Resources	1. *ChristianKeur,AaronHillegass,iosprogramming:TheBigNerdRanchGuide,6th ed.,Pearson,2016.* 2. *Jon Hoffman, Mastering Swift,4th ed.,Packt Publishing Ltd.,2017.*	3. *Fahim Farook, Matthijs Hollemans, ios Apprentice,7th ed.,Razeware LLC,2018.* 4. *Michael Grant, ios Navigation101,2019.*

Learning Assessment											
	Bloom's Level of Thinking	Continuous Learning Assessment (50%								Final Examination (50% weightage)	
		CLA – 1 (10%)		CLA – 2 (15%)		CLA – 3 (15%)		CLA – 4 (10%)			
		Theory	Practice	Theory	Practice	Theory	Practice	Theory	Practice	Theory	Practice
Level 1	Remember Understand	*40 %*	-	*30 %*	-	*30 %*	-	*30 %*	-	*30%*	-
Level 2	Apply Analyze	*40 %*	-	*40 %*	-	*40 %*	-	*40 %*	-	*40%*	-
Level 3	Evaluate Create	*20 %*	-	*30 %*	-	*30 %*	-	*30 %*	-	*30%*	-
	Total	100 %		100 %		100 %		100 %		100 %	

CLA – 4 can be from any combination of these: Assignments, Seminars, Tech Talks, Mini-Projects, Case-Studies, Self-Study, MOOCs, Certifications, Conf. Paper etc.,

Course Designers		
Experts from Industry	Experts from Higher Technical Institutions	Internal Experts
1. Mr.K.Mahendran, Founder, Dreams Technologies, Chennai.	*1.*	*1. Dr.D.Rajeswari, SRMIST*
2.	*2.*	*2. Mr.K.Navin, SRMIST*

Course Code	18EEO301T	Course Name	SUSTAINABLE ENERGY	Course Category	O	Open Elective	L	T	P	C
							3	0	0	3

Pre-requisite Courses	NIL	Co-requisite Courses	NIL	Progressive Courses	NIL
Course Offering Department	Electrical and Electronics Engineering	Data Book / Codes/Standards		NIL	

Course Learning Rationale (CLR):	*The purpose of learning this course is to:*
CLR-1 :	*Enrich the students on the basics of solar energy*
CLR-2 :	*Develop the knowledge in wind energy conversion system*
CLR-3 :	*Understand the energy generation by biomass*
CLR-4 :	*Gain knowledge on ocean ,tidal energy*
CLR-5 :	*Acquire knowledge in fuel cell and its types*
CLR-6 :	*Apply the concepts of renewable energy in industrial applications*

Course Learning Outcomes (CLO):	*At the end of this course, learners will be able to:*	Learning 1 Level of Thinking (Bloom)	2 Expected Proficiency (%)	3 Expected Attainment (%)	PLO 1 Engineering Knowledge	2 Problem Analysis	3 Design & Development	4 Analysis, Design, Research	5 Modern Tool Usage	6 Society & Culture	7 Environment & Sustainability	8 Ethics	9 Individual & Team Work	10 Communication	11 Project Mgt. & Finance	12 Life Long Learning	13 PSO - 1	14 PSO - 2	15 PSO – 3
CLO-1 :	*Obtain in depth knowledge on solar applications*	*2*	*80*	*75*	*H*	*M*	*M*	-	-	-	*L*	-	-	-	-	-	*H*	*M*	-
CLO-2 :	*Explain the concepts of wind energy conversion systems and their control*	*3*	*80*	*75*	*H*	*M*	*M*	-	-	-	*L*	-	-	-	-	-	*H*	*M*	-
CLO-3 :	*Summarize the biomass technologies and calculate the power conversion of biomass digestion*	*3*	*80*	*75*	*H*	*M*	-	-	-	-	*L*	-	-	-	-	-	*H*	*M*	-
CLO-4 :	*Interpret the environmental impacts of ocean and tidal energy*	*3*	*80*	*75*	*H*	*M*	-	-	-	-	*L*	-	-	-	-	-	*H*	*M*	-
CLO-5 :	*Summarize the working principle of fuels cells and its types*	*3*	*80*	*75*	*H*	*M*	-	-	-	-	*L*	-	-	-	-	-	*H*	*M*	-
CLO-6 :	*Infer the knowledge about various types of renewable energy systems*	*3*	*80*	*75*	*H*	*M*	*M*	-	-	-	*L*	-	-	-	-	-	*H*	*M*	-

Duration (hour)		9	9	9	9	9
S-1	SLO-1	*Solar radiation*	*Wind energy conversion*	*Biogas*	*Ocean thermal energy conversion*	*Fuel Cell*
	SLO-2	*Beam and diffuse radiation, solar constant, earth*	*Principles of Wind energy conversion*	*Energy from Biomass*	*Principle of OTEC*	*Basics of Fuel cell*
S-2	SLO-1	*Sun angles*	*Nature of the wind*	*Types of biomass*	*Lambert law of absorption*	*Components of fuel cells*
	SLO-2	*Calculation of angle of incidence*	*Factors influencing wind*	*Photosynthesis*	*OTEC power plant*	*Difference between batteries and fuel cell*
S-3	SLO-1	*Attenuation and measurement of solar radiation*	*Wind data and energy estimation- wind speed monitoring,*	*Factors affecting digestion system*	*Open loop system for ocean energy conversion*	*Types of fuel cells*
	SLO-2	*Local solar time, derived solar angles, sunrise, sunset and day length*	*Site selection*	*Classification of biogas plants*	*Closed loop system for ocean energy conversion*	*Ionic conductivity of fuel cell*
S-4	SLO-1	*Flat plate collectors, concentrating collectors*	*Power in the wind*	*Advantages and disadvantages of biogas plants*	*Single basin*	*Electronic conductivity in fuel cell*
	SLO-2	*Solar air heaters, types, solar driers*	*Betz limit*	*Factors affecting bio digestion*	*dual basin ocean energy conversion system*	*Principle of working of fuel cell*
S-5	SLO-1	*Storage of solar energy, thermal storage*	*Components of a wind energy conversion system*	*Biomass as Renewable Energy Source*	*Major problems and operational experience Tidal energy*	*Performance characteristics of fuel cells*
	SLO-2	*Solar pond , solar water heaters*	*Torque on wind*	*Cofiring*	*Site selection of tidal power plant*	*Selection of fuel cells*
S-6	SLO-1	*Solar distillation*	*Wind thrust calculations Repowering concept*	*Dry Process*	*Tide ,Spring tide*	*Fuel cell stack*
	SLO-2	*Solar Pond*	*Horizontal Axis Wind Turbine(HAWT design consideration)*	*Photosynthesis*	*Neap tide, Tidal range*	*fuel cell power plant*
S-7	SLO-1	*Solar heating & cooling of buildings*	*Tip Speed Ratio*	*Energy forming*	*Types of Tidal power plant*	*Cross section of typical PEM fuel cell*
	SLO-2	*Solar still, solar cooker*	*Solidity*	*Pyrolysis*	*Advantages and disadvantages of tidal power plant*	*Storage methods for fuel cells*
S-8	SLO-1	*Photo voltaic. Types of PV cells*	*Types of generators and power converters in WECS*	*Types of Biomass Fuels*	*Wave Energy*	*Challenges and trends in fuel cell*

	SLO-2	*Characteristics and working principles of PV*	*Control schemes for power converters.*	*Biomass power plant*	*Wave Characteristics*	*Efficiency of fuel cell*
S-9	SLO-1	*Maximum power point tracking methods*	*Introduction to grid integration of WECS*	*Biomass cogeneration*	*Different wave energy convertors, Saltor Duck*	*Applications of fuel cell*
	SLO-2	*Net metering concepts*	*Issues in grid integration*	*Digester design*	*Oscillating water column and dolphin types*	*Advantages and disadvantages of fuel cell*

Learning Resources	1. *Rai ,G.D.,Non Conventional sources of Energy, Khanna Publishers ,5th Edition 2016.* 2. *Khan. B.H, "Non-Conventional Energy Resources", The McGraw Hills,2nd Edition, 2016*	3. *O'Hayre, R.P.,S. Cha, W. Colella, F.B.Prinz, Fuel Cell Fundamentals, Wiley, NY (2006).* 4. *https://onlinecourses-archive.nptel.ac.in/.*

Learning Assessment

	Bloom's Level of Thinking	Continuous Learning Assessment (50% weightage)								Final Examination (50% weightage)	
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Level 2	Apply Analyze	*40 %*	-	*40 %*	-	*40 %*	-	*40 %*	-	*40%*	-
Level 3	Evaluate Create	*20 %*	-	*30 %*	-	*30 %*	-	*30 %*	-	*30%*	-
	Total	100 %		100 %		100 %		100 %		100 %	

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Course Designers		
Experts from Industry	Experts from Higher Technical Institutions	Internal Experts
1. Er.P.Velumani, TANGEDCO ,velumaniyazhini@gmail.com	*1. Dr.P.DhamodHaran, IIITM, damodharan@iiitdm.ac.in*	*1. Dr.K.Saravanan, SRM IST*
2.Er.R.Ramanavasu,BAVINI,BARC,rramanavasu@igcar.gov.in	*2. Dr.S.Kumaravel , NIT Calicut,kumaravel_s@nitc.ac.in*	*2. Dr.R.Sridhar, SRM IST*

Course Code	18EEO302T	Course Name	ANALOG ELECTRONICS	Course Category	O	Open Elective	L	T	P	C
							3	0	0	3

Pre-requisite Courses	Nil	Co-requisite Courses	Nil	Progressive Courses	Nil
Course Offering Department	Electrical and Electronics Engineering	Data Book / Codes/Standards	Nil		

Course Learning Rationale (CLR):	*The purpose of learning this course is to:*
CLR-1 :	*Know the basic amplifier circuits*
CLR-2 :	*Acquire knowledge on different power amplifiers*
CLR-3 :	*Construct different waveform generating circuits*
CLR-4 :	*Discuss the basics of operational amplifiers*
CLR-5 :	*Understand different analog to digital and digital to analog converters*
CLR-6 :	*Design amplifier circuits using transistor and operational amplifiers*

Course Learning Outcomes (CLO):	*At the end of this course, learners will be able to:*	Learning 1: Level of Thinking (Bloom)	2: Expected Proficiency (%)	3: Expected Attainment (%)	PLO 1: Engineering Knowledge	2: Problem Analysis	3: Design & Development	4: Analysis, Design, Research	5: Modern Tool Usage	6: Society & Culture	7: Environment & Sustainability	8: Ethics	9: Individual & Team Work	10: Communication	11: Project Mgt. & Finance	12: Life Long Learning	13: PSO - 1	14: PSO - 2	15: PSO – 3
CLO-1 :	*Analyze the amplifier circuits using small signal model and hybrid model*	2	75	75	H	M	-	H	-	-	-	-	-	-	-	-	M	L	-
CLO-2 :	*Recognize the different power amplifiers*	2	75	75	H	M	-	H	-	-	-	-	-	-	-	-	M	L	-
CLO-3 :	*Design oscillators and multivibrators*	3	75	75	H	M	H	M	-	-	-	-	-	-	-	-	M	L	-
CLO-4 :	*Apply different operational amplifiers*	2	75	75	H	-	-	-	-	-	-	-	-	-	-	-	M	L	-
CLO-5 :	*Evaluate filters and converter circuits*	3	75	75	H	L	H	M	H	-	-	-	-	-	-	-	M	L	-
CLO-6 :	*Demonstrate various electronic circuits for real time applications*	2	75	75	H	M	H	H	H	-	-	-	-	-	-	-	M	L	-

Duration (hour)		9	9	9	9	9
S-1	SLO-1	*BJT -Biasing methods -Base bias, base bias with emitter feedback*	*Power amplifiers – Types. Determination of efficiency for class A and class B power amplifiers*	*Oscillators and classification of oscillators*	*Introduction to Linear Integrated Technology*	*Filters basics and types*
	SLO-2	*Base bias with collector feedback and voltage divider bias*	*Frequency response of RC coupled class A amplifier*	*Design and Analysis of RC Phase shift oscillator.*	*Fabrication process for Integrated Circuits*	*Design of I and II Order LPF*
S-2	SLO-1	*Emitter bias using BJT in CE configuration*	*Frequency response of Transformer coupled class A amplifier*	*Operation of Hartley's oscillator*	*DC characteristics of op amp and input bias current.*	*Design of I Order HPF*
	SLO-2	*Transistor biasing stability using BJT in CE configuration*	*Operation of Class B push pull power amplifier*	*Analysis of Hartley's oscillator*	*Input offset voltage, Thermal Drift*	*Design of II Order HPF*
S-3	SLO-1	*Operation of BJT as an amplifier.*	*Operation of Differential amplifier*	*Operation of Armstrong oscillator*	*AC characteristics of op-amp and Frequency Response characteristics*	*Design of BPF and BRF*
	SLO-2	*CE, CB, CC Amplifier –Evaluation of h parameters*	*Analysis of Differential amplifier*	*Operation of UJT Relaxation oscillator*	*Frequency compensation and Slew rate*	*Switched variable filters and state variable filters*
S-4	SLO-1	*Small signal analysis of CE Amplifier*	*Self – biased active load differential amplifier*	*Operation of Cross coupled Oscillator*	*Inverting amplifier and Non-inverting amplifier*	*Oscillators- Wein bridge Oscillator using IC 741*
	SLO-2	*Small signal analysis of CB and CC amplifier*	*Source degenerated common source amplifier*	*Integrators*	*Summer and Subtractor*	*Amplitude control and Quadrature control Oscillator*
S-5	SLO-1	*Large signal analysis of CE Amplifier*	*Classification of class C power amplifiers (Tuned amplifiers)*	*Differentiators*	*Voltage follower and ac amplifiers*	*Introduction to simple MOSFET based op amp circuits*
	SLO-2	*Large signal analysis of CB and CC amplifier*	*Frequency response of Single , Double and Staggered Tuned Class C power amplifiers*	*Schmitt trigger*	*V to I and I to V converters*	*Analog to Digital converters and classification*
S-6	SLO-1	*JFET - CS Amplifier - Operation*	*Cascode and Cascaded circuits*	*Multivibrator and classification of multivibrators. Operation of Astable Multivibrator.*	*Instrumentation amplifier*	*Counter type ADC*

	SLO-2	*CS Amplifier – small signal analysis*	*Feedback amplifiers - Barkhausen criterion and Types of feedback amplifier*	*Analysis of Astable Multivibrator*	*Log and Antilog amplifiers*	*Sigma Delta type ADC*
S-7	SLO-1	*JFET - CD Amplifier - Operation*	*Analysis of voltage series feedback amplifier*	*Operation of Monostable Multivibrator.*	*Comparators and classification of comparators.*	*Successive approximation type ADC*
	SLO-2	*Small signal analysis of MOSFET*	*Analysis of voltage shunt feedback amplifier*	*Analysis of Monostable Multivibrator.*	*Applications of Comparators*	*Digital to Analog converters*
S-8	SLO-1	*Biasing of MOSFET*	*Analysis of current series amplifier*	*Operation of Bistable Multivibrator.*	*Basics of IC 555 Timer and Pin Details*	*Pulse width modulator DAC*
	SLO-2	*CD Amplifier – small signal analysis*	*Analysis of current shunt feedback amplifier*	*Analysis of Bistable Multivibrator.*	*Astable operation using IC 555 Timer with applications*	*R -2R Ladder DAC*
S-9	SLO-1	*Problems on biasing of circuits*	*Problems on power amplifiers*	*Voltage and time-based circuits.*	*Monostable operation using IC 555 Timer with applications*	*Inverted R-2R Ladder DAC*
	SLO-2	*Problems on hybrid parameters*	*Problems on feedback amplifiers*	*Series and shunt voltage regulator*	*Voltage regulator using IC 723*	*Binary coded DAC*

Learning Resources	1. *Jacob Millman, Christos C.Halkias, Satyabrata Jit, Millman's Electronic Devices and Circuits, 4th ed., Tata McGraw Hill, 2015* 2. *Boylestead, Nashelsky, Electronic Devices and Circuit Theory, 11th ed., Pearson, 2015* 3. *David A. Bell, Electronic Devices and Circuits, 5th ed., PrenticeHall, 2004*	4. *Sergio Franco, Design with operational amplifiers and Analog Integrated circuits, 5th Edition, McGraw-Hill, 2014* 5. *Roy Choudhary and Shail Jain, Linear Integrated Circuits, 4th ed., New Age International Publishers, 2014.* 6. *https://ocw.mit.edu/courses/electrical-engineering-and-computer-science/6-002-circuits-and-electronics-spring-2007/syllabus/*

Learning Assessment

	Bloom's Level of Thinking	Continuous Learning Assessment (50% weightage)								Final Examination (50% weightage)	
		CLA – 1 (10%)		CLA – 2 (15%)		CLA – 3 (15%)		CLA – 4 (10%)#			
		Theory	Practice	Theory	Practice	Theory	Practice	Theory	Practice	Theory	Practice
Level 1	Remember Understand	*40 %*	-	*30 %*	-	*30 %*	-	*30 %*	-	*30%*	-
Level 2	Apply Analyze	*40 %*	-	*40 %*	-	*40 %*	-	*40 %*	-	*40%*	-
Level 3	Evaluate Create	*20 %*	-	*30 %*	-	*30 %*	-	*30 %*	-	*30%*	-
	Total	100 %		100 %		100 %		100 %		100 %	

CLA – 4 can be from any combination of these: Assignments, Seminars, Tech Talks, Mini-Projects, Case-Studies, Self-Study, MOOCs, Certifications, Conf. Paper etc.,

Course Designers

Experts from Industry	Experts from Higher Technical Institutions	Internal Experts
1. Dr. S.Paramasivam, Danfoss Industries Pvt Ltd, paramsathya@yahoo.com	*1. Dr.P.Satheesh Kumar, Anna University, silkart@gmail.com*	*1. R.C.Ilambirai, SRMIST*
2. A.Thiyagarajan, TANGEDCO, athiyagu3177@gmail.com	*2. Dr.S.Kamalakannan, Anna University, kamalakannan1612@gmail.com*	*2. Dr.K.Mohanraj, SRMIST*

Course Code	18EEO303T	Course Name	ELECTRICAL MATERIALS	Course Category	O	Open Elective	L	T	P	C
							3	0	0	3

Pre-requisite Courses	Nil	Co-requisite Courses	Nil	Progressive Courses	Nil
Course Offering Department	Electrical and Electronics Engineering	Data Book / Codes/Standards	Nil		

Course Learning Rationale (CLR):	*The purpose of learning this course is to:*
CLR-1 :	*Understand the basics of electrical materials*
CLR-2 :	*Describe conducting and dielectric materials*
CLR-3 :	*Explore knowledge on the insulating and magnetic materials*
CLR-4 :	*Acquire knowledge on superconducting materials*
CLR-5 :	*Interpret opto phenomena on electrical materials*
CLR-6 :	*Enrich the students on different electrical materials and its applications*

Course Learning Outcomes (CLO):	*At the end of this course, learners will be able to:*	Learning			Program Learning Outcomes (PLO)														
		1	2	3	1	2	3	4	5	6	7	8	9	10	11	12	13	14	15
		Level of Thinking (Bloom)	Expected Proficiency (%)	Expected Attainment (%)	Engineering Knowledge	Problem Analysis	Design & Development	Analysis, Design, Research	Modern Tool Usage	Society & Culture	Environment & Sustainability	Ethics	Individual & Team Work	Communication	Project Mgt. & Finance	Life Long Learning	PSO - 1	PSO - 2	PSO – 3
CLO-1 :	*Outline the electrical and electronics materials, their importance, classification and operational requirement*	*2*	*80*	*75*	*H*	*L*	*L*	-	-	-	*M*	-	-	-	-	-	*M*	*M*	-
CLO-2 :	*Obtain knowledge on conducting and dielectric materials used in engineering application*	*2*	*80*	*75*	*H*	*L*	*L*	-	-	-	*M*	-	-	-	-	-	*M*	*M*	-
CLO-3 :	*Gain idea on insulators and magnetic materials used in engineering, their properties and classification*	*2*	*80*	*75*	*H*	*L*	*L*	-	-	-	*M*	-	-	-	-	-	*M*	*M*	-
CLO-4 :	*Define the phenomenon superconductivity, super conducting materials and their application in engineering*	*2*	*80*	*75*	*H*	*L*	*L*	-	-	-	*M*	-	-	-	-	-	*M*	*M*	-
CLO-5 :	*Understand optical characteristics of conducting and non-conducting electrical materials*	*2*	*80*	*75*	*H*	*L*	*L*	-	-	-	*M*	-	-	-	-	-	*M*	*M*	-
CLO-6 :	*Summarize the different electrical materials and its applications*	*2*	*80*	*75*	*H*	*L*	*L*	-	-	-	*M*	-	-	-	-	-	*M*	*M*	-

Duration (hour)		9	9	9	9	9
S-1	SLO-1	*Importance of materials*	*Types of conducting materials*	*Insulating materials– Ceramic, Mica, Porcelain, Glass, Micanite and Glass bonded mica*	*Concept of superconductors*	*Introduction to Thermoplastics*
	SLO-2	*Classification of electrical and electronic materials*	*Low resistivity materials, High resistivity materials*	*Insulating material applications*	*Meaning of phenomenon of superconductivity*	*Introduction to Rubbers*
S-2	SLO-1	*Scope of electrical and electronic materials*	*Contact materials*	*Polymeric materials – Bakelite, Polyethylene. Natural and synthetic rubber and paper*	*Properties of superconductors*	*Introduction to Thermosets*
	SLO-2	*Requirement of Engineering materials*	*Fusible materials*	*Choice of solid insulating material for different applications*	*Types of superconductors*	*DC and AC properties of plastics*
S-3	SLO-1	*Classification of solids on the basis of energy gap*	*Filament materials*	*Liquid insulating materials requirements*	*Critical magnetic field*	*Mechanical properties and processing of plastic*
	SLO-2	*Types of engineering materials, Levels of material structure*	*Carbon as filamentary and brush material*	*Transformer oil, Bubble theory, Aging of mineral insulating oils.*	*Critical temperature*	*Materials for Opto – Electronic Devices - Introduction*
S-4	SLO-1	*Spintronic and its materials*	*Material for conductors, cables,*	*Gaseous insulating Materials – Air*	*Effects of Isotopic mass on critical temperature*	*Optical phenomena*
	SLO-2	*Ferromagnetic semiconductors, Left handed materials*	*Material for wires, solder, sheathing and sealing*	*Gaseous insulating Materials –Nitrogen, Vacuum*	*Silsbee rule*	*Reflection and Refraction*
S-5	SLO-1	*Conductor materials*	*Introduction to dielectric materials*	*Origin of permanent magnetic dipole, Magnetic terminology,*	*Depth of penetration*	*Transmittivity and Scattering,*
	SLO-2	*Factors affecting conductivity*	*classification of dielectric materials*	*Relation between relative permeability and magnetic susceptibility*	*Coherence length*	*Optical absorption*
S-6	SLO-1	*Thermal conductivity*	*Dielectric constant*	*Classification of magnetic materials - Diamagnetic, Paramagnetism, Ferromagnetism*	*Ideal and Hard superconductors*	*Optical properties of non-metals*

	SLO-2	*Heating effect of current*	*Dielectric strength and Dielectric loss*	*Anti-ferromagnetism and the corresponding materials*	*Mechanism of super conduction*	*Optical properties of metals*
S-7	SLO-1	*Thermoelectric effect*	*Polarization, Mechanisms of polarization*	*Ferrimagnetism and ferrites properties and applications*	*London's theory for Type I superconductors, GLAG theory for Type I superconductors*	*Optical properties of semiconductors*
	SLO-2	*Seebeck effect*	*Comparison of different polarization process*	*Ferrimagnetism and ferrites applications*	*BCS theory, Applications and limitations*	*Penetration depth and absorption coefficient*
S-8	SLO-1	*Thomson effect*	*Factors affecting polarization*	*Soft and hard ferrites. Curie temperature*	*Applications of high temperature superconductors*	*Optical properties of insulators*
	SLO-2	*Thomson effect's application*	*Spontaneous polarization*	*Laws of magnetic materials.*	*Superconducting solenoids and magnets*	*Luminescence*
S-9	SLO-1	*Wiedemann – Franz law*	*Behaviour of polarization under impulse and frequency switching*	*Magnetization curve, Initial and maximum permeability*	*MRI for medical mechanism*	*Opto – Electronic devices, Photoconductivity*
	SLO-2	*Lorentz relation*	*Decay and build-up of polarization under ac field*	*Hysteresis loop and loss, Eddy current loss*	*MRI for medical diagnostics*	*Photoconductive cell*

Learning Resources	*1. K.M. Gupta Nishu Gupta, Advanced Electrical and Electronics Materials; Processes and Applications, Wiley, First Edition, 2015* *2. R.K. Shukla, Archana Singh, Electronic Engineering Materials, McGraw Hill, 2012* *3. Solymar, Electrical Properties of Materials, Oxford , 9th Edition, 2014*	*4. A.J. Dekker, Electrical Engineering Materials, Pearson, 2016* *5. S.O. Kasap, Principle of Electronic Materials and Devices , McGraw Hill, 3rd Edition, 2010* *6. https://nptel.ac.in/courses/122102008/36*

Learning Assessment

	Bloom's Level of Thinking	Continuous Learning Assessment (50% weightage)								Final Examination (50% weightage)	
		CLA – 1 (10%)		CLA – 2 (15%)		CLA – 3 (15%)		CLA – 4 (10%)#			
		Theory	Practice	Theory	Practice	Theory	Practice	Theory	Practice	Theory	Practice
Level 1	Remember Understand	*40 %*	-	*30 %*	-	*30 %*	-	*30 %*	-	*30%*	-
Level 2	Apply Analyze	*40 %*	-	*40 %*	-	*40 %*	-	*40 %*	-	*40%*	-
Level 3	Evaluate Create	*20 %*	-	*30 %*	-	*30 %*	-	*30 %*	-	*30%*	-
	Total	100 %		100 %		100 %		100 %		100 %	

CLA – 4 can be from any combination of these: Assignments, Seminars, Tech Talks, Mini-Projects, Case-Studies, Self-Study, MOOCs, Certifications, Conf. Paper etc.

Course Designers

Experts from Industry	Experts from Higher Technical Institutions	Internal Experts
1. Dr.S.Sambath, TANGEDCO Tamilnadu, yeses.eng@gmail.com	*1. Dr.Chandramohan, CEG, Anna University, c_dramo@annauniv.edu*	*1. Dr. C. Subramani, SRMIST*
2. Mr. R. Ramanavasu, BHAVINI, Kalpakkam. rramanavasu@igcar.gov.in	*2. Dr. Srinivasan Mallan, Bannari Amman Institute of Technology, Coimbatore. srinivasanm@bitsathy.ac.in*	*2. Dr. S. Vidyasagar, SRMIST*

Course Code	18EEO304T	Course Name	POWER PLANT ENGINEERING	Course Category	O	Open Elective	L	T	P	C
							3	0	0	3

Pre-requisite Courses	Nil	Co-requisite Courses	Nil	Progressive Courses	Nil
Course Offering Department	Electrical and Electronics Engineering	Data Book / Codes/Standards	Nil		

Course Learning Rationale (CLR):	*The purpose of learning this course is to:*
CLR-1 :	*Provide an overview on power generation through various methods*
CLR-2 :	*Gain knowledge of power plant measurements and devices*
CLR-3 :	*Categorize the various analyzer In Power Plants*
CLR-4 :	*Get detailed knowledge on Nuclear power plant*
CLR-5 :	*Outline the concept of Renewable energy*
CLR-6 :	*Educate various concept in conventional and non-conventional resources*

Course Learning Outcomes (CLO):	*At the end of this course, learners will be able to:*	Learning 1: Level of Thinking (Bloom)	Learning 2: Expected Proficiency (%)	Learning 3: Expected Attainment (%)	PLO 1: Engineering Knowledge	PLO 2: Problem Analysis	PLO 3: Design & Development	PLO 4: Analysis, Design, Research	PLO 5: Modern Tool Usage	PLO 6: Society & Culture	PLO 7: Environment & Sustainability	PLO 8: Ethics	PLO 9: Individual & Team Work	PLO 10: Communication	PLO 11: Project Mgt. & Finance	PLO 12: Life Long Learning	PLO 13: PSO - 1	PLO 14: PSO - 2	PLO 15: PSO – 3
CLO-1 :	*Familiarize about different power generation process*	*2*	*80*	*75*	*H*	-	-	-	-	-	*H*	-	-	-	-	-	*H*	*M*	*H*
CLO-2 :	*Understand the various measurement techniques in power plant*	*3*	*80*	*75*	*H*	*M*	-	-	-	-	*M*	*M*	-	-	-	-	*M*	*M*	*M*
CLO-3 :	*Analyze important parameter for control of power plant*	*3*	*80*	*75*	*H*	*M*	-	-	-	-	*M*	*M*	-	-	-	-	*H*	*M*	*M*
CLO-4 :	*Summarize the working of Nuclear Reactor*	*3*	*80*	*75*	*H*	*M*	-	-	-	-	*M*	*M*	-	-	-	-	*H*	*H*	*M*
CLO-5 :	*Employ the acquired knowledge of Renewable energy in power plant*	*3*	*80*	*75*	*H*	-	-	-	-	-	*M*	*M*	-	-	-	-	*H*	*M*	*M*
CLO-6 :	*Gain knowledge on various concepts related to Power Plant Engineering*	*3*	*80*	*75*	*H*	*M*	-	-	-	-	*M*	*M*	-	-	-	-	*H*	*M*	*M*

Duration (hour)		9	9	9	9	9
S-1	SLO-1	*Brief survey of methods of power generation*	*Electrical measurements: Current, Voltage*	*Introduction of Flue gas*	*Basics of Nuclear Engineering*	*Hydro Electric Power Plants*
	SLO-2	*Thermal power*	*Power, Frequency, Power factor*	*oxygen analyzer*	*Layout and subsystems of Nuclear Power Plants*	*Elements of Hydro-electric power plant*
S-2	SLO-1	*Overview of Nuclear*	*Non– electrical parameters: Flow of feed water*	*Analysis of impurities in feed water*	*Fission reactions*	*Types of Dams*
	SLO-2	*Solar and Wind power*	*Flow of feed fuel*	*Analysis of impurities in feed steam*	*Working of Nuclear Reactors*	*classification of Hydro-electric power plants*
S-3	SLO-1	*Importance of instrumentation in power generation*	*Flow of feed air*	*Dissolved oxygen analyzer*	*Classification of Reactors*	*Hydro sources and power plants Energy strategies*
	SLO-2	*Factors affecting power plant*	*Steam pressure*	*Dissolved oxygen analyzer working principle*	*Nuclear reactor control loops*	*Size of the plant and choice of units*
S-4	SLO-1	*Building blocks for all types of power generation plants*	*Steam temperature*	*Methods of measuring dissolved oxygen*	*reactor dynamics*	*Typical Layout and associated components including Turbines*
	SLO-2	*Hydro and Thermal power plant*	*Drum level measurement*	*Chromatography-principles-applications*	*Boiling Water Reactor (BWR)*	*Turbine Governing*
S-5	SLO-1	*Building blocks for all types of power generation plants*	*Radiation detector*	*Types of Chromatography- Gas Chromatography*	*Pressurized Water Reactor (BWR)*	*Comparison of hydro and steam power plant*
	SLO-2	*Nuclear- Solar power*	*Smoke density measurement*	*Liquid Chromatography*	*CANada Deuterium-Uranium reactor (CANDU), Breeder*	*Cost of Hydroelectric Power Plant*
S-6	SLO-1	*Building blocks for all types of power generation plants-wind power*	*Dust monitor*	*PH meter*	*Gas Cooled Reactor*	*Principle, Construction and working of Wind energy*
	SLO-2	*Tidal power plant*	*flame monitoring*	*PH meter-design and working principle*	*Liquid Metal Cooled Reactor*	*Principle, Construction and working of tidal energy and Types of tidal power plants*
S-7	SLO-1	*Details of boiler process*	*speed vibration*	*Classifications of Analyzer*	*Economics of Nuclear Power Plants*	*Solar Photo Voltaic cell (SPV)*

	SLO-2	*P&I diagram of boiler*	*shell temperature*	*Fuel analyzer*	*Nuclear power plant in India*	*Solar thermal power systems use concentrated solar energy*
S-8	SLO-1	*Piping diagram of boiler*	*pedestal vibration*	*Portable fuel property analyzer*	*Uranium Enrichment*	*Geo Thermal power plants - types*
	SLO-2	*Instrumentation diagram of boiler*	*shaft vibration*	*Natural Gas analyzer*	*instrumentation diagram of different types of nuclear power plant*	*Biogas Photosynthesis and origin of biogas energy*
S-9	SLO-1	*Power plant performance efficiency*	*eccentricity measurement*	*Pollution monitoring instruments*	*Control Safety measures for Nuclear Power plants*	*Biogas energy resources*
	SLO-2	*Cogeneration system*	*temperature monitoring & control*	*Pollution control technologies*	*Waste Disposal Options for Coal and Nuclear Power Plants*	*Fuel Cell power systems*

Learning Resources	1. *K. Krishnaswamy, M. Ponnibala, Power Plant Instrumentation, PHI Learning Pvt Ltd.,2013.* 2. *Philip Kiameh, Power Plant Instrumentation and Controls, McGraw-Hill Professional, 2014.* 3. *David Lindsley, Power-plant Control and Instrumentation: The Control of Boilers and HRSG Systems, IET, London, 2000.*	4. *G. F. Gilman, Jerry Gilman, Boiler Control Systems Engineering, ISA, 2010.* 5. *G.R.Nagpal, Power Plant Engineering,khanna Publisher ,2005* 6. *M.M. El-Wakil, Power Plant Engineering, Tata McGraw – Hill Publishing Company Ltd., 2010*

Learning Assessment											
	Bloom's Level of Thinking	Continuous Learning Assessment (50% weightage)								Final Examination (50% weightage)	
		CLA – 1 (10%)		CLA – 2 (15%)		CLA – 3 (15%)		CLA – 4 (10%)#			
		Theory	Practice	Theory	Practice	Theory	Practice	Theory	Practice	Theory	Practice
Level 1	Remember Understand	40 %	-	30 %	-	30 %	-	30 %	-	30%	-
Level 2	Apply Analyze	40 %	-	40 %	-	40 %	-	40 %	-	40%	-
Level 3	Evaluate Create	20 %	-	30 %	-	30 %	-	30 %	-	30%	-
	Total	100 %		100 %		100 %		100 %		100 %	

CLA – 4 can be from any combination of these: Assignments, Seminars, Tech Talks, Mini-Projects, Case-Studies, Self-Study, MOOCs, Certifications, Conf. Paper etc.

Course Designers		
Experts from Industry	Experts from Higher Technical Institutions	Internal Experts
1. Mr. Sitanghsu Sekhar Biswas, Bhavini, biswas@bhavini.gov.in	*1. Dr. P. SOMASUNDARAM, CEG, Anna University, mpsomasundaram@annauniv.edu*	*1.Mr.R.Senthilkumar, SRMIST*
2.Mr Ramanavasu, Bhavini, ramanavasu@igcar.gov.in	*2.Dr.S.K.Patnaik, CEG, Anna University, skpatnaik@annauniv.edu*	*2.Dr.S.Padmini, SRMIST*

Course Code	18EEO305T	Course Name	ELECTRICAL DRIVES	Course Category	O	Open Elective	L	T	P	C
							3	0	0	3

Pre-requisite Courses	NIL	Co-requisite Courses	NIL	Progressive Courses	NIL
Course Offering Department	Electrical and Electronics Engineering	Data Book / Codes/Standards	Nil		

Course Learning Rationale (CLR):	*The purpose of learning this course is to:*
CLR-1 :	*Enrich the students on the basics of electric drives*
CLR-2 :	*Learn the concepts of DC motor drives and its speed control*
CLR-3 :	*Familiarize the power electronic based speed control of induction motor drives*
CLR-4 :	*Get an idea of speed control of synchronous motor*
CLR-5 :	*Understand the basic of digital speed control techniques*
CLR-6 :	*Get an idea about selection of drives and control schemes*

Course Learning Outcomes (CLO):	*At the end of this course, learners will be able to:*	Learning 1: Level of Thinking (Bloom)	2: Expected Proficiency (%)	3: Expected Attainment (%)	PLO 1: Engineering Knowledge	2: Problem Analysis	3: Design & Development	4: Analysis, Design, Research	5: Modern Tool Usage	6: Society & Culture	7: Environment & Sustainability	8: Ethics	9: Individual & Team Work	10: Communication	11: Project Mgt. & Finance	12: Life Long Learning	13: PSO - 1	14: PSO - 2	15: PSO – 3
CLO-1 :	*Acquire knowledge on the concept of electric drives*	*2*	*80*	*75*	*H*	*L*	*L*	*L*	-	-	-	-	-	-	-	-	*M*	*M*	-
CLO-2 :	*Analyze the concept & characteristics of dc motors*	*3*	*80*	*75*	*H*	*M*	*M*	*M*	*M*	-	-	-	-	-	-	-	*M*	*M*	-
CLO-3 :	*Interpret of speed-control of induction motors*	*3*	*80*	*75*	*H*	*M*	*M*	*M*	*M*	-	-	-	-	-	-	-	*M*	*M*	-
CLO-4 :	*Get detailed knowledge on synchronous motor drives*	*3*	*80*	*75*	*H*	*M*	*M*	*M*	-	-	-	-	-	-	-	-	*M*	*M*	-
CLO-5 :	*Apply the digital speed control techniques for various drives*	*2*	*80*	*75*	*H*	*M*	*L*	*L*	-	-	-	-	-	-	-	-	*M*	*M*	-
CLO-6 :	*Apply the drives and control schemes for real time applications*	*3*	*80*	*75*	*H*	*M*	*M*	*M*	*M*	-	-	-	-	-	-	-	*M*	*M*	-

Duration (hour)		9	9	9	9	9
S-1	SLO-1	*Electric drives - Advantage of electric drives*	*DC Motor Drives:-Introduction*	*Induction motor drives-Introduction*	*Synchronous motor drives – introduction*	*Digital technique in speed control*
	SLO-2	*Block diagram of electric drives*	*DC motor and their performance*	*Advantages and Disadvantages*	*Synchronous Motor Drives*	*Advantages of digital techniques*
S-2	SLO-1	*Selection of motor power rating*	*Braking methods*	*Stator control of IM*	*Speed control of synchronous motors*	*Limitations of digital techniques*
	SLO-2	*Thermal Modeling*	*Ward Leonard drives*	*Stator voltage control*	*Synchronous motors – Frequency control*	*Speed control system with multirate sampling*
S-3	SLO-1	*Thermal model of motor for heating and cooling*	*Transformer fed DC drive*	*Stator Frequency control*	*Synchronous motors – Start with Prime mover & damper winding*	*Microprocessor based control - introduction*
	SLO-2	*Thermal model of motor for heating and cooling - derivation*	*Uncontrolled rectifier fed DC drive*	*Stator Frequency control – advantages and disadvantages*	*Synchronous motors –damper winding*	*Microprocessor based control of DC drive*
S-4	SLO-1	*Classes of motor duty cycle*	*Single phase half controlled rectifier fed DC drives - operation*	*V/F control*	*Voltage Source Inverter fed synchronous motor*	*Microprocessor based control of induction motor drive*
	SLO-2	*Determination of motor rating*	*Single phase half controlled rectifier fed DC drives - derivation*	*Closed loop V/F control*	*Chopper fed VSI with synchronous motor*	*Microprocessor based control of synchronous motor drive*
S-5	SLO-1	*Control of electric drives*	*Single phase fully controlled rectifier fed DC drive- operation*	*Cycloconverter - introduction*	*Current Source Inverter fed synchronous motor*	*Selection of drives for paper mill*
	SLO-2	*Modes of operation*	*Single phase fully controlled rectifier fed DC drive- derivation*	*Cycloconverter fed induction motor drive*	*Chopper fed CSI with synchronous motor*	*Control schemes for paper mill*
S-6	SLO-1	*Speed control of electric drives*	*Chopper - introduction*	*VSI Inverter fed induction motor drives*	*Cycloconverter fed synchronous motors*	*Selection of drives for steel rolling mill*
	SLO-2	*Drive classifications*	*Chopper controlled DC drives*	*Comparison: VSI and CSI*	*Limitations - Cycloconverter fed synchronous motors*	*Control schemes for steel rolling mill*
S-7	SLO-1	*Closed loop control of drives*	*Time ratio control*	*Rotor control*	*Self control*	*Selection of drives for lift*
	SLO-2	*Speed, torque and current control*	*Current limit control*	*Rotor resistance control*	*Separate control*	*Control schemes for lift*
S-8	SLO-1	*Multiquadrant operation of electrical drive*	*Single, two quadrant operations*	*Slip power recovery schemes*	*Open loop operation of synchronous drive*	*Selection of drives for crane*

	SLO-2	*Torque equation for rotating system*	*Four quadrant operation*	*Static Kramer & static scherbius scheme*	*Closed loop operation of synchronous drive*	*Control schemes for crane*
S-9	SLO-1	*Speed torque characteristics*	*Simulation of 1-phase rectifier fed DC motor*	*Simulation of three phase VSI using SPWM*	*Closed loop operation of power factor control*	*FPGA based control of electric drives*
	SLO-2	*Applications of electric drives*	*Simulation of 3-phase rectifier fed DC motor*	*Simulation of three phase VSI using pulse generator*	*Applications synchronous drive*	*Application of Digital technique in speed control*

Learning Resources	1. *G. K. Dubey, Fundamentals of Electrical Drives, Second Edition, CRC Press, 2010.* 2. *R. Krishnan, Electric Motor Drives: Modeling, Analysis and Control, Second Edition, Prentice Hall, 2008.*	3. *W. Leonhard, Control of Electric Drives, Springer Science & Business Media, Third Edition, 2001.* 4. *https://onlinecourses-archive.nptel.ac.in/.*

Learning Assessment

	Bloom's Level of Thinking	Continuous Learning Assessment (50% weightage)								Final Examination (50% weightage)	
		CLA – 1 (10%)		CLA – 2 (15%)		CLA – 3 (15%)		CLA – 4 (10%)#			
		Theory	Practice	Theory	Practice	Theory	Practice	Theory	Practice	Theory	Practice
Level 1	Remember Understand	*40 %*	-	*30 %*	-	*30 %*	-	*30 %*	-	*30%*	-
Level 2	Apply Analyze	*40 %*	-	*40 %*	-	*40 %*	-	*40 %*	-	*40%*	-
Level 3	Evaluate Create	*20 %*	-	*30 %*	-	*30 %*	-	*30 %*	-	*30%*	-
	Total	100 %		100 %		100 %		100 %		100 %	

CLA – 4 can be from any combination of these: Assignments, Seminars, Tech Talks, Mini-Projects, Case-Studies, Self-Study, MOOCs, Certifications, Conf. Paper etc.,

Course Designers

Experts from Industry	Experts from Higher Technical Institutions	Internal Experts
1. Mr. A.Kannan, Seshasayee paper and board limited akannan@sbppapers.com	*1. Dr. S. Ramareddy, Jerusalem College of Engineering,srr.victory@gmail.com*	*1. R.Palanisamy, SRMIST*
2. Mr. M.Jayakumar,Danfoss, Industries Pvt Ltd.,Jaya.kumar@danfoss.com	*2. Dr. A. Venkadesan, NIT Puducherry, venkadesan@nitpy.ac.in*	*2. Dr.K.Mohanraj, SRMIST*

Course Code	18EEO306T	Course Name	ENERGY CONSERVATION	Course Category	O	Open Elective	L	T	P	C
							3	0	0	3

Pre-requisite Courses	Nil	Co-requisite Courses	Nil	Progressive Courses	Nil
Course Offering Department	Electrical and Electronics Engineering	Data Book / Codes/Standards	Nil		

Course Learning Rationale (CLR):	*The purpose of learning this course is to:*
CLR-1 :	*Outline the concepts of world energy scenario in industries*
CLR-2 :	*Describe the basics of electrical system*
CLR-3 :	*Impart knowledge on various methods of improving energy efficiency in industries*
CLR-4 :	*Give an overview about the energy policies, energy planning and policy making in India*
CLR-5 :	*Provide an understanding of the basics of energy conservation method and energy auditing in industries*
CLR-6 :	*Create overall structure of energy conservation starting from environmental aspects to energy management systems*

Course Learning Outcomes (CLO):	*At the end of this course, learners will be able to:*	Learning 1: Level of Thinking (Bloom)	Learning 2: Expected Proficiency (%)	Learning 3: Expected Attainment (%)	PLO 1: Engineering Knowledge	PLO 2: Problem Analysis	PLO 3: Design & Development	PLO 4: Analysis, Design, Research	PLO 5: Modern Tool Usage	PLO 6: Society & Culture	PLO 7: Environment & Sustainability	PLO 8: Ethics	PLO 9: Individual & Team Work	PLO 10: Communication	PLO 11: Project Mgt. & Finance	PLO 12: Life Long Learning	PLO 13: PSO - 1	PLO 14: PSO - 2	PLO 15: PSO – 3
CLO-1 :	*Gain knowledge of world energy scenario*	2	75	75	H	-	-	-	-	-	-	-	-	-	-	-	L	L	L
CLO-2 :	*Understand the concepts of electrical system*	3	75	75	H	-	-	-	-	-	-	-	-	-	-	-	M	M	M
CLO-3 :	*Assess the energy efficiency in industrial system*	3	75	75	H	-	-	-	-	-	H	H	-	-	-	-	M	H	M
CLO-4 :	*Analyse the energy policies, energy planning and policy making in india*	3	75	75	H	-	-	-	-	-	L	H	-	-	-	-	M	M	H
CLO-5 :	*Correlate with various methods of energy conservation*	3	75	75	H	-	-	-	-	-	L	H	M	M	-	-	M	H	M
CLO-6 :	*Implement energy conservation methods and laws to save energy*	3	75	75	H	-	-	-	-	-	M	H	M	M	-	-	M	M	H

Duration (hour)		9	9	9	9	9
S-1	SLO-1	*Energy classificatios*	*Introduction Electrical Systems*	*Air condition and refrigeration*	*Introduction to energy policy*	*Investment - need, appraisal and criteria*
	SLO-2	*Power Past & Present scenario of World*	*Electrical network types and classifications*	*Diesel Generator*	*National energy policy in the last plan periods*	*Financial analysis techniques*
S-2	SLO-1	*Sectorial energy consumption*	*HT supply*	*Energy Efficiency in Building*	*ISO-50001, PDCA, PAT scheme*	*Simple payback period*
	SLO-2	*domestic, industrial and other sectors*	*LT supply*	*Energy Efficiency in Building*	*BEE & State Development Agencies & EESL Programmes*	*Return on investment*
S-3	SLO-1	*energy needs of growing economy, energy intensity*	*Transformers and its operation*	*Savings opportunities in HVAC*	*Municipal & Agriculture DSM Initiatives*	*Net present value, internal rate of return, cash flows*
	SLO-2	*long term energy scenario, energy pricing*	*Types of transformer*	*Fans and blowers*	*Energy use and Energy supply*	*Net present value, internal rate of return, cash flows*
S-4	SLO-1	*energy security, energy conservation*	*Cables – and its construction*	*Conservation opportunities*	*Overview of renewable energy policy and the Five Year Plan programme*	*Risk and sensitivity analysis*
	SLO-2	*energy conservation importance, energy strategy for the future*	*Types and Cable Sizing*	*Pumps - CASE STUDY*	*Standards and Labelling Programme EEC initiatives in Other Sectors*	*Financing options*
S-5	SLO-1	*National Energy consumption Data*	*Concept of Capacitors*	*Control strategies*	*Basic concept of Input-Output analysis*	*Energy performance contracts and role of Energy Service Companies (ESCOs)*
	SLO-2	*Energy Pricing*	*Types of Capacitors*	*Conservation opportunities*	*Concept of energy multiplier and Implication of energy multiplier for analysis of regional and national energy policy Organizational structure*	*Energy Monitoring*
S-6	SLO-1	*Environmental aspects associated with energy utilization*	*Power Factor Improvemen*	*Cooling Tower -performance*	*key developments and changes in India's energy policies and planning in the context of energy efficiency and environmental concerns*	*Targeting: Defining monitoring & targeting*

	SLO-2	*Environmental aspects associated with energy conservation*	*Harmonics*	*Efficient system operation*	*key developments and changes in India's energy policies and planning in the context of energy efficiency and environmental concerns*	*Targeting: Defining monitoring & targeting*
S-7	SLO-1	*Energy Auditing: Needs, Types,*	*Electric Motors – Motor Efficiency Computation*	*Efficient system operation*	*regulatory frameworks and reforms across various energy sectors*	*elements of monitoring & targeting*
	SLO-2	*Methodology and Barriers*	*Energy Efficient Motors*	*Validation of energy saving using application software*	*regulatory frameworks and reforms across various energy sectors*	*Data and information-analysis, techniques*
S-8	SLO-1	*Role of Energy Managers*	*Illumination – Lux, Lumens*	*Energy saving opportunities*	*Energy Policies success stories, failures*	*Energy consumption*
	SLO-2	*Needs of Energy Managers*	*Types of lighting, Efficacy*	*Energy saving opportunities*	*Energy saving potential of technology*	*Production, cumulative sum of differences (CUSUM).*
S-9	SLO-1	*Instruments for energy auditing*	*LED Lighting And types*	*Assessment of cooling towers*	*Energy tariffs and Energy Instrument*	*Energy Management Information Systems (EMIS)*
	SLO-2	*Energy conservation*	*Scope Of Encon In Illumination*	*Assessment of cooling towers*	*CASE STUDY for energy tariffs in industry*	*Energy Management Information Systems (EMIS)*

Learning Resources	*1. Witte. L.C., P.S. Schmidt, D.R. Brown, Industrial Energy Management and Utilisation, Hemisphere Publ, Washington, 1988* *2. Callaghn, P.W. Design and Management for Energy Conservation, Pergamon Press, Oxford, 1981* *3. Energy Manager Training Manual (4 Volumes) available at www.energymanager training.com, a website administered by Bureau of Energy Efficiency (BEE), a statutory body under Ministry of Power, Government of India, 2004*	*4. R Loulou, P R Shukla and A Kanudia, Energy and Environment Policies for a sustainable Future, Allied Publishers Ltd, New Delhi, 1997* *5. Handbook on Energy Efficiency, TERI, New Delhi, 2001* *6. https://www.edx.org/course/incorporating-renewable-energy-in-electricity-grids-2*

Learning Assessment

	Bloom's Level of Thinking	Continuous Learning Assessment (50% weightage)								Final Examination (50% weightage)	
		CLA – 1 (10%)		CLA – 2 (15%)		CLA – 3 (15%)		CLA – 4 (10%)#			
		Theory	Practice	Theory	Practice	Theory	Practice	Theory	Practice	Theory	Practice
Level 1	Remember Understand	*40 %*	-	*30 %*	-	*30 %*	-	*30 %*	-	*30%*	-
Level 2	Apply Analyze	*40 %*	-	*40 %*	-	*40 %*	-	*40 %*	-	*40%*	-
Level 3	Evaluate Create	*20 %*	-	*30 %*	-	*30 %*	-	*30 %*	-	*30%*	-
	Total	100 %		100 %		100 %		100 %		100 %	

CLA – 4 can be from any combination of these: Assignments, Seminars, Tech Talks, Mini-Projects, Case-Studies, Self-Study, MOOCs, Certifications, Conf. Paper etc.

Course Designers		
Experts from Industry	Experts from Higher Technical Institutions	Internal Experts
1. Dr. P. Dharmalingam, Executive Director, EnsavePvt Ltd, pdlingam@gmail.com	*1. Dr.M.Premalathar,NIT-Trichy, latha@nitt.edu*	*1. Mr. M. Sadees, SRMIST*
2. Mr. N. Saravanan, Engineering Manageer Electrical, L&T Ltd, n-saravanan@lntecc.com	*2. Dr.Ruben sudhakar D, NIT-Trichy, rubensudhakar@nitt.edu*	*2. Dr. D. Sattianadan, SRMIST*

Course Code	18EEO307T	Course Name	ELECTRIC POWER UTILIZATION AND ILLUMINATION	Course Category	O	Open Elective	L	T	P	C
							3	0	0	3

Pre-requisite Courses	Nil	Co-requisite Courses	Nil	Progressive Courses	Nil
Course Offering Department	Electrical and Electronics Engineering	Data Book / Codes/Standards	Nil		

Course Learning Rationale (CLR):	*The purpose of learning this course is to:*
CLR-1 :	*Outline the basic concepts of conventional and modern electric heating methods used for various applications*
CLR-2 :	*Impart knowledge on fundamentals of illumination technology and design the lighting schemes*
CLR-3 :	*Educate the students on electroplating , electrodeposition and electroforming*
CLR-4 :	*Enumerate the concept of electric traction systems and braking methodologies*
CLR-5 :	*Understand and analyze the working of electric-hybrid vehicles and design the illumination schemes for smart building .*
CLR-6 :	*Create a deep knowledge on the electric power utilization and model the illumination schemes*

Course Learning Outcomes (CLO):	*At the end of this course, learners will be able to:*	Learning			Program Learning Outcomes (PLO)														
		1	2	3	1	2	3	4	5	6	7	8	9	10	11	12	13	14	15
		Level of Thinking (Bloom)	Expected Proficiency (%)	Expected Attainment (%)	Engineering Knowledge	Problem Analysis	Design & Development	Analysis, Design, Research	Modern Tool Usage	Society & Culture	Environment & Sustainability	Ethics	Individual & Team Work	Communication	Project Mgt. & Finance	Life Long Learning	PSO - 1	PSO - 2	PSO – 3
CLO-1 :	*Understand electric heating, welding and implement the modern methodologies for various applications*	2	80	75	M	M	M	-	-	-		-	-	-	-	-	M	M	-
CLO-2 :	*Gain knowledge on basic laws of illumination and design the lighting system*	3	80	75	H	H	H	H	M	-	M	M	-	-	-	-	M	M	M
CLO-3 :	*Apply the various process like electroplating, electrolysis and electroforming for modern applications*	2	80	75	M	M	M	M	M	-	-	-	-	-	-	-	M	M	-
CLO-4 :	*Interpret the design of electric traction systems*	3	80	75	H	H	H	H	-	-	-	-	-	-	-	-	M	M	-
CLO-5 :	*Obtain an in depth knowledge on the concepts of electric, hybrid vehicles and model the lighting schemes for smart building*	3	80	75	H	H	M	M	-	-	-	M	-	-	-	-	M	M	M
CLO-6 :	*Design a illumination schemes for buildings along with a in depth knowledge of power utilization concepts*	3	80	75	H	H	M	M	M	-	M	M	-	-	-	-	M	M	M

Duration (hour)		9	9	9	9	9
S-1	SLO-1	*Principle of heating, modes of transfer*	*Review of laws of illumination*	*Fundamental principles of extraction*	*Electric Traction*	*History of electric and hybrid vehicles*
	SLO-2	*Methods of Electrical Heating*	*Luminous efficacy*	*Refining of metals*	*Traction Principles*	*Vehicle motion*
S-2	SLO-1	*Types of electric furnance: resistance*	*Lighting Calculations*	*Electroplating concepts*	*Types of traction systems*	*Dynamic equation for the vehicle*
	SLO-2	*Arc, dielectric furnance*	*Lighting sources and its types*	*Methods of electroplating*	*Services and supply systems for traction*	*Configuration of electrical vehicles*
S-3	SLO-1	*Microwave, induction heating*	*Lighting sources in domestic application*	*Estimation of power and current for depositing metals*	*Traction motor characteristics*	*Tractive effort, force and gear ratio for electric vehicle*
	SLO-2	*Eddy current heating*	*Street Lighting*	*Factors affecting electro deposition process*	*equation of train motion*	*Transmission requirement for electric cars*
S-4	SLO-1	*Types of welding: Arc*	*Industrial lighting*	*Electrolysis process and its chemistry*	*Speed time curve*	*Vehicle performance analysis*
	SLO-2	*Resistance welding*	*Indoor lighting*	*Electrodes,*	*Energy and specific energy consumption*	*Energy consumption*
S-5	SLO-1	*Air conditioning working*	*Outdoor lighting*	*Cell.potential, Emf of Galvanic cell*	*Quantitative analysis of speed time curve*	*Drives for Electric cars*
	SLO-2	*Different types of Air conditioning system*	*Design of lighting*	*Nernst equation*	*Quantitative analysis of energy consumption for drives used in traction*	*Braking*
S-6	SLO-1	*Heating of buildings.*	*light pollution and light trespass*	*Concept of equilibrium in electrochemical cells*	*Quantitative analysis of specific energy consumption*	*Control equipments of electric car*
	SLO-2	*Power supply for heating and welding*	*photometry Energy consideration*	*Faradays law of electrolysis*	*Tramways*	*Auxillary equipments*
S-7	SLO-1	*comparison of types of heating and welding*	*IES,ANSI STANDARDS for Lighting schemes*	*Electroforming process*	*Railways trolley buses*	*Introduction to smart buildings*
	SLO-2	*Quantitative analysis of Electric heating*	*Polar curves of different types of sources*	*Modern applications of electroplating,*	*Riding index*	*Design of lighting schemes in smart building*
S-8	SLO-1	*Quantitative analysis of welding*	*Rousseau's Construction*	*Applications of Electrolysis and Electroforming*	*Quantitative analysis of Riding index*	*Intelligent illuminance control in smart building*
	SLO-2	*Modern trends in electric heating*	*Quantitative analysis of illumination*	*Applications of Electroforming*	*Disadvantages of conventional traction over modern days drive*	*Quantitative analysis of electric vehicle tractive force calculations*

S-9	SLO-1	*Modern trends in welding process*	*Energy efficient*	*Difference between electroplating electroforming and electrolysis*	*Introduction to green energy for traction*	*Quantitative analysis on gear ratio*
	SLO-2	*Applications of heating and welding*	*Lighting scheme of the building using simulation tools*	*Electroplating design tools*	*Pros and cons of electric and non electric traction system*	*Quantitative analysis on efficiency calculations*

Learning Resources	*1. S.Sivanagaraju,M.Balasubba Reddy,D.Srilatha, Generation and Utilization of Electrical energy, Pearson publication,2010.* *2. Wadhwa C.L., Generation, Distribution and Utilization of Electrical Energy, New Age International publishers, 3rd edition, 2010.*	*3. Mehrdad Ehsani, Yimi Gao, Sebastian E. Gay, Ali Emadi, Modern Electric, Hybrid Electric and Fuel Cell Vehicles: Fundamentals, Theory and Design, CRC Press, 2004.* *4. G.C.Garg, Utilization ofElectric Powerand Electric Traction, KhannaPublishers, 2006.* *5. https://swayam.gov.in/explorer?ncCode=NPTEL*

Learning Assessment

	Bloom's Level of Thinking	Continuous Learning Assessment (50% weightage)								Final Examination (50% weightage)	
		CLA – 1 (10%)		CLA – 2 (15%)		CLA – 3 (15%)		CLA – 4 (10%)#			
		Theory	Practice	Theory	Practice	Theory	Practice	Theory	Practice	Theory	Practice
Level 1	Remember Understand	*40 %*	-	*30 %*	-	*30 %*	-	*30 %*	-	*30%*	-
Level 2	Apply Analyze	*40 %*	-	*40 %*	-	*40 %*	-	*40 %*	-	*40%*	-
Level 3	Evaluate Create	*20 %*	-	*30 %*	-	*30 %*	-	*30 %*	-	*30%*	-
	Total	100 %		100 %		100 %		100 %		100 %	

CLA – 4 can be from any combination of these: Assignments, Seminars, Tech Talks, Mini-Projects, Case-Studies, Self-Study, MOOCs, Certifications, Conf. Paper etc.

Course Designers

Experts from Industry	Experts from Higher Technical Institutions	Internal Experts
1. Mr. A.Kannan, Seshasayee paper and board limited akannan@sbppapers.com	*1. Dr. S. Arul Daniel, NIT Trichy, daniel@nitt.edu*	*1. Mrs.R.Rajarajeswari,SRMIST*
2. Dr. P. Dharmalingam, Executive Director, EnsavePvt Ltd, pdlingam@gmail.com	*2. Dr. R.Ramesh, CEG, rramesh@annauniv.edu*	*2. Dr. D.Suchitra, SRMIST*

Course Code	18EEO308T	Course Name	ELECTRICAL POWER SYSTEM	Course Category	O	Open Elective	L	T	P	C
							3	0	0	3

Pre-requisite Courses	Nil	Co-requisite Courses	Nil	Progressive Courses	Nil
Course Offering Department	Electrical and Electronics Engineering	Data Book / Codes/Standards	Nil		

Course Learning Rationale (CLR):	*The purpose of learning this course is to:*
CLR-1 :	*Understand the fundamentals of power stations*
CLR-2 :	*Understand economics of power generation*
CLR-3 :	*Acquire knowledge on AC power supply schemes and insulators*
CLR-4 :	*Understand the basics of substations*
CLR-5 :	*Understand the design of cables and protection equipments*
CLR-6:	*Acquire knowledge of transmission lines and cables*

Course Learning Outcomes (CLO):	*At the end of this course, learners will be able to:*	Learning			Program Learning Outcomes (PLO)														
		1	2	3	1	2	3	4	5	6	7	8	9	10	11	12	13	14	15
		Level of Thinking (Bloom)	Expected Proficiency (%)	Expected Attainment (%)	Engineering Knowledge	Problem Analysis	Design & Development	Analysis, Design, Research	Modern Tool Usage	Society & Culture	Environment & Sustainability	Ethics	Individual & Team Work	Communication	Project Mgt. & Finance	Life Long Learning	PSO - 1	PSO - 2	PSO – 3
CLO-1 :	*Understand the various aspects of power station*	1	75	75	H	-	-	-	-	-	-	-	-	-	-	-	M	-	-
CLO-2 :	*Execute the performance of transmission lines*	2	75	75	H	L	-	-	-	-	M	-	-	-	-	-	M	-	-
CLO-3 :	*Summarize the AC power supply schemes and DC power transmission*	2	75	75	H	L	-	-	-	-	-	-	-	-	-	-	M	-	-
CLO-4 :	*Analyse the transmission substation and grounding*	2	75	75	H	M	-	-	-	-	-	-	-	-	-	-	M	-	-
CLO-5 :	*Enrich the types of cables and protection equipments*	1	75	75	H	H	-	-	-	-	-	-	-	-	-	-	M	-	-
CLO-6 :	*Understand the supply systems, design of transmission lines and cables*	2	75	75	H	H	-	-	-	-	M	-	-	-	-	-	M	-	-

Duration (hour)		9	9	9	9	9
S-1	SLO-1	*Importance of Electrical Energy*	*Structure of Electric Supply System*	*Typical AC power supply scheme*	*Introduction to substation*	*Underground cables*
	SLO-2	*Generation of Electrical Energy*	*Variable load on power station*	*Types of power transmission*	*Classification of substation*	*Construction of cables*
S-2	SLO-1	*Sources of Energy*	*Types of loads*	*Comparison of DC and AC transmission*	*Comparison between outdoor and indoor sub stations*	*Properties of insulation materials*
	SLO-2	*Comparison of Energy Sources, Units of Energy*	*Load curves and selection of generating units*	*Advantages of high transmission voltage*	*Step up substation*	*Insulation materials for cables*
S-3	SLO-1	*Relationship among energy units*	*Base load and peak load on power station*	*Limitations of high transmission voltage*	*Primary grid substation*	*Classification of cables*
	SLO-2	*Arrangement of Steam Power Station*	*Methods of meeting the load*	*Elements of a transmission line*	*Secondary substation*	*Switchgear*
S-4	SLO-1	*Choice of site and Equipment's of Steam Power Stations*	*Economics of power generation*	*Economics of power transmission,*	*Distribution substation*	*Essential features of switchgear*
	SLO-2	*Hydro – electric Power Station*	*Cost of electrical energy*	*Economic choice of conductor size*	*Symbols for equipment in sub station*	*Faults in power system*
S-5	SLO-1	*Choice of site and Equipment's of Hydro Power Stations*	*Objective of tariff*	*Economic choice of Transmission voltage*	*Equipments in a substation*	*Circuit breakers*
	SLO-2	*Diesel Power Station*	*Characteristics of tariff*	*Requirements of satisfactory electric power*	*Key diagram of a substation*	*Arc phenomenon*
S-6	SLO-1	*Nuclear Power Plant*	*Types of tariff*	*Main components of overhead lines*	*Need for grounding*	*Types of circuit breakers*
	SLO-2	*Connected load, Maximum demand, Average load*	*Types of power factor tariff*	*Conductor materials*	*Grounding equipments*	*Need for Fuses*
S-7	SLO-1	*Calculation of Load duration curve, Types of loads*	*Power factor*	*Line supports*	*System grounding*	*Characteristics of fuse element*
	SLO-2	*Load curves and selection of generating units*	*Power triangle*	*Types of Insulators*	*Neutral grounding*	*Fuse element materials*
S-8	SLO-1	*Energy, power, efficiency calculations of conventional power plant*	*Disadvantages of low power factor*	*Factors affecting Transmission*	*Advantages of neutral grounding*	*Types of Fuses*

	SLO-2	*Basic layout of sustainable energy resources –Photovoltaic system*	*Causes of low power factor*	*Constants of a transmission line*	*Voltage surge*	*Low voltage fuses*
S-9	SLO-1	*Wind energy*	*Power factor improvement- static capacitor*	*Resistance of a transmission line*	*Causes of over voltages*	*High voltage fuses*
	SLO-2	*Different operating voltages of generation, transmission and distribution*	*Synchronous condenser*	*Inductance of a transmission line*	*Internal causes of overvoltages*	*Difference between a fuse and circuit breaker*

Learning Resources	1. *C.L.Wadhwa, Electrical Power systems, 7th edition, New age international publisher, Delhi 2017* 2. *P.S.R. Murty, Electrical Power Systems, 1st edition, Butterworth-Heinemann publisher, 2017*	3. *Metha.V.K and Rohit Metha, Principles of Power System, 3rd edition , S.Chand, 2005.* 4. *Despande.M.V, Electrical Power Systems Design, 1st edition, Tata McGraw Hill Publishing Company, New Delhi, 2009* 5. *https://www.coursera.org/learn/electric-power-systems*

Learning Assessment

	Bloom's Level of Thinking	Continuous Learning Assessment (50% weightage)								Final Examination (50% weightage)	
		CLA – 1 (10%)		CLA – 2 (15%)		CLA – 3 (15%)		CLA – 4 (10%)#			
		Theory	Practice	Theory	Practice	Theory	Practice	Theory	Practice	Theory	Practice
Level 1	Remember Understand	*40 %*	-	*30 %*	-	*30 %*	-	*30 %*	-	*30%*	-
Level 2	Apply Analyze	*40 %*	-	*40 %*	-	*40 %*	-	*40 %*	-	*40%*	-
Level 3	Evaluate Create	*20 %*	-	*30 %*	-	*30 %*	-	*30 %*	-	*30%*	-
	Total	100 %		100 %		100 %		100 %		100 %	

CLA – 4 can be from any combination of these: Assignments, Seminars, Tech Talks, Mini-Projects, Case-Studies, Self-Study, MOOCs, Certifications, Conf. Paper etc.,

Course Designers

Experts from Industry	Experts from Higher Technical Institutions	Internal Experts
1.Dr.S.Sambath, TANGEDCO, eses.eng@gmail.com	*1.Dr Subhransu Sekhar Dash, Government College of Engineering, Keonjhar, Subhransudash_fee@gcekjr.ac.in*	*1. Mrs.C.Nithya, SRMIST*
2.Mr.Manjunath rao, Alstrom,manjunath.rao1103@gmail.com	*2. Dr. P. Somasundaram, CEG, Anna University, mpsomasundaram@annauniv.edu*	*2. Dr.J.Preetha Roselyn, SRMIST*

Course Code	18ECO101T	Course Name	SHORT RANGE WIRELESS COMMUNICATION	Course Category	O	Open Elective	L	T	P	C
							3	0	0	3

Pre-requisite Courses	Nil	Co-requisite Courses	Nil	Progressive Courses	Nil
Course Offering Department	Electronics and Communication Engineering	Data Book / Codes/ Standards	Nil		

Course Learning Rationale (CLR):	*The purpose of learning this course is to:*
CLR-1 :	*Overview of different modulation scheme and wireless system*
CLR-2 :	*understand the various components used to implement a short-range radio system.*
CLR-3 :	*Analysis of the various kinds of transmitters and receivers used for Short range Wireless Communication.*
CLR-4 :	*know about regulations and standards of ISM band communications*
CLR-5 :	*Design and analysis of short-range radio like UWB and Visible light.*

Course Learning Outcomes (CLO):	*The purpose of this course is to :*	Learning 1: Level of Thinking (Bloom)	Learning 2: Expected Proficiency (%)	Learning 3: Expected Attainment (%)	PLO 1: Engineering Knowledge	PLO 2: Problem Analysis	PLO 3: Design & Development	PLO 4: Analysis, Design, Research	PLO 5: Modern Tool Usage	PLO 6: Society & Culture	PLO 7: Environment & Sustainability	PLO 8: Ethics	PLO 9: Individual & Team Work	PLO 10: Communication	PLO 11: Project Mgt. & Finance	PLO 12: Life Long Learning	PLO 13: PSO - 1	PLO 14: PSO - 2	PLO 15: PSO – 3
CLO-1 :	*cover the various forms of signals used for information transmission and modulation, and overall wireless system properties.*	2	80	70	L	-	-	-	-	-	-	-	-	-	-	-	-	H	-
CLO-2 :	*present various component types that can be used to implement a short-range radio system.*	2	85	75	-	-	M	L	-	-	-	-	-	-	-	-	H	-	-
CLO-3 :	*describe the various kinds of transmitters and receivers.*	2	75	70	-	-	H	M	-	-	-	-	-	-	-	-	-	H	-
CLO-4 :	*covers regulations and standards of ISM band communications*	2	85	80	M	-	-	-	-	-	-	-	-	-	-	-	M	-	-
CLO-5 :	*covers some of the most important new developments in short-range radio like UWB and Visible light.*	2	85	75	-	-	L	M	-	-	-	-	-	-	-	-	-	-	H

Duration (hour)		Wireless Systems	Baseband Coding basics	RF transceivers	Wireless standards	Optical wireless Technologies
		9	9	9	9	9
S-1	SLO-1	*Introduction to wireless systems*	*Types of Antennas-Dipole, groundplane, loop*	*RF Receivers- Introduction*	*Technical Background to the WPAN Concept - Regulation and Standardization Issues*	*Fundamentals of UROOF Technologies*
	SLO-2	*Reasons for the Spread of Wireless Applications*	*Helical, Patch antennas*	*RF Source-Frequency control*	*European Consortium: Overview*	*Conversion from RF to Optical Domain*
S-2	SLO-1	*Characteristics of Short-range Radio*	*Antenna Characteristics-Impedence, directivity and gain, Effective area*	*Modulation types*	*Millimeter-Wave Applications and Services - PAN scenarios in the IST Magnet project*	*Conversion from Optical to RF Domain*
	SLO-2	*Wireless Applications*	*Polarization, Bandwidth, Antenna factor*	*Amplifiers*	*Typical LDR services connected to the IST-FP6 MAGNET project*	*Optical Microwave Mixing Used for UWB Over Systems*
S-3	SLO-1	*Elements of Wireless Communication Systems-Transmitter*	*Baseband Data Format and Protocol - Radio Communication Link Diagram*	*Impedance matching in transmitter and receivers*	*Frequency Regulation and Standardization Issues - Optional UM4 usage models issued from the IEEE802.15.3c TG*	*Integrated UROOF Transceiver (IUT)*
	SLO-2	*Elements of Wireless Communication Systems-Receiver*	*Code Hopping*	*Filtering*	*Flexible antenna gain, 60 GHz regulation status for wireless transmissions.*	*Mixed Wireless-wired UROOF Channel, Carrier-to-noise Ratio*
S-4	SLO-1	*Wireless Local Area Networks (WLAN)-WIFI*	*Baseband Coding-Digital systems*	*SAW band pass filter matching*	*Channel Propagation Characterization and Modeling- 60 GHz Propagation Measurements*	*Laser and Photodetector Noise Baseline,*
	SLO-2	*Network Architecture*	*Wireless Microphone System*	*Tuned Radio Frequency (TRF)*	*Propagation Channel Characterization*	*Clipping Distortion Implication , Latency*
S-5	SLO-1	*Bluetooth Transceiver*	*RF Frequency and Bandwidth-factors*	*ASH Receiver*	*Multipath Propagation Modeling*	*Modelling the Propagation through the Fibre*
	SLO-2	*Bluetooth Modes*	*Propagation characteristics*	*Super regenerative Receiver –Block diagram*	*France Telecom Propagation Channel Models*	*Analysis of UWB Technologies for UROOF- Comparing UWB Technologies for Radio-over- fibre*

S-6	SLO-1	*Zigbee Architecture, Frame Structure*	*Modulation types*	*Super regenerative Receiver – Operation*	*MSK-Based System for LOS Gb/s Communications*	*MB-OFDM Over Multimode Fibre*
	SLO-2	*Applications and conflicts*	*Modulation for digital event communication*	*Super heterodyne Receiver-Block diagram*	*System architecture for an MSK-based system to operate in a LOS channel.*	*All-optical Generation of Ultra-wideband Impulse Radio*
S-7	SLO-1	*Ultra-wideband Technology-Bit Sequence detection*	*Continuous Digital Communication*	*Super heterodyne Receiver- Operation*	*OFDM-Based System for NLOS Gb/s Communications*	*Operation Principles and Theoretical Approach*
	SLO-2	*UWB Block Diagram*	*Advanced Digital Modulation*	*Direct Conversion Receiver- Block diagram*	*System architecture for an OFDM-based system to operate in a NLOS channel.*	*VLC Link –Transmitter*
S-8	SLO-1	*Wireless Modules-Japan,UK,USA*	*Spread Spectrum-DHSS*	*Direct Conversion Receiver- Operation*	*System Design Aspects-Channel Plan*	*The VLC Channel*
	SLO-2	*Wireless Modules-Austria, Honeywell, Norway*	*Spread Spectrum-FHSS*	*Digital Receivers-Software radio*	*60 GHz Channel Characteristics, Baseband Modulation: OFDM versus Single Carrier*	*Receiver, Modulation*
S-9	SLO-1	*FCC Regulations-Terms and definitions*	*RFID-transceiver*	*Software radio operation*	*60 GHz Analog Front-End Architectures*	*Potential Applications*
	SLO-2	*Nomenclature for defining Emission, modulation and transmission*	*Design issues for RFID*	*Repeaters*	*Multiple Antenna Technologies*	*Challenges*

Learning Resources	1. *Alan Bensky, "Short range Wireless Communications-Fundamentals of RF system design and Applications", Elsevier Inc, 2004* 2. *Antti V. Raisanen, Arto Lehto, "Radio engineering for wireless communication and sensor applications", Artech House, 2003*	3. *Rolf Kraemer and Marcos Katz, "Short-range wireless communications emerging technologies and applications", Wiley WWRF series, March 2009* 4. *Shlomi Arnon, John Barry, George Karagiannidis, Robert Schober, Murat Uysal, "Advanced Optical Wireless Communication Systems" , Cambridge University Press, 2012*

Learning Assessment

	Bloom's Level of Thinking	Continuous Learning Assessment (50% weightage)								Final Examination (50% weightage)	
		CLA – 1 (10%)		CLA – 2 (15%)		CLA – 3 (15%)		CLA – 4 (10%)#			
		Theory	Practice	Theory	Practice	Theory	Practice	Theory	Practice	Theory	Practice
Level 1	Remember Understand	*40 %*	-	*30 %*	-	*30 %*	-	*30 %*	-	*30%*	-
Level 2	Apply Analyze	*40 %*	-	*40 %*	-	*40 %*	-	*40 %*	-	*40%*	-
Level 3	Evaluate Create	*20 %*	-	*30 %*	-	*30 %*	-	*30 %*	-	*30%*	-
	Total	100 %		100 %		100 %		100 %		100 %	

CLA – 4 can be from any combination of these: Assignments, Seminars, Tech Talks, Mini-Projects, Case-Studies, Self-Study, MOOCs, Certifications, Conf. Paper etc.,

Course Designers

Experts from Industry	Experts from Higher Technical Institutions	Internal Experts
1. Mr. Anuj Kumar, Bombardier Transportation, Ahmedabad, kumaranuj.anii@gmail.com	*1. Dr. Meenakshi, Professor of ECE, CEG, Anna University, meena68@annauniv.edu*	*1. Dr. J. Subhashini, SRM IST*
2. Mr. Hariharasudhan - Johnson Controls, Pune, hariharasudhan.v@jci.com	*2. Dr. Venkatesan, Sr. Scientist, NIOT, Chennai, venkat@niot.res.in*	

Course Code	18EC0102J	Course Name	ELECTRONIC CIRCUITS AND SYSTEMS	Course Category	O	Open Elective	L	T	P	C
							2	0	2	3

Pre-requisite Courses	Nil	Co-requisite Courses	Nil	Progressive Courses	Nil
Course Offering Department	Electronics and Communication Engineering	Data Book / Codes/ Standards	Nil		

Course Learning Rationale (CLR):	*The purpose of learning this course is to:*
CLR-1 :	*Provide a basis for understanding semiconductor material, how a pn junction is formed and its principle of operation*
CLR-2 :	*Describe the basic structure, operation and characteristics of transistors BJTs and FETs, and discuss their use as a switch and an amplifier*
CLR-3 :	*Learn the basics of op-amp: the principle, operation, characteristics and fundamentally important circuits*
CLR-4 :	*Describe and analyze the basic operation of sinusoidal oscillators and use a 555 Timer in an oscillator application.*
CLR-5 :	*Learn the fundamentals of analog and digital communication, networking, radio transmission and mobile telephones*
CLR-6 :	*Encourage the learner to assemble and test real circuits in the laboratory*

Course Learning Outcomes (CLO):	*At the end of this course, learners will be able to:*	Learning 1: Level of Thinking (Bloom)	Learning 2: Expected Proficiency (%)	Learning 3: Expected Attainment (%)	PLO 1: Engineering Knowledge	PLO 2: Problem Analysis	PLO 3: Design & Development	PLO 4: Analysis, Design, Research	PLO 5: Modern Tool Usage	PLO 6: Society & Culture	PLO 7: Environment & Sustainability	PLO 8: Ethics	PLO 9: Individual & Team Work	PLO 10: Communication	PLO 11: Project Mgt. & Finance	PLO 12: Life Long Learning	PLO 13: PSO - 1	PLO 14: PSO - 2	PLO 15: PSO – 3
CLO-1 :	*Understand the operation, characteristics, parameters and specifications of semiconductor diodes and demonstrate its important applications*	*1*	*80*	*70*	*L*	*L*	-	-	-	-	-	-	-	-	-	-	-	-	-
CLO-2 :	*Review the transistor (BJT & FET) construction, operation, characteristics and parameters, as well as its application in amplification and switching.*	*1*	*80*	*70*	*L*	*L*	-	-	-	-	-	-	-	-	-	-	-	-	-
CLO-3 :	*Identify different configurations of op-amp analyze the parameters of op-amp and observe the frequency response of operational-amplifier.*	*1*	*80*	*70*	*L*	*L*	-	-	-	-	-	-	-	-	-	-	-	-	-
CLO-4 :	*Understand & demonstrate different applications based on operational-amplifier and special linear ICs*	*1*	*80*	*70*	*L*	*L*	-	-	-	-	-	-	-	-	-	-	-	-	-
CLO-5 :	*Understand the basic concepts and techniques of telecommunication systems and networks*	*1*	*80*	*70*	*L*	*L*	-	-	-	-	-	-	-	-	-	-	-	-	-
CLO-6 :	*Understand how circuit behavior can be studied with a computer, using a circuit simulation software*	*2*	*90*	*80*	-	-	*H*	-	*H*	-	-	-	-	*L*	-	*M*	*L*	-	-

		Active Discrete Components & Circuits – I	Active Discrete Components & Circuits – II	Linear Integrated Circuits	Oscillators and Timers	Telecommunications
Duration (hour)		12	12	12	12	12
S-1	SLO-1	*Conduction in semiconductors*	*JFETs: Structure & Operation*	*Introduction to Op-amp*	*RC Phase-Shift oscillator Operation*	*Analog & Digital Communication: Stages in telecommunication systems*
	SLO-2	*Conduction in diodes*	*Characteristics & Parameters*	*Basic op-amp and its characteristics*	*& Design*	*Carriers and Modulation*
S-2	SLO-1	*Basic operation of PN junction diode*	*JFET Biasing (Voltage-Divider Biasing)*	*op-amp modes*	*Wein bridge Oscillator operation*	*Carriers and Modulation*
	SLO-2	*VI Characteristics of diode*	*CS-JFET Amplifier operation*	*parameters*	*& Design*	*Pulse Modulation*
S 3-4	SLO-1 SLO-2	*Lab-1: VI Characteristics of PN Junction Diode*	*Lab-4: Design & Analysis of CE BJT Amplifier*	*Lab-7: Negative Feedback op-amp circuits*	*Lab-10: Analysis & Design of RC Oscillators*	*Lab-13: Demonstration of AM & FM*
S-5	SLO-1	*Applications of diode: HWR & FWR*	*MOSFETs: Structure*	*Op-amp circuits: Scale changer, adder, subtractor*	*LC oscillators operation: Hartley Oscillator*	*Pulse Modulation*
	SLO-2	*Clippers & Clampers*	*Operation*	*HWR & FWR*	*Colpitts Oscillator*	*Digital Transmission, Frequency Division MultiplexingTime Division Multiplexing*
S-6	SLO-1	*Basic operation of Zener diode and its VI characteristics*	*Characteristics*	*Clipper &Clamper*	*555 Timer IC: Basic Operation*	*Networks: RS-232, circuit switching*
	SLO-2	*Zener diode as a voltage regulator*	*Parameters*	*Log & Antilog amplifiers*	*Astable Operation*	*Message switching, TCP/IP*
S	SLO-1	*Lab-2: VI Characteristics of Zener Diode*		*Lab-8: Op-amp Circuits-I*		

7-8	SLO-2		*Lab-5: Design & Analysis of CS-JFET Amplifier*		*Lab-11: 555 Timer Operation & Applications*	*Lab-14: Demonstration of Pulse Modulation*
S-9	SLO-1	*BJTs: Structure & Operation*	*MOSFET as an amplifier*	*Instrumentation amplifier*	*Monostable Operation*	*Radio Transmission: Electromagnetic Spectrum, ground waves, sky waves*
	SLO-2	*Characteristics & Parameters*	*MOSFET as a switch*	*Comparator*	*Applications of 555 Timer*	*antennas, directional transmissions,*
S-10	SLO-1	*CE BJT amplifier operation*	*MOSFET Biasing (Voltage-Divider Biasing)*	*Comparator applications*	*Applications of 555 Timer*	*Transmitters, Receivers*
	SLO-2	*Differential amplifier operation*	*CS-MOSFET amplifier operation*	*Schmitt trigger*	*Voltage-Controlled Oscillators*	*Mobile telephones*
S 11-12	SLO-1 SLO-2	*Lab-3: Applications of PN Junction diode and Zener diode*	*Lab-6: Design & Analysis of CS-MOSFET Amplifier*	*Lab-9: Op-amp Circuits-II*	*Lab-12: VCO Operation*	*Mini Project / Model Practical Examination*

Learning Resources	1. *Owen Bishop, "Electronic Circuits and Systems", 4th edition, Elsevier, 2011.* 2. *Harry Kybett, Earl Boysen, "All New Electronics", 3rd edition, Wiley, 2008.*	3. *Paul Scherz, "Practical Electronics for Inventors", McGraw-Hill, 2000.*

Learning Assessment

	Bloom's Level of Thinking	Continuous Learning Assessment (50% weightage)								Final Examination (50% weightage)	
		CLA – 1 (10%)		CLA – 2 (15%)		CLA – 3 (15%)		CLA – 4 (10%)#			
		Theory	Practice	Theory	Practice	Theory	Practice	Theory	Practice	Theory	Practice
Level 1	Remember Understand	*20%*	*20%*	*15%*	*15%*	*15%*	*15%*	*15%*	*15%*	*15%*	*15%*
Level 2	Apply Analyze	*20%*	*20%*	*20%*	*20%*	*20%*	*20%*	*20%*	*20%*	*20%*	*20%*
Level 3	Evaluate Create	*10%*	*10%*	*15%*	*15%*	*15%*	*15%*	*15%*	*15%*	*15%*	*15%*
	Total	100 %		100 %		100 %		100 %		-	

CLA – 4 can be from any combination of these: Assignments, Seminars, Tech Talks, Mini-Projects, Case-Studies, Self-Study, MOOCs, Certifications, Conf. Paper etc.,

Course Designers

Experts from Industry	Experts from Higher Technical Institutions	Internal Experts
1. Mr. Anuj Kumar, Bombardier Transportation, Ahmedabad, kumaranuj.anii@gmail.com	*1. Dr. Meenakshi, Professor of ECE, CEG, Anna University, meena68@annauniv.edu*	*1. Mr. Manikandan AVM, SRM IST*
2. Mr. Hariharasudhan - Johnson Controls, Pune, hariharasudhan.v@jci.com	*2. Dr. Venkatesan, Sr. Scientist, NIOT, Chennai, venkat@niot.res.in*	*2. Dr. Rajesh Agarwal, SRM IST*

Course Code	18ECO103T	Course Name	MODERN WIRELESS COMMUNICATION SYSTEM	Course Category	O	Open Elective	L	T	P	C
							3	0	0	3

Pre-requisite Courses	Nil	Co-requisite Courses	Nil	Progressive Courses	Nil
Course Offering Department	Electronics and Communication Engineering	Data Book / Codes/Standards	Nil		

Course Learning Rationale (CLR):	*The purpose of learning this course is to:*
CLR-1 :	*Learn to analyze the transmission of various wireless communication systems*
CLR-2 :	*Understand the fundamentals of various networks in wireless communication*
CLR-3 :	*Understand the techniques involved in personal communication services.*
CLR-4 :	*Introduce various wireless systems for 3G and future communication*
CLR-5 :	*Learn to analyze wireless networks for short range communication*
CLR-6 :	*Understand the Fundamentals, Techniques and Networks of Wireless Communication Systems*

Course Learning Outcomes (CLO):	*At the end of this course, learners will be able to:*	Learning 1: Level of Thinking (Bloom)	2: Expected Proficiency (%)	3: Expected Attainment (%)	PLO 1: Engineering Knowledge	2: Problem Analysis	3: Design & Development	4: Analysis, Design, Research	5: Modern Tool Usage	6: Society & Culture	7: Environment & Sustainability	8: Ethics	9: Individual & Team Work	10: Communication	11: Project Mgt. & Finance	12: Life Long Learning	13: PSO - 1	14: PSO - 2	15: PSO – 3
CLO-1 :	*Discuss the fundamentals of transmission in wireless systems*	*2,3*	*80*	*75*	-	-	-	*H*	-	-	-	-	-	-	-	-	*H*		
CLO-2 :	*Provide an overview of various approaches to communication networks*	*2,3*	*80*	*85*	-	-	-	*H*	-	-	-	-	-	-	-	-	-	-	*H*
CLO-3 :	*Study the numerous different-generation technologies with their individual pros and cons*	*2,3*	*85*	*85*	-	-	-	*H*	-	-	-	-	-	-	-	-	*M*	-	*H*
CLO-4 :	*Discuss about the principles of operation of the different access technologies like FDMA, TDMA, SDMA and CDMA and their pros and cons.*	*2,3*	*85*	*80*	-	-	-	*H*	-	-	-	-	-	-	-	-	*M*	-	*H*
CLO-5 :	*Learn about the various mobile data services and short range networks.*	*2,3*	*85*	*80*	-	-	-	-	-	-	-	-	-	-	-	-	-	-	*H*
CLO-6 :	*Gain knowledge on Fundamentals, Techniques and Networks of Wireless Communication Systems*	*2,3*	*85*	*80*	-	-	-	-	-	-	-	-	-	-	-	-	*H*	-	-

Duration (hour)		Transmission Fundamentals	Network Concepts	Personal Communication Services	3G and Beyond	Mobile Data Services and Short- Range Network
		9	9	9	9	9
S-1	SLO-1	*Cellphone Generations*	*Communication Networks*	*Personal communication Introduction, HSCSD, GPRS, D-AMPS, CDMA One, CDMA Two, Packet Data Systems*	*3G Introduction*	*Mobile Data Services Introduction Messaging, wireless web, WAP, site design Short-Range Wireless Networks: Unlicensed spectrum, WLANs, cordless telephony, IrDA, Bluetooth Smart Phones: Future phones, mobile OSs, smart phone applications.*
	SLO-2	*1G and 2G*	*LANs*	*GSM*	*IMT-2000 Introduction*	*Data Services*
S-2	SLO-1	*2.5G*	*MANs*	*GSM*	*IMT-2000*	*Messaging*
	SLO-2	*3G*	*WANs*	*HSCSD*	*IMT-2000*	*Wireless web*
S-3	SLO-1	*4G Transmission Introduction*	*Circuit switching*	*HSCSD*	*W-CDMA Introduction*	*WAP*
	SLO-2	*4G Transmission Fundamentals*	*Packet switching*	*GPRS*	*W-CDMA*	*Site design*
S-4	SLO-1	*Time domain concepts*	*ATM Cellular Networks Introduction*	*GPRS*	*CDMA 2000 Introduction*	*Short-Range Wireless Networks*
	SLO-2	*Frequency domain concepts*	*Cells*	*D-AMPS*	*EDGE*	*Unlicensed spectrum*
S 5-6	SLO-1 SLO-2	*Radio Media*	*Duplexing*	*D-AMPS*	*EDGE*	*WLANs*
S-7	SLO-1	*Analog Vs Digital*	*Multiplexing*	*CDMA Introduction*	*Wi-Fi Introduction*	*Cordless telephony*
	SLO-2	*Channel capacity*	*Voice coding*	*CDMA One*	*Wi-Fi*	*IrDA*
S-8	SLO-1	*Transmission media*	*Multiple Access Techniques: FDMA*	*CDMA One*	*WiMAX Introduction*	*Bluetooth Smart Phones*
	SLO-2	*Signaling Schemes*	*TDMA, SDMA*	*CDMA Two*	*WiMAX*	*Future phones*
S-9	SLO-1	*Carrier-based signaling,*	*CDMA*	*CDMA Two*	*OFDM*	*Mobile OSs*
	SLO-2	*Spread-spectrum signaling*	*Spectral efficiency*	*Packet Data Systems*	*MIMO*	*Smart phone applications*

Learning Resources	1. *Simon Haykin, David Koilpillai, Michael Moher," Modern Wireless Communication", 1/e, Pearson Education, 2011* 2. *Rappaport T.S, "Wireless Communications: Principles and Practice", 2nd edition, Pearson education.* 3. *Andrea Goldsmith, "Wireless Communications", Cambridge University Press, Aug. 2005.*	4. *Andy Dornan, "The essential guide to wireless communications applications: from cellular systems to Wi-Fi", 2nd Edition, Prentice Hall, 2002.* 5. *Ian F.Akyildiz, David M. Gutierrez Estevez, and Elias Chavarria Reyes, " The evolution of 4G cellular systems: LTE advanced", Physical communication, Volume 3, No. 4, pp. 217-298, Dec. 2010* 6. *William Stallings, " Wireless Communication & Networking", Pearson Education Asia, 2004* 7. *Andrea .F.Molisch, "Wireless communications", 2nd edition, Wiley Publications.*

Learning Assessment											
	Bloom's Level of Thinking	Continuous Learning Assessment (50% weightage)								Final Examination (50% weightage)	
		CLA – 1 (10%)		CLA – 2 (15%)		CLA – 3 (15%)		CLA – 4 (10%)#			
		Theory	Practice	Theory	Practice	Theory	Practice	Theory	Practice	Theory	Practice
Level 1	Remember Understand	*30 %*	-	*30 %*	-	*30 %*	-	*30 %*	-	*30%*	-
Level 2	Apply Analyze	*40 %*	-	*40 %*	-	*40 %*	-	*40 %*	-	*40%*	-
Level 3	Evaluate Create	*30 %*	-	*30 %*	-	*30 %*	-	*30 %*	-	*30%*	-
	Total	100 %		100 %		100 %		100 %		100 %	

CLA – 4 can be from any combination of these: Assignments, Seminars, Tech Talks, Mini-Projects, Case-Studies, Self-Study, MOOCs, Certifications, Conf. Paper etc.,

Course Designers		
Experts from Industry	Experts from Higher Technical Institutions	Internal Experts
1. Mr. Anuj Kumar, Bombardier Transportation, Ahmedabad, kumaranuj.anii@gmail.com	*1. Dr. Meenakshi, Professor of ECE, CEG, Anna University, meena68@annauniv.edu*	*1. Dr. Sabitha Gauni, SRMIST*
2. Mr. Hariharasudhan - Johnson Controls, Pune, hariharasudhan.v@jci.com	*2. Dr. Venkatesan, Sr. Scientist, NIOT, Chennai, venkat@niot.res.in*	

Course Code	18ECO104J	Course Name	AUDIO AND SPEECH SIGNAL PROCESSING	Course Category	O	Open Elective	L	T	P	C
							2	0	2	3

Pre-requisite Courses	Nil	Co-requisite Courses	Nil	Progressive Courses	Nil
Course Offering Department	Electronics and Communication Engineering	Data Book / Codes/Standards	Nil		

Course Learning Rationale (CLR):	*The purpose of learning this course is to:*
CLR-1 :	*To explore about Speech signal processing*
CLR-2 :	*To explore about the human auditory system*
CLR-3 :	*Feature Extraction of Speech signal using Time characteristics*
CLR-4 :	*Frequency characteristics of Speech signal*
CLR-5 :	*Provide a foundation for developing applications in this field.*
CLR-6 :	*Understand the concept of speech processing both in time and frequency domain*

Course Learning Outcomes (CLO):	*At the end of this course, learners will be able to:*	Learning 1	2	3	Program Learning Outcomes (PLO) 1	2	3	4	5	6	7	8	9	10	11	12	13	14	15
		Level of Thinking (Bloom)	Expected Proficiency (%)	Expected Attainment (%)	Engineering Knowledge	Problem Analysis	Design & Development	Analysis, Design, Research	Modern Tool Usage	Society & Culture	Environment & Sustainability	Ethics	Individual & Team Work	Communication	Project Mgt. & Finance	Life Long Learning	PSO - 1	PSO - 2	PSO – 3
CLO-1 :	*Understand the functioning of the human vocal and auditory systems in terms of signal processing*	*1*	*90*	*68*	*H*		*H*		*H*				-	-	-	-	*M*	*H*	
CLO-2 :	*Analyze the function of feature extraction in speech and audio signal processing using Time Domain Characteristics*	*2*	*85*	*67*	*H*			*H*				*M*	-	-	-	-	*M*		*H*
CLO-3 :	*Understand the frequency characteristics of speech signal*	*2*	*85*	*68*	*H*		*H*			*M*		*M*	-	-	-	-		*H*	*H*
CLO-4 :	*Understand the Digital models for speech signal*	*1&2*	*85*	*65*	*H*		*H*	*H*					-	-	-	-	*H*	*M*	
CLO-5 :	*Understand the elements of music*	*2&3*	*85*	*66*			*H*		*H*			*H*	-	-	-	-	*H*		*H*
CLO-6:	*Understand Speech signal processing in time and frequency domain and their models.*	*1,2,3*	*85*	*68*	*H*		*H*			*M*		*H*	-	-	-	-		*M*	*M*

		Basic Audio Processing	Human auditory system	Speech Signal Analysis in Time Domain	Speech Signal Analysis in Frequency Domain	Speech and Audio processing applications
Duration (hour)		12	12	12	12	12
S-1	SLO-1	*Introduction to Digital audio*	*Human auditory system*	*Speech signal analysis*	*Short Time Fourier analysis*	*Introduction to Speech recognition*
	SLO-2	*Capturing and converting sound*	*Human auditory system*	*Speech signal analysis*	*Short Time Fourier analysis*	*Introduction to Speech recognition*
S-2	SLO-1	*Sampling of sound wave*	*simplified model of cochlea*	*Segmental, sub-segmental levels*	*Filter bank analysis*	*Complete system for an isolated word recognition with vector quantization /DTW*
	SLO-2	*Handling audio in MATLAB*	*simplified model of cochlea*	*Suprasegmental levels*	*Formant extraction and Pitch extraction*	*Complete system for an isolated word recognition with vector quantization /DTW*
S 3-4	SLO-1 SLO-2	*Lab 1: Read & write a speech signal, Record a speech signal, playback, convert into a wave file, plot the speech signal, and spectrogram plot.*	*Lab 4: Short-term energy of a speech signal*	*Lab 7: Estimation of pitch period using simplified inverse filter tracking (SIFT) algorithm*	*Lab 10: Phoneme-level segmentation of speech*	*Lab 13: Compute pitch period and fundamental frequency for speech signal*
S-5	SLO-1	*Normalization*	*Sound pressure level and loudness*	*Time domain parameters of speech signal*	*Homomorphic speech analysis*	*Complete system for speaker identification, verification*
	SLO-2	*Audio processing*	*Sound pressure level and loudness*	*Time domain parameters of speech signal*	*Cepstral analysis of Speech*	*Introduction to speech enhancement*
S-6	SLO-1	*Segmentation*	*Sound intensity and Decibel sound levels*	*Methods for extracting the parameters Energy*	*Formant and Pitch Estimation*	*Introduction to speech enhancement*
	SLO-2	*Analysis of window sizing*	*Sound intensity and Decibel sound levels*	*Average ,Magnitude*	*Linear Predictive analysis of speech*	*Speech enhancement using spectral subtraction method*
S 7-8	SLO-1 SLO-2	*Lab 2: Convert into a wave file, plot the speech signal, and spectrogram plot*	*Lab 5: Short-time Fourier transform magnitude spectrum*	*Lab 8: Estimation of pitch period using harmonic product spectrum*	*Lab 11:To study the quantization and aliasing effect of speech signal*	*Lab 14: Short term speech analysis*

S-9	SLO-1	*Visualization*	*Concept of critical band*	*Zero crossing Rate*	*Autocorrelation method, Covariance method*	*Introduction to Text to speech conversion*
	SLO-2	*Sound generation*	*Uniform filter bank , Non- uniform filter bank*	*Silence Discrimination using ZCR and energy*	*Solution of LPC equations*	*Introduction to Musical instrument classification*
S-10	SLO-1	*Speech production mechanism, Charistics of speech*	*Mel scale and bark scale,*	*Short Time Auto Correlation Function*	*Durbin's Recursive algorithm, Application of LPC parameters*	*Musical Information retrieval.*
	SLO-2	*Understanding of speech*	*Speech perception: vowel perception*	*Pitch period estimation using Auto Correlation Function*	*Pitch detection using LPC parameters, Formant analysis*	*Sample Programs*
S 11-12	SLO-1 SLO-2	*Lab 3:Cepstrum smoothed magnitude spectrum*	*Lab 6: (i)Linear prediction magnitude spectrum, (ii) (ii) Estimation of formant frequencies using linear prediction*	*Lab 9: Pitch and duration modification using time-domain pitch synchronous overlap and add (TD-PSOLA) method*	*Lab 12:: Speech signal to symbol transformation using wavesurfer*	*Lab 15: Study of Praat*

Learning Resources	1. *Ian McLaughlin, "Applied Speech and Audio processing, with MATLAB examples", 1st Edition, Cambridge University Press, 2009* 2. *Ben Gold, Nelson Morgan, Dan Ellis, Wiley, "Speech and Audio Signal Processing: Processing and Perception of Speech and Music", 2nd Edition, John Wiley & Sons, 01-Nov-2011.* 3. *Rabiner,B.H.Juang, "Fundamentals of Speech Recognition", 2 nd Edition, Prentice-hall Signal Processing Series, April 1993* 4. *Ken Pohlmann, "Principles of Digital Audio", 6th Edition, McGraw-Hill, 2007* 5. *A.R.Jayan, "Speech and Audio Signal Processing", ISBN : 978-81-203-5256-8, PHI Learning Pvt. Ltd, 2016.*

Learning Assessment

	Bloom'sLevel of Thinking	Continuous Learning Assessment (50% weightage)								Final Examination (50% weightage)	
		CLA – 1 (10%)		CLA – 2 (15%)		CLA – 3 (15%)		CLA – 4 (10%)#			
		Theory	Practice	Theory	Practice	Theory	Practice	Theory	Practice	Theory	Practice
Level 1	Remember Understand	*20%*	*20%*	*15%*	*15%*	*15%*	*15%*	*15%*	*15%*	*15%*	*15%*
Level 2	Apply Analyze	*20%*	*20%*	*20%*	*20%*	*20%*	*20%*	*20%*	*20%*	*20%*	*20%*
Level 3	Evaluate Create	*10%*	*10%*	*15%*	*15%*	*15%*	*15%*	*15%*	*15%*	*15%*	*15%*
	Total	100 %		100 %		100 %		100 %		100 %	

CLA – 4 can be from any combination of these: Assignments, Seminars, Tech Talks, Mini-Projects, Case-Studies, Self-Study, MOOCs, Certifications, Conf. Paper etc.,

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Experts from Industry	Experts from Higher Technical Institutions	Internal Experts
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Course Code	18ECO105T	Course Name	UNDERWATER ACOUSTICS	Course Category	O	Open Elective	L	T	P	C
							3	0	0	3

Pre-requisite Courses	Nil	Co-requisite Courses	Nil	Progressive Courses	Nil
Course Offering Department	Electronics and Communication Engineering	Data Book / Codes/Standards	Nil		

Course Learning Rationale (CLR):	The purpose of learning this course is to:
CLR-1 :	*Understand what is Sound Navigation and Ranging (SONAR) and how it can be used in underwater applications.*
CLR-2 :	*Study about Ocean Acoustic Processing and sound wave propagation and analyze sea floor characteristics and ocean sounds.*
CLR-3 :	*Understand about Underwater reverberation and how types of noises affects the underwater acoustics signal data analysis.*
CLR-4 :	*Study about Acoustic transducers.*
CLR-5 :	*Know which transducers can be used for underwater applications.*
CLR-6 :	*Understand the basic theory and signal processing application for underwater communication and navigation.*

		Learning			Program Learning Outcomes (PLO)														
		1	2	3	1	2	3	4	5	6	7	8	9	10	11	12	13	14	15
Course Learning Outcomes (CLO):	At the end of this course, learners will be able to:	Level of Thinking (Bloom)	Expected Proficiency (%)	Expected Attainment (%)	Engineering Knowledge	Problem Analysis	Design & Development	Analysis, Design, Research	Modern Tool Usage	Society & Culture	Environment & Sustainability	Ethics	Individual & Team Work	Communication	Project Mgt. & Finance	Life Long Learning	PSO - 1	PSO - 2	PSO – 3
CLO-1 :	*Acquire in-depth knowledge and analyze on Sound Navigation and Ranging (SONAR) equations and it characteristics.*	1	85	65	M	-	-	-	-	-	-	-	-	-	-	M	L	-	-
CLO-2 :	*Analyze Ocean Acoustic Processing and sound wave propagation.*	2	85	65	M	H	H	H	H	-	-	-	-	-	-	L	H	H	H
CLO-3 :	*Acquire knowledge and analyze Underwater reverberation and various types of noises.*	1&2	85	65	M		H	H	H	-	-	-	-	-	-	L	H	M	H
CLO-4 :	*Acquire knowledge on working of underwater Acoustic transducers.*	1	85	65	H	H	H	H	H	-	-	-	-	-	-	L	H	H	H
CLO-5 :	*Gain knowledge and apply SONAR concepts for underwater applications.*	1& 3	85	65	L		H	H	-	-	-	-	-	-	-	L	H	M	H
CLO-6 :	*Understand the development and dynamics of underwater acoustic engineering*	2 &3	85	65	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-

		Sound Navigation and Ranging (SONAR)	Ocean Acoustic Processing and sound wave propagation	Reverberation and Noises	Acoustic Transduction	SONAR Application
Duration (hour)		9	9	9	9	9
S-1	SLO-1	*Introduction to SONAR equation,*	*Processing ocean sound-Sampling rules*	*Reverberation-Scattering, back scattering strength and target strength*	*Piezoelectric transducer-Introduction*	*Echo sounder*
	SLO-2	*Source Intensity, Source Directivity*	*Spatial sampling and Temporal sampling*	*Surface and bottom scattering*	*Piezoelectric transducer-33-Mode longitudinal vibrator*	*Echo Sounder*
S-2	SLO-1	*Transmission loss*	*Filter operations-Finite Fourier transformation*	*Volume scattering, bottom scattering, reverberation target strength*	*Piezoelectric transducer-33-Mode longitudinal vibrator*	*Sub-bottom profiling*
	SLO-2	*Transmission loss*	*Filter operations-Time domain view of Band pass filtering. convolution operations, frequency domain*	*Calculation of reverberation for use in the sonar equation, Volume reverberation level*	*Electrostrictive transducers*	*Fishing sonars*
S-3	SLO-1	*Target Strength*	*Gated Signals-Dependence of Spectrum on ping carrier periodicity*	*Reverberation frequency spread and Doppler gain potential-Power spectral density of a CW pulse*	*Electrostrictive transducers*	*Side scan terrain mapping sonar*
	SLO-2	*Reflection Intensity Loss Coefficient*	*Power spectra of random signal-Signal having random characteristics, Spectral density,*	*Environmental frequency sampling*	*Magnetostrictive transducers*	*Side scan terrain mapping sonar*
S-4	SLO-1	*Sea-floor Loss,*	*Radom signal simulations-Intensity spectral density, Spectral smoothing*	*Frequency spreading due to transmitter and receiver motion*	*Magnetostrictive transducers*	*Acoustic positioning and navigation*
	SLO-2	*Sea-surface Loss*	*Matched filters and autocorrelation*	*Frequency spreading due to target, important observation with respect to reverberation*	*Electostatic Transducers*	*Acoustic positioning and navigation*

S-5	SLO-1	*Noise, Reverberation*	*Sounds in the oceans-natural physical sounds and biological sounds*	*Noise-Ambient noise models*	*Electostatic Transducers*	*3D Imaging Processing-data model*
	SLO-2	*Active and Passive Sonar Equations*	*Sound propagation in the ocean and underwater acoustic channel-Sound wave and vibration, velocity of sound*	*Ambient noise-seismic noise, ocean turbulence, shipping noise*	*Variable Reluctance Transducers*	*3D Imaging Processing-acquisition of 3D information*
S-6	SLO-1	*Passive Sonar Equations, Signal-to-Noise Ratio*	*Sound propagation in the ocean and underwater acoustic channel-Sound wave velocity of sound*	*Wave noise, thermal noise*	*Variable Reluctance Transducers*	*3D Imaging Processing-matrix approach and real time systems*
	SLO-2	*Signal Excess, Figure of Merit*	*Wave and ray theories of underwater sound fields*	*Rain noise, temporal variability of ambient noise, depth effects of noise*	*Moving coil transducers*	*3D Imaging Processing-Image representation, Acoustic image processing*
S-7	SLO-1	*Active SONAR target strength*	*Wave and ray theories of underwater sound fields*	*Under ice noise*	*Moving coil transducers*	*3D Imaging Processing-Segmentation and reconstruction of underwater tubular structures*
	SLO-2	*Active SONAR- reverberation, detection threshold*	*Wave and ray theories of underwater sound fields*	*Spatial coherence of ambient noise*	*Equivalent circuits-Basics Circuit Resonance*	*3D Imaging Processing-Segmentation and reconstruction of underwater tubular structures*
S-8	SLO-1	*Active Sonar Sources- Source Level, Cavitation*	*Sound absorption in sea water and its characteristics*	*Self-noise-Flow noise*	*Circuit Q and Bandwidth*	*Acoustic communication-Cross attributes of the received signal*
	SLO-2	*Near-Field Interactions Explosive Sources*	*Upper boundary of acoustic channel*	*Self-noise – Flow noise*	*Transducers as projectors-principle*	*Acoustic communication-channel transfer function*
S-9	SLO-1	*Physics of Shock Waves in Wate, Bubble Pulses*	*Lower boundary of acoustic channel and its characteristics*	*Self noise-turbulent noise coherence*	*Transducers as Hydrophones-principles of operations*	*Acoustic communication-combating multipath*
	SLO-2	*Pros and Cons of Explosive Charges, Parametric Acoustic Sources*	*sound field in shallow water*	*Self noise-strumming noise*	*Transducers as Hydrophones-simplified equivalent circuit*	*Acoustic communication-diversity reception, equalization*

Learning Resources	*1. Richard P HODGES, "Underwater Acoustics – Analysis, Design and Performance of SONAR", Wiley 1 edition2010, ISBN 978-0-470-68875-* *2. Rodney F W Coates, "Underwater Acoustics Systems", Macmillan New Electronics,Wiley, 1st edition , 1990, ISBN 978-0-333-42542-8* *3. Robert S H Istepanian and MilicaStojanovic, "Underwater Acoustic Digital Signal Processing and Communication Systems", Springer, 2002 edition, ISBN 978-1-4419-4882-3*	*4. Charles H Sherman, John L Butler, "Transducers and Arrays for Underwater Sound", Springer; 2nd edition, 2016, ISBN-10: 0-387-32940-4 ISBN-13: 978-0387-32940-6* *5. Qihu Li, "Digital Sonar Design in underwater acoustics: Principles and applications", Springer, Zhejang University Press, 2012* *6. Herman Medwin, Clarence S.Clay, "Fundamentals of Acoustical Oceanography", Academic Press, 1998.*

Learning Assessment

	Bloom's Level of Thinking	Continuous Learning Assessment (50% weightage)								Final Examination (50% weightage)	
		CLA – 1 (10%)		CLA – 2 (15%)		CLA – 3 (15%)		CLA – 4 (10%)#			
		Theory	Practice	Theory	Practice	Theory	Practice	Theory	Practice	Theory	Practice
Level 1	Remember Understand	*40 %*	-	*30 %*	-	*30 %*	-	*30 %*	-	*30%*	-
Level 2	Apply Analyze	*40 %*	-	*40 %*	-	*40 %*	-	*40 %*	-	*40%*	-
Level 3	Evaluate Create	*20 %*	-	*30 %*	-	*30 %*	-	*30 %*	-	*30%*	-
	Total	100 %		100 %		100 %		100 %		100 %	

CLA – 4 can be from any combination of these: Assignments, Seminars, Tech Talks, Mini-Projects, Case-Studies, Self-Study, MOOCs, Certifications, Conf. Paper etc.,

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Course Code	18ECO107T	Course Name	FIBER OPTICS AND OPTOELECTRONICS	Course Category	O	Open Elective	L	T	P	C
							3	0	0	3

Pre-requisite Courses	Nil	Co-requisite Courses	Nil	Progressive Courses	Nil
Course Offering Department	Electronics and Communication Engineering	Data Book / Codes/Standards	Nil		

Course Learning Rationale (CLR):	*The purpose of learning this course is to:*
CLR-1 :	*Analyze the basic laws and theorems of light associated with the optical fiber communication and the classification of optical fibers*
CLR-2 :	*Address concepts related to transmission characteristics such as attenuation and dispersion.*
CLR-3 :	*Explore the fundamentals of optoelectronics display devices, Sources and Detectors*
CLR-4 :	*Gain to information on Optical modulators and amplifiers*
CLR-5 :	*Illustrate the integration methods available for optoelectronic circuits and devices*
CLR-6 :	*Utilize the basic optical concepts applied in various engineering problems and identify appropriate solutions*

		Learning			Program Learning Outcomes (PLO)														
		1	2	3	1	2	3	4	5	6	7	8	9	10	11	12	13	14	15
Course Learning Outcomes (CLO):	*At the end of this course, learners will be able to:*	Level of Thinking (Bloom)	Expected Proficiency (%)	Expected Attainment (%)	Engineering Knowledge	Problem Analysis	Design & Development	Analysis, Design, Research	Modern Tool Usage	Society & Culture	Environment & Sustainability	Ethics	Individual & Team Work	Communication	Project Mgt. & Finance	Life Long Learning	PSO - 1	PSO - 2	PSO – 3
CLO-1 :	*Review the basic theorems related to fiber optic communication, and attain knowledge of types of optical fibers*	*2*	*80*	*70*	*H*	*H*	-	-	-	-	-	-	-	-	-	-	-		*H*
CLO-2 :	*Understand the optical signal distortion factors in optical fiber communication*	*2*	*85*	*75*	*H*	-	*M*	-	-	-	-	-	-	-	-	-	-	-	*M*
CLO-3 :	*Familiarize the principle and operation of various display devices, light sources and detectors*	*2*	*75*	*70*	*H*	*M*	*M*	-	-	-	-	-	-	-	-	-	-	-	*L*
CLO-4 :	*Acquire knowledge of various optoelectronic modulators and amplifiers*	*2*	*85*	*80*	*H*	-	*M*	-	-	-	-	-	-	-	-	-	-	-	*H*
CLO-5 :	*Understand the various optoelectronic integrated circuits*	*2*	*85*	*75*	*H*	-	*M*	*L*	-	-	-	-	-	-	-	-	-	-	*L*
CLO-6:	*Acquire fundamental concepts related to optical communication and optoelectronic devices*	*2*	*80*	*75*	*H*	*M*	*M*	*L*	-	-	-	-	-	-	-	-	-	-	*H*

Duration (hour)		Introduction to Optical Fibers	Transmission Characteristics of Optical Fibers	Display Devices, Light Sources and Detection Devices	Optoelectronic Modulators and Switching Devices	Optoelectronic Integrated Circuits
		9	9	9	9	9
S-1	SLO-1	*Evolution of fiber optic system*	*Attenuation – Absorption, Attenuation units*	*Display devices – Photo luminescence*	*Analog and Digital Modulation*	*Optoelectronic integrated circuits - Introduction*
	SLO-2	*Elements of an optical fiber transmission link*	*Attenuation – Scattering losses*	*Cathode luminescence*	*Electro optic modulators – Electro optic effect – Longitudinal electro optic modulator*	*Need for Integration - Hybrid and Monolithic Integration*
S-2	SLO-1	*Elements of an optical fiber transmission link*	*Attenuation – Bending losses, microbending and macro bending losses*	*Electro luminescence*	*Electro optic modulators – Transverse electro optic modulator*	*Hybrid and Monolithic Integration*
	SLO-2	*Advantages of fiber optic system*	*Attenuation - Core cladding losses*	*Injection luminescence*	*Acousto optic modulators – Transmission type – Raman Nath modulator*	*Materials and processing of OEICs*
S-3	SLO-1	*Characteristics and behavior of light*	*Signal distortion in optical waveguides*	*Light source materials*	*Acousto optic modulators – Reflection type – Bragg modulator*	*Application of optoelectronic integrated circuits*
	SLO-2	*Total internal reflection*	*Types of dispersion-Intramodal and Intermodal dispersion*	*Surface emitting LEDs*	*Solving Problems*	*Slab and Strip Waveguides*
S-4	SLO-1	*Acceptance angle*	*Material dispersion*	*Edge emitting LEDs*	*Optical switching and logic devices – self-electro-optic-device*	*Integrated transmitters and receivers – Front end photo receivers*
	SLO-2	*Numerical aperture, Critical angle*	*Material dispersion, Waveguide dispersion*	*Quantum efficiency and LED power – Internal quantum efficiency derivation*	*Optical switching and logic devices – Bipolar controller modulator*	*Integrated transmitters and receivers – photoreceiver noise and bandwidth considerations*
S-5	SLO-1	*Solving Problems*	*Waveguide dispersion*	*Quantum efficiency and LED power – External quantum efficiency and total LED power*	*Optical switching and logic devices- tunable threshold logic gate – Switching speed and energy.*	*Integrated transmitters and receivers – PIN-HBT photoreceivers*

	SLO-2	*Solving Problems*	*Signal distortion in single mode fibers*	*Solving Problems*	*Optical Amplifiers – General applications of optical amplifiers*	*Integrated transmitters and receivers – OEIC transmitters – equivalent circuit for integrated receivers*
S-6	SLO-1	*Ray optics*	*Polarization mode dispersion*	*Semiconductor laser diode*	*Semiconductor optical amplifiers – Basic configuration*	*Integrated transmitters and receivers – Complex circuits and arrays*
	SLO-2	*Types of rays*	*Polarization mode dispersion, Intermodal dispersion*	*Modes and threshold condition*	*Semiconductor optical amplifiers – Optical gain - Limitations*	*Integrated transmitters and receivers - optical control and microwave oscillators*
S-7	SLO-1	*Optical fiber modes*	*Intermodal dispersion*	*Photo detection principle*	*Erbium doped fiber amplifiers – energy level diagram and amplification mechanism*	*Guided wave devices – Waveguide and couplers*
	SLO-2	*Optical fiber configurations*	*Solving Problems*	*PIN Photodiode*	*Erbium doped fiber amplifiers – EDFA configuration*	*Guided wave devices – Active guided wave devices*
S-8	SLO-1	*Single mode fibers*	*Solving Problems*	*PIN photodiode - Avalanche Photodiode*	*Solving Problems*	*Guided wave devices – Mach Zehnder Interferometers*
	SLO-2	*Multimode Fibers*	*Pulse Broadening in Graded Index Waveguides*	*Avalanche Photodiode*	*Solving Problems*	*Active couplers*
S-9	SLO-1	*Step Index Fibers*	*Mode Coupling*	*Noise mechanism in photodetectors*	*Fiber Raman Amplifiers – Configuration – Forward pumping*	*Active Couplers*
	SLO-2	*Graded Index Fibers*	*Design Optimization of Single Mode Fibers*	*Solving Problems*	*Fiber Raman Amplifiers – Backward pumping*	*Active Couplers*

Learning Resources	1. *Gerd Keiser, "Optical Fiber Communications", 5th Edition, McGraw Hill Education (India), 2015.* 2. *Khare R P, "Fiber Optics and Optoelectronics", Oxford University Press, 2014.*	3. *J. Wilson and J. Hawkes, "Optoelectronics – An Introduction", Prentice Hall, 1995.* 4. *Pallab Bhattacharya, "Semiconductor Optoelectronic Devices", Prentice Hall of India Pvt. Ltd, 2006.*

Learning Assessment

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	Total	100 %		100 %		100 %		100 %		100 %	

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Course Designers		
Experts from Industry	Experts from Higher Technical Institutions	Internal Experts
1. Mr. Anuj Kumar, Bombardier Transportation, Ahmedabad, kumaranuj.anii@gmail.com	*1. Dr. Meenakshi, Professor of ECE, CEG, Anna University, meena68@annauniv.edu*	*1. Dr. S. Sathiyan, SRMIST*
2. Mr. Hariharasudhan - Johnson Controls, Pune, hariharasudhan.v@jci.com	*2. Dr. Venkatesan, Sr. Scientist, NIOT, Chennai, venkat@niot.res.in*	

Course Code	18ECO109J	Course Name	EMBEDDED SYSTEM DESIGN USING RASPBERRY PI	Course Category	O	Open Elective	L	T	P	C
							2	0	2	3

Pre-requisite Courses	Nil	Co-requisite Courses	Nil	Progressive Courses	Nil
Course Offering Department	Electronics and Communication Engineering	Data Book / Codes/Standards	Nil		

Course Learning Rationale (CLR):	The purpose of learning this course is to:
CLR-1 :	*Understanding the programing of python for Raspberry Pi*
CLR-2 :	*Applying python programming on GPIO and interfacing motors using Raspberry Pi*
CLR-3 :	*Applying python programming on GPIO switch and keyboard*
CLR-4 :	*Create insights to the concepts and programming of motion detection ,GPS programming, light sensor ,gas detection*
CLR-5 :	*Analyze and understand the working principle and data sheet of temperature sensor, gas sensor ,ADC, ultrasonic rangefinder, Acceleration and light sensor*
CLR-6 :	*Utilize the technology of node js ,cloud service and MQTT Protocol for moving sensor data to web*

Course Learning Outcomes (CLO):	At the end of this course, learners will be able to:	Learning 1: Level of Thinking (Bloom)	Learning 2: Expected Proficiency (%)	Learning 3: Expected Attainment (%)	PLO 1: Engineering Knowledge	PLO 2: Problem Analysis	PLO 3: Design & Development	PLO 4: Analysis, Design, Research	PLO 5: Modern Tool Usage	PLO 6: Society & Culture	PLO 7: Environment & Sustainability	PLO 8: Ethics	PLO 9: Individual & Team Work	PLO 10: Communication	PLO 11: Project Mgt. & Finance	PLO 12: Life Long Learning	PLO 13: PSO - 1	PLO 14: PSO - 2	PLO 15: PSO – 3
CLO-1 :	*Apply python for Raspberry Pi*	2	80	70	H	H	-	-	H	-	-	-	-	-	-	-	H	-	-
CLO-2 :	*Analyze data sheet and functioning of sensors*	2	85	75	H	H	H	H	H	-	-	-	-	-	-	-	-	-	H
CLO-3 :	*Apply python programming on GPIO of Raspberry Pi and interfacing of sensor*	2	75	70	H	H	H	H	-	-	-	-	-	-	-	-	H	-	-
CLO-4 :	*Apply python programming on GPIO of Raspberry Pi to interfacing of actuators*	2	85	80	H	H	H	H	H	-	-	-	-	-	-	-	H	-	-
CLO-5 :	*Apply python programming on GPIO of Raspberry Pi to interfacing input and display device*	2	85	75	H	-	H	H	-	-	-	-	-	-	-	-	H	-	-
CLO-6 :	*Apply technology of node js ,cloud service and MQTT Protocol for IOT application*	2	80	70	H	-	H	-	H	-	-	-	-	-	-	-	-	-	H

Duration (hour)		Basic python programming	Programming interrupts –Motor control, switches and keyboard interface	Sensor interface and programming	Temperature sensor and display interface programming	Publishing sensor data on web service
		12	12	12	12	12
S-1	SLO-1	*Python Basics- Editing Python Programs with IDLE, Variables, displaying Output, Reading User Input , Arithmetic, Creating Strings*	*Programming with Interrupts*	*Detecting Movement-PIR sensor*	*Measuring Temperature Using a Digital Sensor*	*publish sensor data on web service-building a home security dash board*
	SLO-2	*Concatenating (Joining) Strings, Converting Numbers to Strings, Converting Strings to Numbers ,Find the Length of a String, Find the Position of One String Inside Another, Extracting Part of a String, Replacing One String of Characters with Another Inside a String ,Converting a String to Upper- or Lowercase*	*Programming with Interrupts*	*Data sheet analysis of PIR sensor*	*Data sheet analysis Digital Temperature Sensor*	*publish sensor data on web service-building a home security dash board*
S-2	SLO-1	*Running Commands Conditionally, Comparing Values, Logical Operators,*	*Controlling GPIO Outputs Using a Web Interface*	*Adding GPS to the Raspberry Pi*	*Measuring Distance-ultrasonic rangefinder*	*MQTT Protocol*
	SLO-2	*Repeating Instructions an Exact Number of Times ,Repeating Instructions Until Some Condition Changes , Breaking Out of a Loop, Defining a Function in Python*	*Controlling GPIO Outputs Using a Web Interface*	*Data sheet analysis of GPS*	*Data sheet analysis ultrasonic rangefinder*	*MQTT Protocol- installation and setting account ,token creation ,reading sensor data and pushing to thingsboard*
S-3-4	SLO-1	*Lab 1: Arithmetic and string*	*Lab 7: Programming on interrupts*	*Lab 13: Programming on PIR sensor*	*Lab 19: Programming on Digital Temperature Sensor*	*Lab 25: Publish sensor data on web service*
	SLO-2	*Lab 2: Loop*	*Lab 8: Programming on Web Interface*	*Lab 14: Programming on GPS*	*Lab 20: Programming on ultrasonic rangefinder*	*Lab 26: Publish sensor data on web service*

S-5	SLO-1	Creating a List , Accessing Elements of a List, Find the Length of a List , Adding Elements to a List , Removing Elements from a List,	Controlling Servo Motors using PWM	Using Resistive Sensors	Logging to a USB Flash Drive	basic of java scripts –node.js
	SLO-2	Creating a List by Parsing a String, Iterating over a List, Enumerating a List, Sorting a List, Cutting Up a List. Applying a Function to a List	Controlling the Speed of a DC Motor	Measuring Light	Logging to a USB Flash Drive	Modules-HTML module
S-6	SLO-1	Creating a Dictionary ,Accessing a Dictionary, Removing Things from a Dictionary,	Controlling the Direction of a DC Motor	Detecting Methane	Using a Four-Digit LED Display	Modules –file –event
	SLO-2	Iterating over Dictionaries	Using a Unipolar Stepper Motor	Data sheet analysis of gas sensor	Displaying Messages on an I2C LED matrix with data sheet discussion	Modules –file –event
S 7-8	SLO-1	Lab 3: Program on list	Lab 9: Programming on Stepper Motor	Lab 15: Programming on light sensor	Lab 21: Programming on Four-Digit LED Display	Lab 27: Programming on node js HTML module
	SLO-2	Lab 4: Program on Dictionary	Lab 10: Programming on DC Motor	Lab 16: Programming on Gas sensor	Lab 22: Programming on I2C LED matrix	Lab 28: Programming on node js file and event module
S-9	SLO-1	Controlling Hardware-Connecting an LED-Controlling the Brightness of an LED	Using a Bipolar Stepper Motor	Measuring a Voltage using MCP3008 And data sheet of MCP3008	Displaying Messages on an Alphanumeric LCD	LED blinking using node.js
	SLO-2	a Buzzing Sound	Building a Simple Robot Rover	Using Resistive Sensors with an ADC	Displaying Messages on an Alphanumeric LCD	LED blinking using node.js
S-10	SLO-1	Switching a High-Power DC Device Using a Transistor	Digital Inputs-Connecting a Push Switch-Toggling with a Push Switch-Using a Two-Position Toggle or Slide Switch	Measuring Temperature with an ADC	Cloud service for IOT	building java script client using MQTT broker
	SLO-2	Switching a High-Power Device Using a Relay	Using a Rotary (Quadrature) Encoder and Using a Keypad	Measuring Acceleration and data sheet discussion of Acceleration sensor	Cloud service for IOT	building java script client using MQTT broker
S 11,12	SLO-1	Lab 5: LED blinking and Brightness control	Lab 11: Programming on Switch	Lab 17: Programming on ADC	Lab 23: Programming on an Alphanumeric LCD	Lab 29: Programming on LED blinking using node.js
	SLO-2	Lab 6: Switching a High-Power DC Device	Lab 12: Programming on Keypad	Lab 18: Programming on Measuring Acceleration	Lab 24: Programming on an Alphanumeric LCD	Lab 30: Building java script client using MQTT broker

Learning Resources	1. Simon Monk, "Raspberry Pi Cookbook", O'Reilly Media, Inc, 2014. 2. Volker Ziemann, "A Hands-On Course in Sensors Using the Arduino and Raspberry Pi, CRC Press, 2018. 3. https://thingsboard.io/docs/	4. Colin Dow, "Internet of Thing: Programming Projects - Build modern IoT solutions with the Raspberry Pi 3 and Python", packtpub 2018. 5. https://www.w3schools.com/nodejs/nodejs_raspberrypi_blinking_led.asp

Learning Assessment

	Bloom's Level of Thinking	Continuous Learning Assessment (50% weightage)								Final Examination (50% weightage)	
		CLA – 1 (10%)		CLA – 2 (15%)		CLA – 3 (15%)		CLA – 4 (10%)#			
		Theory	Practice	Theory	Practice	Theory	Practice	Theory	Practice	Theory	Practice
Level 1	Remember Understand	20%	20%	15%	15%	15%	15%	15%	15%	15%	15%
Level 2	Apply Analyze	20%	20%	20%	20%	20%	20%	20%	20%	20%	20%
Level 3	Evaluate Create	10%	10%	15%	15%	15%	15%	15%	15%	15%	15%
	Total	100 %		100 %		100 %		100 %		100 %	

CLA – 4 can be from any combination of these: Assignments, Seminars, Tech Talks, Mini-Projects, Case-Studies, Self-Study, MOOCs, Certifications, Conf. Paper etc.,

Course Designers

Experts from Industry	Experts from Higher Technical Institutions	Internal Experts
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2. Mr. Hariharasudhan - Johnson Controls, Pune, hariharasudhan.v@jci.com	2. Dr. Venkatesan, Sr. Scientist, NIOT, Chennai, venkat@niot.res.in	

Course Code	18ECO110J	Course Name	3D PRINTING HARDWARE AND SOFTWARE	Course Category	E	Professional Elective	L	T	P	C
							2	0	2	3

Pre-requisite Courses	Nil	Co-requisite Courses	Nil	Progressive Courses	Nil
Course Offering Department	Electronics and Communication Engineering	Data Book / Codes/Standards		Nil	

Course Learning Rationale (CLR):	The purpose of learning this course is to:
CLR-1 :	*Understand the tools available for 3D printing*
CLR-2 :	*Familiarize with 3D design software and hardware*
CLR-3 :	*Understand the 3D design criteria and its limitations.*
CLR-4 :	*Learn the contemporary technology available for 3D design and printing*
CLR-5 :	*Understand various post processing methods involved in 3D printing technology*
CLR-6 :	*Develop the skillset on 3D component design and development using contemporary commercial software and hardware available.*

		Learning			Program Learning Outcomes (PLO)														
		1	2	3	1	2	3	4	5	6	7	8	9	10	11	12	13	14	15
Course Learning Outcomes (CLO):	*At the end of this course, learners will be able to:*	Level of Thinking (Bloom)	Expected Proficiency (%)	Expected Attainment (%)	Engineering Knowledge	Problem Analysis	Design & Development	Analysis, Design, Research	Modern Tool Usage	Society & Culture	Environment & Sustainability	Ethics	Individual & Team Work	Communication	Project Mgt. & Finance	Life Long Learning	PSO - 1	PSO - 2	PSO – 3
CLO-1 :	*Apply the 3D printing tools for components design*	*1*	*80*	*60*	*M*				*M*										
CLO-2 :	*Able to optimistically select the 3D design software and hardware for the given problem*	*1*	*80*	*60*	*M*				*H*										
CLO-3 :	*Capability to solve 3D design components design problems*	*2*	*75*	*60*	*M*			*M*										*M*	
CLO-4 :	*Choose the contemporary technology available for 3D design and printing*	*3*	*80*	*60*			*M*											*M*	*L*
CLO-5 :	*Apply various post processing methods involved in 3D printing technology*	*2*	*80*	*60*		*H*													
CLO-6 :	*Ability to develop the skillset on 3D component design and development using contemporary commercial software and hardware available.*	*2*	*80*	*60*											*M*			*M*	

Duration (hour)		Introductions to 3D design tools	Three-dimensional (3D) Modeling	3D Design Fundamentals and Projects	3D Printing and its Technologies	Post Processing - Product Visualization and Print Cleaning
		12	12	12	12	12
S-1	SLO-1 SLO-2	*Introduction to Maya GUI - Object creation workflow, Constructing object primitives to scale and with accuracy*	*An overview of CAD software packages - Introduction to Fusion 360 - Drawing based workflow, Drawing constraints - Surfacing operations.*	*The good, the bad, and the ugly of design*	*History of 3D printing - Overview of 3D Printing technologies*	*Workflows for printing*
S-2	SLO-1 SLO-2	*Duplication and arrayed duplication - Grid and point/vertex snapping*	*Moving Parts and Articulation Hinges - Ball and sockets*	*Prominent Designers*	*Selective Laser Sintering (SLS) Direct Metal Laser Sintering (DMLS)*	*Software and Drivers - Formats for Printing (SLA, OBJ, CAD, etc.)*
S 3-4	SLO-1 SLO-2	*Understanding NURBS: NURBS Surfaces advantages, Similarities and differences between NURBS and CAD drawings Curve and surface construction*	*Creating a part negative, Creating Text in Maya the proper way (NURBS Curves, surface lofts, conversion to polygon) Painterly tools (Sculpt Geometry Tool, etc.)*	*Franchises Success stories, Pop culture*	*Vacuum forming - Resin casting - Injection Molding - Terms and standards for injection molding systems*	*Post and Export Print Lab setup*
S-5	SLO-1 SLO-2	*Understanding 3D geometry - Modeling workflows for Polygons - Additive vs. Subtractive Tools - Mesh editing*	*Flexibility and elasticity, Locks, bolts, and fasteners Threading (taps and dies)*	*Early decision making criteria*	*Fused Deposition Modeling (FDM) - Stereolithography (SLA)*	*Cleanup and airtight modeling*
S-6	SLO-1	*Best Practices for constructing printable polygon meshes*	*Interfacing, support, and reinforcement*	*Knowing the product*	*Laminated Object Manufacturing (LOM) - Electron Beam Melting (EBM)*	*Loading models and arranging print stage*
	SLO-2	*Fundamental Structure - Combining, merging, and sewing up polygon meshes*				

S 7-8	SLO-1	*Best Practices for constructing printable polygon meshes - Fundamental Structure - Combining, merging, and sewing up polygon meshes*	*How the modeling software packages differ from CAD packages, Sketch/drawing based workflows, Similarities and differences between CAD and NURBS.*	*Brainstorming and critique in the early design phase Group critiques of in-progress projects*	*Printing Resolutions and Tolerances Materials Properties (Temperature, Flexibility, Strength, Brittleness)*	*Printing - Removing support material*
	SLO-2					
S-9	SLO-1	*Understanding two-manifold vs. non-manifold geometry*	*Form and function visualizing the assembly process*	*Early decision-making criteria Knowing the product Vision and Reality*	*3D Printing (3DP) – Selective laser melting (SLM)*	*Special topics – 3D Scanners and its types*
	SLO-2	*Exporting geometry - Laying out a simple model on a stage for print*				
S-10	SLO-1	*Hollow forms and the importance of reducing volume Cost of size, cost of volume, cost of detail, cost of time State table*	*Complex interactions and motorizations*	*Calculating the total cost Progress checks and group critiques of in-progress projects*	*Final cleanup and processing of files for printing*	*Reverse engineering, Concepts and its hardware and software*
	SLO-2					
S 11-12	SLO-1	*Clean and uniform topology, Illustrator, IGES, and other import/export pipelines*	*Broad overview of manufacturing techniques Molding, sculpting, lathing, lofting, welding, cutting, drilling, gluing, etc*	*Brainstorming and critique in the early design phase Group critiques of in-progress projects*	*Planning for injection molding - 3D Printing for injection molding*	*High speed machining*
	SLO-2					

Learning Resources	1. *Hod Lipson, Melba Kurman, Fabricated: The New World of 3D Printing, Wiley, 2013* 2. *Matthew Griffin, Design and Modeling for 3D Printing, Maker Media, Inc., 2013.* 3. *Rob Thompson, Manufacturing Processes for Design Professionals, Thames & Hudson; Reprint edition, 2007.* 4. *https://web.stanford.edu/class/me137/* 5. *SolidWorks Gallery: http://www.3dcontentcentral.com/default.aspx*	6. *3D Anatomy Models: http://lifesciencedb.jp/bp3d/?lng=en* 7. *AutoDesk Fusion360 HomePage: http://fusion360.autodesk.com* 8. *International Journal of Rapid Manufacturing* 9. *Academic Journals on 3D Printing* 10. *International Journal of Rapid Manufacturing*

Learning Assessment

	Bloom's Level of Thinking	Continuous Learning Assessment (50% weightage)								Final Examination (50% weightage)	
		CLA – 1 (10%)		CLA – 2 (15%)		CLA – 3 (15%)		CLA – 4 (10%)#			
		Theory	Practice	Theory	Practice	Theory	Practice	Theory	Practice	Theory	Practice
Level 1	Remember Understand	*20%*	*20%*	*15%*	*15%*	*15%*	*15%*	*15%*	*15%*	*15%*	*15%*
Level 2	Apply Analyze	*20%*	*20%*	*20%*	*20%*	*20%*	*20%*	*20%*	*20%*	*20%*	*20%*
Level 3	Evaluate Create	*10%*	*10%*	*15%*	*15%*	*15%*	*15%*	*15%*	*15%*	*15%*	*15%*
	Total	100 %		100 %		100 %		100 %		100 %	

CLA – 4 can be from any combination of these: Assignments, Seminars, Tech Talks, Mini-Projects, Case-Studies, Self-Study, MOOCs, Certifications, Conf. Paper etc.,

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2. Mr. Hariharasudhan - Johnson Controls, Pune, hariharasudhan.v@jci.com	*2. Dr. Venkatesan, Sr. Scientist, NIOT, Chennai, venkat@niot.res.in*	*2. Dr. P. Eswaran, SRMIST*

Course Code	18ECO126T	Course Name	SPORTS BIOMECHANICS	Course Category	E	Professional Elective	L	T	P	C
							3	0	0	3

Pre-requisite Courses	18ECE267J	Co-requisite Courses	Nil	Progressive Courses	Nil
Course Offering Department	Electronics and Communication Engineering	Data Book / Codes/Standards	Nil		

Course Learning Rationale (CLR):	*The purpose of learning this course is to:*
CLR-1 :	*Understand the fundamental muscle action and locomotion in biomechanical point of view*
CLR-2 :	*Get an idea about the movement patterns and causes of movements*
CLR-3 :	*Understand the qualitative and quantitative analysis of sports movements*
CLR-4 :	*Acquire an idea about the basic concept of jumping & aerial movement and throwing & hitting*
CLR-5 :	*Get an idea about the injury prevention, rehabilitation and special Olympic sports*
CLR-6 :	*Get an overall idea about the applications of biomechanics in sports*

Course Learning Outcomes (CLO):	*At the end of this course, learners will be able to:*	Learning			Program Learning Outcomes (PLO)														
		1	2	3	1	2	3	4	5	6	7	8	9	10	11	12	13	14	15
		Level of Thinking (Bloom)	Expected Proficiency (%)	Expected Attainment (%)	Engineering Knowledge	Problem Analysis	Design & Development	Analysis, Design, Research	Modern Tool Usage	Society & Culture	Environment & Sustainability	Ethics	Individual & Team Work	Communication	Project Mgt. & Finance	Life Long Learning	PSO - 1	PSO - 2	PSO – 3
CLO-1 :	*Illustrate the muscle action in sport and locomotion*	*1*	*80*	*70*	*M*												*L*		
CLO-2 :	*Analyze the movement patterns and its causes*	*1,2*	*80*	*70*	*M*												*M*		
CLO-3 :	*Describe the Qualitative and Quantitative analysis of sports movements*	*2*	*80*	*70*	*M*												*M*		
CLO-4 :	*Analyze the movement of action such as jumping, throwing, hitting and aerial movement*	*2*	*80*	*70*			*L*										*L*	*L*	*L*
CLO-5 :	*Identify the injury scenario and special Olympic sports*	*2*	*80*	*70*													*L*	*L*	*L*
CLO-6 :	*Outline the major concepts in sports biomechanics*																		

Duration (hour)		Muscle Action in Sport and Exercise and locomotion- Biomechanical view	Movement patterns and its causes	Qualitative and Quantitative analysis of sports movements	Jumping and Aerial Movement, Throwing and Hitting	Injury Prevention, Rehabilitation and Special Olympic Sports
		9	9	9	9	9
S-1	SLO-1	*Introduction to Biomechanics*	*Introduction to Movement patterns*	*Introduction to Analysis of Sport Movements*	*Introduction to Aerial movement*	*Mechanisms of Musculoskeletal Injury*
	SLO-2	*Applications of Biomechanics*	*Defining human movements*	*A structured analysis framework*	*Types of Aerial Movement - Rotation during flight, Motion of the mass centre*	*Musculoskeletal Loading During Landing*
S-2	SLO-1	*Neural Contributions to Changes in Muscle Strength*	*Fundamental movements-Walking, Running*	*Preparation stage*	*Types of Aerial Movement : Somersaulting, Twisting,*	*Sport-Related Spinal Injuries and their Prevention*
	SLO-2	*Mechanical Properties and Performance in Skeletal Muscles*	*Fundamental movements-Throwing, Jumping*	*Observation stage*	*Control of aerial movement*	*Sport-Related Spinal Injuries and their Prevention*
S-3	SLO-1	*Muscle-Tendon Architecture*	*qualitative and quantitative movement*	*Evaluation and diagnosis stage*	*Introduction : High Jump*	*Impact Propagation and its Effects on the Human Body*
	SLO-2	*Athletic Performance*	*Comparison of qualitative and quantitative movement analysis*	*Intervention stage – providing appropriate feedback*	*Techniques of Jumping - Skating, Springboard and Platform Diving*	*Impact Propagation and its Effects on the Human Body*
S-4	SLO-1	*Eccentric Muscle Action in Sport and Exercise*	*Movement patterns-geometry of motion*	*Identifying critical features of a movement*	*Determinants of Successful Ski-Jumping Performance*	*Neuromechanics of the Initial Phase of Eccentric Contraction*
	SLO-2	*Stretch–Shortening Cycle of Muscle Function*	*Fundamentals of movement*	*Identifying critical features of a movement*	*Determinants of Successful Ski-Jumping Performance*	*Induced Muscle Injury*
S-5	SLO-1	*Biomechanical Foundations of Strength*	*Linear motion and the centre of mass*	*The use of videography in recording sports movements*	*Principles of Throwing*	*Manual Wheelchair Propulsion*
	SLO-2	*Power Training*	*The geometry of angular motion and the coordination of joint rotations*	*The use of videography in recording sports movements*	*The Flight of Sports Projectiles*	

S-6	SLO-1	*Factors Affecting Preferred Rates of Movement in Cyclic Activities*	*Forces in sport*	*Recording the movement*	*Javelin Throwing: an Approach to Performance Development*	*Sports after Amputation*
	SLO-2	*The Dynamics of Running*	*Combinations of forces on the sports performer*	*Experimental procedures -Two dimensional videography*		
S-7	SLO-1	*Resistive Forces in Swimming*	*Momentum and the laws of linear motion*	*Experimental procedures -Three dimensional videography*	*Shot Putting*	*Biomechanics of Dance*
	SLO-2	*Propulsive Forces in Swimming*	*Force–time graphs as movement patterns*	*Data processing*	*Hammer Throwing: Problems and Prospects*	
S-8	SLO-1	*Performance-Determining Factors in Speed Skating*	*Determination of the centre of mass of the human body*	*Projectile motion*	*Hammer Throwing: Problems and Prospects*	*Biomechanics of Martial arts*
	SLO-2	*Cross-Country Skiing: Technique*	*Fundamentals of angular kinetics and Generation and control of angular momentum*	*Linear velocities and accelerations caused by rotation*	*Hitting*	
S-9	SLO-1	*Cross-Country Skiing: Equipment*	*Measurement of force*	*Rotation in three-dimensional space*	*Kicking*	*Biomechancis of YOGA*
	SLO-2	*Factors Affecting Performance*	*Measurement of pressure*	*Rotation in three-dimensional space*	*Simple concept problems*	

Learning Resources	1. *Susan J Hall, "Basic Biomechanics", McGraw-Hill Higher Education, 7th edition, 2014* 2. *Vladimir M. Zatsiorsky, Biomechanics in Sports: Performance Enhancement and Injury Prevention, 1st ed., Blackwell Science Ltd, 2000*	3. *Jules Mitchell,"Yoga Biomechanics", 1 edition , Handspring Publishing Limited ,2018* 4. *Roger Bartlett, Introduction to Sports Biomechanics: Analysing Human Movement Patterns, 2nd ed., Routledge, 2007*

Learning Assessment

	Bloom's Level of Thinking	Continuous Learning Assessment (50% weightage)								Final Examination (50% weightage)	
		CLA – 1 (10%)		CLA – 2 (15%)		CLA – 3 (15%)		CLA – 4 (10%)#			
		Theory	Practice	Theory	Practice	Theory	Practice	Theory	Practice	Theory	Practice
Level 1	Remember Understand	*40 %*	-	*40 %*	-	*40 %*	-	*30 %*	-	*30%*	-
Level 2	Apply Analyze	*40 %*	-	*40 %*	-	*40 %*	-	*40 %*	-	*40%*	-
Level 3	Evaluate Create	*20 %*	-	*20 %*	-	*20 %*	-	*30 %*	-	*30%*	-
	Total	100 %		100 %		100 %		100 %		100 %	

CLA – 4 can be from any combination of these: Assignments, Seminars, Tech Talks, Mini-Projects, Case-Studies, Self-Study, MOOCs, Certifications, Conf. Paper etc.,

Course Designers

Experts from Industry	Experts from Higher Technical Institutions	Internal Experts
1. Sathyanarayanan J, Mindray Medical India Pvt Ltd, sathyanarayananjayagopal@mindray.com	*1. Dr. S. Poonguzhali, Anna University, poongs@annauniv.edu*	*1. Ms. Oinam Robita Chanu, SRMIST*
2. Mr. Anuj Kumar, Bombardier Transportation, Ahmedabad, kumaranuj.anii@gmail.com	*2. Dr. Meenakshi, Professor of ECE, CEG, Anna University, meena68@annauniv.edu*	*2. Dr .D. Ashok kumar, SRMIST*
3 Mr. Hariharasudhan - Johnson Controls, Pune, hariharasudhan.v@jci.com	*3. Dr. Venkatesan, Sr. Scientist, NIOT, Chennai, venkat@niot.res.in*	

Course Code	18ECO135T	Course Name	FUNDAMENTALS OF MEMS	Course Category	O	Open Elective	L	T	P	C
							3	0	0	3

Pre-requisite Courses	Nil	Co-requisite Courses	Nil	Progressive Courses	Nil
Course Offering Department	Electronics and Communication Engineering	Data Book / Codes/Standards	Nil		

Course Learning Rationale (CLR):	*The purpose of learning this course is to:*
CLR-1 :	*Understand the importance of micro system technology*
CLR-2 :	*Learn the operating principle of various micro sensors and actuators*
CLR-3 :	*Impart the applications of various micro fabrication techniques*
CLR-4 :	*Understand the differences and need for microfabrication*
CLR-5 :	*Operate MEMS design tools to design simple micro devices*
CLR-6 :	*Understand recent developments and challenges in MEMS*

Course Learning Outcomes (CLO):	*At the end of this course, learners will be able to:*	Learning 1: Level of Thinking (Bloom)	2: Expected Proficiency (%)	3: Expected Attainment (%)	PLO 1: Engineering Knowledge	2: Problem Analysis	3: Design & Development	4: Analysis, Design, Research	5: Modern Tool Usage	6: Society & Culture	7: Environment & Sustainability	8: Ethics	9: Individual & Team Work	10: Communication	11: Project Mgt. & Finance	12: Life Long Learning	13: PSO - 1	14: PSO - 2	15: PSO – 3
CLO-1 :	*Appreciate the fundamental concepts in MEMS technology*	2,3	80	80	H	-	-	-	-	H	-	-	-	-	-	H	H	-	H
CLO-2 :	*Understand the fabrication and machining techniques of MEMS devices*	1,2	80	80	H	-	-	-	-	H	-	-	-	-	-	H	-	-	H
CLO-3 :	*Familiarize with the concepts of packaging of MEMS devices*	1	80	80	H	-	-	H	-	H	-	-	-	-	-	H	H	-	H
CLO-4 :	*Appreciate the significance of micro fabrication processes*	3	80	80	H	-	-	H	-	-	-	-	-	-	-	H	-	-	H
CLO-5 :	*Design and Simulate simple structures using MEMS software*	3	80	80	H	-	H	H	H	-	-	H	H	-	-	H	H	-	H
CLO-6 :	*Analyze recent trends and developments in MEMS technology*	3	80	80	H	-	-	H	-	-	-	-	-	-	-	H	H	-	H

		Introduction	Fabrication overview	Micromachining	Bonding & Sealing	Recent trends
Duration (hour)		9	9	9	9	9
S-1	SLO-1	*Introduction to MEMS and Brief recap of Macro devices*	*Introduction to Micro fabrication process*	*Introduction of micro machining(MMC) process*	*Introduction to MEMS packaging*	*Introduction to design tools and simulation*
	SLO-2	*Microelectronics and Micro systems*	*Significance of each technique*	*Significance of MMC*	*Challenges in packaging*	*FEM analysis*
S-2	SLO-1	*Scaling laws in geometry*	*Process Description of Photolithography*	*Bulk MMC process – merits and demerits*	*Different levels of Packaging*	*Design of a silicon die for a micro pressure sensor*
	SLO-2	*Silicon as ideal material and as substrate*	*Implementation of Photolithography*	*Sequence of steps*	*Die, device and system level*	*Simulation in software*
S-3	SLO-1	*Si wafer production*	*Process Description of CVD*	*Significance of Isotropic etching*	*Differences in IC packaging technology and MEMS packaging*	*Application of MEMS in automotive industry*
	SLO-2	*Cz process*	*Implementation, merits and demerits of CVD*	*Anisotropic etching*		*Airbag deployment*
S-4	SLO-1	*Sequential steps in wafer processing*	*Process Description of PVD*	*Surface MMC process*	*Die Preparation*	*Optical MEMS Application*
	SLO-2		*Implementation, merits and demerits of PVD*	*Sequence of steps*	*Plastic encapsulation and its significance*	*Micro mirrors*
S-5	SLO-1	*Chemical and mechanical properties of Si and compounds*	*Process Description, implementation of Ion implantation*	*Challenges in surface MMC*	*Types of wire bonding Thermo compression type*	*Micro fluidics Application*
	SLO-2	*Chemical and mechanical properties of Polymers, Quartz and GaAs*	*Oxidation process*	*Interfacial & Residual stresses*	*Thermo sonic, Ultra sonic type*	*Lab on chip module*
S-6	SLO-1	*Chemical, Biomedical type Micro sensors*	*Diffusion process*	*LIGA process- description merits and demerits*	*Types of surface bonding – Adhesive*	*IR and Gas sensing*
	SLO-2	*Piezoelectric type of Micro sensors*	*Wet etching methods*	*Implementation*	*soldering, SOI type of bonding*	*Thermal sensors*
S-7	SLO-1	*Thermal, SMA, Piezoelectric actuators*	*Properties of etchants*	*Process Design-block diagram and description*	*Anodic bonding and lift off process*	*Micro power generation*

	SLO-2	*Electro static type Micro Actuators*	*Dry etching methods*	*Electro-mechanical design, Thermo-electric design*	*Precautions to be taken*	*Micro TEG*
S-8	SLO-1	*Micro devices- operation of Micro gears and micromotors*	*Production of plasma*	*CAD- block diagram description and implementation*	*Types of sealing- Micro shells, Hermetic sealing*	*Chemical sensors*
	SLO-2	*Micro devices –operation of Micro valves and pumps*	*Etch stop methods*		*Micro 'O' rings,Reactive seal*	*Micro humidity sensors*
S-9	SLO-1	*Case study*	*Case study*	*Case study*	*Selection of packaging materials*	*Micro pressure sensors*
	SLO-2				*Material requirements*	*Paper MEMS*

Learning Resources	*1. Tai-Ran Hsu, "MEMS and MICROSYSTEMS", 22nd reprint edition, Wiley & sons, 2015* *2. M. Madou, "Fundamentals of Micro fabrication", Taylor and Francis group, 2002*	*3. VardhanGardener,"Micro sensors and smart devices", John Wiley & Sons,2001* *4. NPTEL link: https://nptel.ac.in/downloads/112108092/*

Learning Assessment

	Bloom's Level of Thinking	Continuous Learning Assessment (50% weightage)								Final Examination (50% weightage)	
		CLA – 1 (10%)		CLA – 2 (15%)		CLA – 3 (15%)		CLA – 4 (10%)#			
		Theory	Practice	Theory	Practice	Theory	Practice	Theory	Practice	Theory	Practice
Level 1	Remember Understand	*30 %*	-	*30 %*	-	*30 %*	-	*30 %*	-	*30%*	-
Level 2	Apply Analyze	*40 %*	-	*40 %*	-	*40 %*	-	*40 %*	-	*40%*	-
Level 3	Evaluate Create	*30 %*	-	*30 %*	-	*30 %*	-	*30 %*	-	*30%*	-
	Total	100 %		100 %		100 %		100 %		100 %	

CLA – 4 can be from any combination of these: Assignments, Seminars, Tech Talks, Mini-Projects, Case-Studies, Self-Study, MOOCs, Certifications, Conf. Paper etc.,

Course Designers

Experts from Industry	Experts from Higher Technical Institutions	Internal Experts
1. D. Karthikeyan, Controlsoft Engineering India Pvt Ltd, karthikeyan.d@controlsoftengg.in	*1. Dr. J. Prakash, MIT, Chennai, prakaiit@rediffmail.com*	*1. Dr. A. Vimala Juliet, SRMIST*
2. Mr. Hariharasudhan - Johnson Controls, Pune, hariharasudhan.v@jci.com	*2. Dr. D. Nedumaran, Madras University, dnmaran@gmail.com*	*2. R.Bakiyalakshmi,SRMIST*

Course Code	18MEO101T	Course Name	ROBOTICS ENGINEERING AND APPLICATIONS	Course Category	O	Open Elective	L	T	P	C
							3	0	0	3

Pre-requisite Courses	NIL	Co-requisite Courses	NIL	Progressive Courses	NIL
Course Offering Department	Mechanical Engineering	Data Book / Codes/Standards	NIL		

Course Learning Rationale (CLR):	*The purpose of learning this course is to:*
CLR-1 :	*Be familiar with basic concepts of robotics*
CLR-2 :	*Be familiar with various end effectors and transformation techniques*
CLR-3 :	*Be familiar with different sensors and system controllers*
CLR-4 :	*Be familiar with the design of robot work cell layouts and interfacing*
CLR-5 :	*Be familiar with different robot programming languages and applications in different fields*

		Learning			Program Learning Outcomes (PLO)														
		1	2	3	1	2	3	4	5	6	7	8	9	10	11	12	13	14	15
Course Learning Outcomes (CLO):	*At the end of this course, learners will be able to:*	Level of Thinking (Bloom)	Expected Proficiency (%)	Expected Attainment (%)	Engineering Knowledge	Problem Analysis	Design & Development	Analysis, Design, Research	Modern Tool Usage	Society & Culture	Environment & Sustainability	Ethics	Individual & Team Work	Communication	Project Mgt. & Finance	Life Long Learning	PSO - 1	PSO - 2	PSO – 3
CLO-1 :	*Understand the basic concepts of robotics*	*1& 2*	*90*	*85*	*H*		*M*												
CLO-2 :	*Understand the various end effectors and application of transformation techniques*	*1*	*90*	*85*	*H*		*M*		*M*		*M*								
CLO-3 :	*Understand the different sensors and system controllers*	*1*	*90*	*85*	*H*						*M*								
CLO-4 :	*Understand the design of robot work cell layouts and interfacing*	*1&2*	*90*	*85*	*H*								*H*						
CLO-5 :	*Understand the different robot programming languages and applications in different fields*	*1&2*	*90*	*85*	*H*														

		Basic concepts of robotics	End effectors and transformation techniques	Sensors and system controllers	Work cell design layouts and interfacing	Robot programming languages and applications
Duration (hour)		9	9	9	9	9
S-1	SLO-1	*Basic concepts of robotics (Laws of robotics, robotic systems), RIA definition*	*End effectors-Introduction, classification.*	*Sensor devices*	*Robot cell lay outs*	*Robot language, classification.*
S-2	SLO-1	*Robot anatomy (Robot configurations, Robot motions, Joint notation scheme) , Manipulators*	*Mechanical, Magnetic grippers.*	*Types of sensors (contact, position and displacement sensors)*	*Robot work cell design and control*	*Programming methods, off and on line programming.*
S-3	SLO-1	*Precision movement (Spatial resolution, accuracy, repeatability) Work volume, robot specifications*	*Vacuum and adhesive gripper*	*Force and torque sensors*	*Multiple robots*	*Lead through method, powered and Manual lead through and Teach pendent method.*
S-4	SLO-1	*Types of Robot drives - electric drives*	*Gripper design and Gripper force analysis*	*Proximity and range sensors, acoustic sensors.*	*Machine interface*	*VAL systems and language, Simple program.*
S-5	SLO-1	*Hydraulic and pneumatic drives*	*Orientation of wrist*	*Robot vision systems, Sensing and digitizing.*	*Safety considerations in cell design*	*Application of Robots, Material handling, Constrains, Machine loading and unloading.*
S-6	SLO-1	*Basic robot motions, Point to point control and continuous path control.*	*2D transformation (scaling, rotation, translation)*	*Image processing and analysis.*	*Interlocks in work cell*	*Assembly Robot, Assembly operation, RCC device, Benefits- Inspection robot, used in Quality control.*
S-7	SLO-1	*Forward and inverse kinematics for 2DOF manipulator*	*3D transformation (scaling, rotation, translation)*	*Robot control system - Unit control system*	*Types of work cell controllers*	*Welding and Spray painting Robots, features, sensors, Advantages*
S-8	SLO-1	*Forward and inverse kinematics for 3DOF manipulator*	*Homogeneous transformations*	*Adaptive and Optimal control*	*Robot cycle time analysis*	*Mobile and microbots, types, mobility and application.*
S-9	SLO-1	*Machine intelligence*	*Coordinate frames - Description of Objects in Space*	*Basic Relationship Between Pixels*	*Error detection and Error recovery*	*Search techniques in AI and robotics*

Learning Resources	1. *Mikell P. Groover, "Industrial Robotics Technology Programming and Applications",McGraw Hill Co., New Delhi, 2012.* 2. *Deb .S.R, "Robotics technology and flexible automation", Tata McGraw Hill publishing company limited, New Delhi, 2010.* 3. *Klafter.R.D, Chmielewski.T.A and Noggins, "Robot Engineering: An Integrated Approach", Prentice Hal of India Pvt. Ltd., New Delhi, 2010.* 4. *Fu K.S, Gonzalez, R.C.,& Lee, C.S.G., "Robotics control, sensing, vision and intelligence", McGraw Hill Book Co., Singapore, Digitized 2007.*	5. *Craig.J.J, "Introduction to Robotics mechanics and control", Addison- Wesley, London, 2008.* 6. *References:* 7. *S. Mukherjee, Robotics, Khanna Book Publishing Co., New Delhi* 8. *S.K. Saha, Introduction to Robotics, TMH* 9. *T.C. Manjunath, Fundamentals of Robotics, Nandu Printers and Publishers Private Limited, Mumbai*

Learning Assessment											
	Bloom's Level of Thinking	Continuous Learning Assessment (50% weightage)								Final Examination (50% weightage)	
		CLA – 1 (10%)		CLA – 2 (15%)		CLA – 3 (15%)		CLA – 4 (10%)#			
		Theory	Practice	Theory	Practice	Theory	Practice	Theory	Practice	Theory	Practice
Level 1	Remember Understand	*40 %*	-	*30 %*	-	*30 %*	-	*30 %*	-	*30%*	-
Level 2	Apply Analyze	*40 %*	-	*40 %*	-	*40 %*	-	*40 %*	-	*40%*	-
Level 3	Evaluate Create	*20 %*	-	*30 %*	-	*30 %*	-	*30 %*	-	*30%*	-
	Total	100 %		100 %		100 %		100 %		100 %	

CA – 4 can be from any combination of these: Assignments, Seminars, Tech Talks, Mini-Projects, Case-Studies, Self-Study, MOOCs, Certifications, Conf. Paper etc., SLO – Session Learning Outcome

Course Designers		
Experts from Industry	Experts from Higher Technical Institutions	Internal Experts
1. Dr.R.Kalimuthu, ISRO, Mahendragiri, r_kalimuthu@vssc.gov.in	*Dr. BIJAY KUMAR ROUT, BITS, Pilani*	*V.RAGHAVENDRA RAO, SRMIST*
2. Dr.A.Velayutham, DRDO, Avadi, velayudham.a@cvrde.drdo.in	*SELVA KUMAR .S, FORD INDIA LIMITED, CHENNAI.*	*Dr. M. Iqbal, SRMIST*

Course Code	18MEO102T	Course Name	ALTERNATIVE SOURCES OF ENERGY	Course Category	E	Open Elective	L	T	P	C
							3	0	0	3

Pre-requisite Courses	NIL	Co-requisite Courses	NIL	Progressive Courses	NIL
Course Offering Department	Mechanical Engineering	Data Book / Codes/Standards	NIL		

Course Learning Rationale (CLR):	*The purpose of learning this course is to:*
CLR-1 :	*Familiarize with the solar energy technologies*
CLR-2 :	*Study the wind energy and hybrid energy systems*
CLR-3 :	*Be familiar with the concepts of ocean, hydro and geothermal energy systems*
CLR-4 :	*Familiarize with the biomass energy conversion technologies*
CLR-5 :	*Familiarize with the operations of direct energy conversion systems*
CLR-6 :	*Be familiar with alternative energy needs with its availability*

Course Learning Outcomes (CLO):	*At the end of this course, learners will be able to:*	Learning 1: Level of Thinking (Bloom)	Learning 2: Expected Proficiency (%)	Learning 3: Expected Attainment (%)	PLO 1: Engineering Knowledge	PLO 2: Problem Analysis	PLO 3: Design & Development	PLO 4: Analysis, Design, Research	PLO 5: Modern Tool Usage	PLO 6: Society & Culture	PLO 7: Environment & Sustainability	PLO 8: Ethics	PLO 9: Individual & Team Work	PLO 10: Communication	PLO 11: Project Mgt. & Finance	PLO 12: Life Long Learning	PLO 13: PSO - 1	PLO 14: PSO - 2	PLO 15: PSO – 3
CLO-1 :	*Recognize and analyze the solar energy systems*	*1&2*	*90*	*80*	*H*	*M*		*M*										*H*	
CLO-2 :	*Acquire knowledge on wind energy conversion systems*	*1*	*90*	*80*	*H*	*M*	*M*	*L*			*M*							*H*	
CLO-3 :	*Understand the ocean, hydro and geothermal energy*	*1*	*90*	*80*	*H*						*M*							*H*	
CLO-4 :	*Understand and identify biologically degradable resources and its energy conversion processes*	*1&2*	*90*	*80*	*H*													*H*	
CLO-5 :	*Recognize the design needs for direct energy conversion systems*	*1&2*	*90*	*80*	*H*		*M*											*H*	
CLO-6 :	*Understand and renovate future energy needstowards renewable energy*	*1*	*90*	*80*	*H*	*M*	*M*				*M*							*H*	

		Solar Energy	Wind Energy	Ocean, Hydro and Geothermal Energy	Biomass	Direct Energy Conversion Systems
Duration (hour)		9	9	9	9	9
S-1	SLO-1	*Solar energy, Solar radiation and its measurements*	*Wind energy, Basic principle and Components of wind energy conversion system*	*Wave characteristics and wave energy conversion systems*	*Biomass,Sources of biomass*	*Basics of direct energy conversion systems, thermo electric and thermionic power generations*
S-2	SLO-1	*Types of solar thermal collectors*	*Wind data, site selection and energy estimation*	*Tidal energy and its types*	*Pyrolysis, combustion and gasification process*	*Fuel cell principles and its classification*
S-3	SLO-1	*Solar thermal applications for water heaters, solar stills and solar pond*	*Types of Horizontal axiswind turbine such as Single blade, Two blades,*	*Estimation of energy and power in single basin tidal system*	*Updraft and downdraft gasifier*	*Types - Phosphoric acid, polymer electrolyte membrane fuelcell, molten carbonate fuel cell and solid oxide fuel cell*
S-4	SLO-1	*Solar thermal applications for refrigeration and air conditioning system*	*Types of Horizontal axis wind turbine such as Multi blades, Dutch and Sail type*	*Ocean thermal energy conversion for open system*	*Fluidized bed gasifier*	*Fuel cell conversion efficiency and applications*
S-5	SLO-1	*Solar thermal applications for solar dryer, solar cookers and solar furnaces*	*Vertical axis wind turbinesuch as Savonius Rotor, Darrieus Type*	*Ocean thermal energy conversion for closed system.*	*Fermentation and digestion process*	*Open cycle magneto hydrodynamic power generation*
S-6	SLO-1	*Drawbacks/Real field issues in solar thermal systems, sensible and latent heat thermal energy storage systems to avoid day night issues*	*Design consideration of horizontal axis wind turbine*	*Hydro power plants for small, mini and micro system*	*Fixed and floating digester biogas plants*	*Closed cycle magneto hydrodynamic power generation*
S-7	SLO-1	*Solar thermal power generation systems*	*Aerofoil theory, Analysis of aerodynamic forces acting on the blade*	*Exploration of geothermal energy.*	*Design considerations of digester*	*Hydrogen energy: properties and its production methods*
S-8	SLO-1	*Solar photovoltaic systems: basic working principle, componentsand its applications*	*Performance of wind turbines*	*Geothermal power plants*	*Operational parameter of biogas plants, Economics of biomass power generation*	*Electrolysis, thermo-chemical, fossil fuels and solar energy methods*

S-9	SLO-1	*Performance assessment of any one solar thermal and electric systems*	*Hybrid energy systems (solar and wind),environmental issues of wind energy*	*Challenges, availability, geographical distribution, scope*	*Sources and production of biodiesel and ethanol*	*Hydrogen storage, transportation and applications*

Learning Resources	1. *Godfrey Boyle, "Renewable energy", 2nd Edition, Oxford University Press, 2010* 2. *G.D Rai, "Non-Conventional Energy Sources", Khanna Publishers, 5th Edition, New Delhi, 2011* 3. *Twidell.J.W and Weir.A.D, "Renewable Energy Resources",1st Edition, UK,E.&F.N. Spon Ltd, 2006* 4. *Domkundwar.V.M, Domkundwar. A.V, "Solar energy and Non-conventional sources of energy",Dhanpatrai& Co. (P) Ltd, 1st Edition, New Delhi, 2010*	5. *B.H Khan, "Non-conventional Energy Resources", 2nd Edition, New Delhi, Tata McGraw Hill, 2009* 6. *S.P. Sukatme, J.K. Mayak, "Solar Energy-Principles of thermal collection and storage", 3rd edition,Newdelhi, McGraw Hill,2008* 7. *Tiwari.G.N, Ghosal.M.K, "Fundamentals of renewable energy sources",1st Edition, UK, Alpha ScienceInternational Ltd, 2007.* 8. *D. LE GOURIERES, "Wind Power Plants, Theory and Design", Pergamon, 1982.*

Learning Assessment

	Bloom's Level of Thinking	Continuous Learning Assessment (50% weightage)								Final Examination (50% weightage)	
		CLA – 1 (10%)		CLA – 2 (15%)		CLA – 3 (15%)		CLA – 4 (10%)#			
		Theory	Practice	Theory	Practice	Theory	Practice	Theory	Practice	Theory	Practice
Level 1	Remember Understand	*40 %*	-	*30 %*	-	*30 %*	-	*30 %*	-	*30%*	-
Level 2	Apply Analyze	*40 %*	-	*40 %*	-	*40 %*	-	*40 %*	-	*40%*	-
Level 3	Evaluate Create	*20 %*	-	*30 %*	-	*30 %*	-	*30 %*	-	*30%*	-
	Total	100 %		100 %		100 %		100 %		100 %	

CLA – 4 can be from any combination of these: Assignments, Seminars, Tech Talks, Mini-Projects, Case-Studies, Self-Study, MOOCs, Certifications, Conf. Paper etc.,

Course designers

Experts from Industry	Experts from Higher Technical Institutions	Faculty in-charges
Mr.M.V.Ramachandran, Sr.Deputy Director & Plant Head (OSD), E-mail - mv.rama@natrip.in	*Dr.B.Durga Prasad Professor, JNTUA College of Engineering, Email: mukdhajntu@gmail.com*	*Dr. R.Senthil Kumar, SRM IST Email: senthilkumar.r@ktr.srmuniv.ac.in*
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Course Code	18MEO103T	Course Name	ENERGY SYSTEMS FOR BUILDINGS	Course Category	O	Open Elective	L	T	P	C
							3	0	0	3

Pre-requisite Courses	NiL	Co-requisite Courses	NIL	Progressive Courses	NIL
Course Offering Department	Mechanical Engineering	Data Book / Codes/Standards	NIL		

Course Learning Rationale (CLR):	*The purpose of learning this course is to:*
CLR-1 :	*Be familiar with the energy transfer in buildings*
CLR-2 :	*Study the solar passive heating and cooling systems*
CLR-3 :	*Be familiar with the lighting systems of buildings*
CLR-4 :	*Study the Heat control and ventilation methods in buildings*
CLR-5 :	*Be familiar with the Green buildings*
CLR-6 :	*Be familiar with the design and energy management of buildings*

Course Learning Outcomes (CLO):	*At the end of this course, learners will be able to:*	Learning 1	2	3	Program Learning Outcomes (PLO) 1	2	3	4	5	6	7	8	9	10	11	12	13	14	15
		Level of Thinking (Bloom)	Expected Proficiency (%)	Expected Attainment (%)	Engineering Knowledge	Problem Analysis	Design & Development	Analysis, Design, Research	Modern Tool Usage	Society & Culture	Environment & Sustainability	Ethics	Individual & Team Work	Communication	Project Mgt. & Finance	Life Long Learning	PSO - 1	PSO - 2	PSO – 3
CLO-1 :	*Acquire knowledge on heating and cooling load calculations on energy efficient buildings*	*1,2 &3*	*90*	*80*	*H*	*M*		*M*										*H*	
CLO-2 :	*Understand the concept of solar passive heating and cooling*	*1,2*	*90*	*80*	*H*	*M*					*M*							*H*	
CLO-3 :	*Understand the concept of Day lighting and electrical lighting systems*	*1&2*	*90*	*80*	*H*					*L*	*M*							*H*	
CLO-4 :	*Recognize the design parameters influencing thermal design of buildings*	*1,2 &3*	*90*	*80*	*H*	*M*		*M*			*M*							*H*	
CLO-5 :	*Understand the concept of green buildings and certifications*	*1 &2*	*90*	*80*	*H*		*M*			*L*	*M*							*H*	
CLO-6 :	*Acquire knowledge on design and energy management of buildings*	*1,2 & 3*	*90*	*80*	*H*	*M*	*M*	*M*		*L*	*M*							*H*	

		Energy transfer in buildings	Passive solar heating & Cooling	Lighting systems of buildings	Heat control & ventilation	Green buildings
Duration (hour)		9	9	9	9	9
S-1	SLO-1	*Concepts of energy efficient buildings*	*General principles of passive solar heating*	*Introduction to lighting systems of buildings*	*Introduction to heat control and ventilation*	*Introduction to green building*
S-2	SLO-1	*Conventional versus Energy Efficient buildings*	*Key design elements of passive heating*	*Glazing materials: Sources and concepts of optical materials*	*Design parameters influencing thermal design of buildings*	*Green building features and green construction materials*
S-3	SLO-1	*Climate and its influence in building design for energy requirement, Thermal properties of building materials*	*Direct solar heat gain by Trombe mass walls*	*Concepts of day lighting*	*Heat transmission through building sections*	*Green building rating tools*
S-4	SLO-1	*Codes and standards for the energy efficient buildings-ECBC codes*	*Passive cooling and its Key design elements, ventilation*	*Components of daylight factors and Recommended daylight factors*	*Effect of heating with orientation of buildings*	*Integrated ecological design, Sustainable site and landscaping*
S-5	SLO-1	*Energy balance for cooling and heating of buildings*	*Water walls, evaporative cooling*	*Day lighting analysis*	*Ventilation requirements for heat control in buildings*	*Indoor air quality, Water and waste management systems*
S-6	SLO-1	*Calculation of heating load, Heat losses and Internal heat sources*	*Convective air loops and solar chimney effects*	*Electrical lighting and Illumination requirement*	*Standards for ventilation*	*Green Globe, LEED, GRIHA, IGBC codes & certifications*
S-7	SLO-1	*Calculation of cooling loads of the building*	*Predicting ventilation in buildings, window ventilation calculations*	*Selection of luminaries and performance parameters*	*Ventilation designs, Energy conservation measurement*	*Standards for green building certifications*
S-8	SLO-1	*Low and zero energy buildings*	*Thermal insulation, load control, air filtration,*	*Electric lighting control for day lighted buildings*	*Natural ventilation methods*	*Economics, managing initial costs of green buildings*
S-9	SLO-1	*Future building design aspects*	*Odor removal and heat recovery in large buildings*	*Comparison of day and electrical lighting*	*Forced ventilation methods*	*Environment benefits of green buildings*

Learning Resources	1. *Means R.S., "Green building: project planning and cost estimating", Kingston, 2006* 2. *Kibert C.J., "Sustainable Construction: Green Building Design", 2nd edition, Wiley, 2007* 3. *Boecker J., Scot Horst, Tom Keiter, Andrew Lau, Markes Sheffer, Brian Toevs, Bill Reed, "Integrative Design Guide to Green Building", Wiley, 2009* 4. *Eicker U., "Low Energy Cooling for Sustainable Buildings", Wiley, 2009* 5. *Gevorkian P., "Alternative Energy Systems in Building Design", McGraw-Hill, 2010.*	6. *Harvey D.L., "Handbook on Low-Energy Buildings and District-Energy Systems", Earthscan, 2006.* 7. *Attmann O., "Green Architecture", McGraw-Hill, 2010* 8. *Kubba S., "Handbook of Green Building Design and Construction", Elsevier, 2012.* 9. *Majumdar, M., "Energy – Efficient Buildings in India", Tata Energy Research Institute, Ministry of Non-Conventional Energy Sources, 2002.* 10. *Energy Conservation Building Codes: www.bee-india.nic.in*

Learning Assessment

	Bloom's Level of Thinking	Continuous Learning Assessment (50% weightage)								Final Examination (50% weightage)	
		CLA – 1 (10%)		CLA – 2 (15%)		CLA – 3 (15%)		CLA – 4 (10%)#			
		Theory	Practice	Theory	Practice	Theory	Practice	Theory	Practice	Theory	Practice
Level 1	Remember Understand	*40 %*	-	*30 %*	-	*30 %*	-	*30 %*	-	*30%*	-
Level 2	Apply Analyze	*40 %*	-	*40 %*	-	*40 %*	-	*40 %*	-	*40%*	-
Level 3	Evaluate Create	*20 %*	-	*30 %*	-	*30 %*	-	*30 %*	-	*30%*	-
	Total	100 %		100 %		100 %		100 %		100 %	

CLA – 4 can be from any combination of these: Assignments, Seminars, Tech Talks, Mini-Projects, Case-Studies, Self-Study, MOOCs, Certifications, Conf. Paper etc.,

Course Designers		
Experts from Industry	Experts from Higher Technical Institutions	Internal Experts
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2. Dr.A.Velayutham, DRDO, Avadi, velayudham.a@cvrde.drdo.in	*Mr. Cibi Chakravarthy N Assistant Engineering Manager-HVAC Engineering Design and Research Centre, L&T Construction, Mount Poonamallee Road, Manapakkam, Chennai-89.*	*Mr. P. Sundaram Assistant Professor, Department of Mechanical Engineering SRM IST Email: sundaram.p@ktr.srmuniv.ac.in*

Course Code	18MEO104T	Course Name	OPERATION RESEARCH	Course Category	O	Open Elective	L	T	P	C
							3	0	0	3

Pre-requisite Courses	NIL	Co-requisite Courses	NIL	Progressive Courses	NIL
Course Offering Department	Mechanical Engineering	Data Book / Codes/Standards	Yes		

Course Learning Rationale (CLR):	*The purpose of learning this course is to:*
CLR-1 :	*Be familiar with the Objectives, Characteristics, Necessity, Scope, Applications of OR and LPP in simplex and to determine what resources are assigned to get most optimum output*
CLR-2 :	*Be familiar with the Applications of LPP in in determining resource allocation in existing business structures and in the decision making process of replacing a used equipment*
CLR-3 :	*Be familiar with the scheduling and operational problems in manufacturing, service and distribution*
CLR-4 :	*Know the waiting line models and all aspects of managing a company's inventories*
CLR-5 :	*Determine how decisions are made given unknown variables and an uncertain decision environment framework and how and why people make decisions*
CLR-6 :	*Familiar with resource management techniques and its applications in industries*

Course Learning Outcomes (CLO):	*At the end of this course, learners will be able to:*	Learning 1 Level of Thinking (Bloom)	2 Expected Proficiency (%)	3 Expected Attainment (%)	Program Learning Outcomes (PLO) 1 Engineering Knowledge	2 Problem Analysis	3 Design & Development	4 Analysis, Design, Research	5 Modern Tool Usage	6 Society & Culture	7 Environment & Sustainability	8 Ethics	9 Individual & Team Work	10 Communication	11 Project Mgt. & Finance	12 Life Long Learning	13 PSO - 1	14 PSO - 2	15 PSO – 3
CLO-1 :	*Understand the Concepts of Linear programming technique*	*1&2*	*90*	*85*	*M*	*H*	-	*M*	-	*L*	-	-	-	-	*M*	-	*H*	*H*	*M*
CLO-2 :	*Learn the applications of Transportation and Replacement models*	*1*	*90*	*85*	*M*	*H*	-	*M*	-	*L*	-	-	-	-	*M*	-	*H*	*H*	*M*
CLO-3 :	*Study the various Techniques of scheduling and sequencing*	*1*	*90*	*85*	*M*	*H*	-	*M*	-	*M*	-	-	-	-	*L*	-	*H*	*H*	*M*
CLO-4 :	*Gain detailed knowledge of Inventory control and Queuing theory*	*1&2*	*90*	*85*	*M*	*H*	-	*M*	-	*M*	-	-	-	-	*H*	-	*H*	*H*	*M*
CLO-5 :	*Understand the techniques involved in Decision theory and Game theory*	*1&2*	*90*	*85*	*M*	*H*	-	*L*	-	*M*	-	-	-	-	*M*	-	*H*	*H*	*M*
CLO-6 :	*Learn resource management techniques to manage resources multiple departments and projects*	*1&2*	*90*	*85*	*M*	*H*	-	*M*	-	*M*	-	-	-	-	*M*	-	*H*	*H*	*M*

Duration (hour)		9	9	9	9	9
S-1	SLO-1	*Operation Research and decision making- Development, Definition, Characteristics, Necessity, Scope, Applications, Advantages, Limitations*	*Assignment models [Balanced, Unbalanced, Maximization]*	*Problem of Sequencing, Processing 'n' jobs through two and three machines.*	*Introduction – Necessity for Maintaining Inventory, Inventory Costs – Types- Variables in an inventory problem – Lead time, Reorder Level, EOQ*	*Steps in Decision theory approach - Decision making Environments - Making under conditions of Certainty, Uncertainty, Conditions of Risk*
S-2	SLO-1	*Objectives, Phases, Types of mathematical models in OR and constructing the model. Linear Programming - Requirements, Assumptions, Advantages, Limitations, Applications*	*Assignment models - Travelling Salesman Problem (Shortest Cyclic Route Models)*	*Problem of Sequencing, Processing 'n' jobs through two and three machines.*	*Deterministic Inventory Models – Purchasing model with no shortages, Manufacturing model with no shortages*	*Steps in Decision theory approach - Decision making Environments - Making under conditions of Certainty, Uncertainty, Conditions of Risk*
S-3	SLO-1	*Formulation of linear programming problem, Simplex method - Graphical method of Solution*	*Transportation problem – Assumption, Definition, Formulation and Solution - North west corner method, Least cost method, Vogel's approximation method.*	*Project - Planning, Scheduling, Controlling – Network Analysis – Constructing a project network - Fulkerson's Rule*	*Purchasing model with shortages, Manufacturing model with shortages*	*Decision making conditions – problems*
S-4	SLO-1	*Simplex method - Analytical - Canonical and Standard forms of LPP*	*Transportation problem – MODI method*	*Network computations – Earliest Completion time of a project and Critical path, Floats*	*Multi item deterministic model, safety stock, storage quantity discount*	*Decision trees. - Utility Theory*
S-5	SLO-1	*Artificial Variables Techniques - Big M- method*	*MODI method [balanced in transportation model]*	*Programme Evaluation Review Technique*	*Problems in Multi item deterministic model*	*Problems in Decision trees*

S-6	SLO-1	*Artificial Variables Techniques - Two Phase method*	*MODI method [Unbalance in transportation model]*	*Total Slack, Free Slack, Probability of achieving completion date*	*Queuing Models - Elements - Kendall's Notation – Poisson arrivals and exponential service times*	*Theory of Games , Characteristics Game models -Definition - Rules - Pure Strategy*
S-7	SLO-1	*Problems in Artificial Variables Techniques*	*Replacement Model, Replacement of items that deteriorate, Gradually, Fail suddenly*	*Cost Analysis - Crashing the network*	*Waiting time, Idle time cost, Single channel problem*	*Optimal solution of two person zero sum games, mixed strategies*
S-8	SLO-1	*Sensitivity analysis – Change in objective function*	*Group Replacement policy analysis - Problems*	*Resource Scheduling - Advantages, Limitations*	*Multi-channel problem*	*Graphical solution of (2xn) and (mx2) games*
S-9	SLO-1	*Sensitivity analysis – Change in the availability of resources*	*Group Replacement policy analysis - Problems*	*Vehicle routing problems*	*Poisson arrivals and service time*	*Solution of (mxn) games by linear programming*

Learning Resources	*1. Premkumar Gupta and Hira, "Operation Research", Third Edition S Chand Company Ltd., New Delhi 2014.* *2. A.C.S.Kumar, "Operation Research", Yes Dee Publishing Ltd., Chennai 2015.* *3. Fredric.S.Hilleer and Gerold J. Lieberman, "Introduction to Operation Research", 10th Edition, 2014.* *4. Handy, "A. Taha, "Operations Research", 10th Edition, Prentice Hall of India, New Delhi, 2016.*	*5. Philip and Ravindran, "Operational Research", John Wiley, 2000.* *6. Sundaresan.V, GanapathySubramanian.K.S, "Resource Management Techniques:Operations Research" A.R Publications, 2003.* *7. Panneerselvam.K, "Operation Research", Prentice Hall of India, 2006.*

Learning Assessment											
	Bloom's Level of Thinking	Continuous Learning Assessment (50% weightage)								Final Examination (50% weightage)	
		CLA – 1 (10%)		CLA – 2 (15%)		CLA – 3 (15%)		CLA – 4 (10%)#			
		Theory	Practice	Theory	Practice	Theory	Practice	Theory	Practice	Theory	Practice
Level 1	Remember Understand	*40 %*	-	*30 %*	-	*30 %*	-	*30 %*	-	*30%*	-
Level 2	Apply Analyze	*40 %*	-	*40 %*	-	*40 %*	-	*40 %*	-	*40%*	-
Level 3	Evaluate Create	*20 %*	-	*30 %*	-	*30 %*	-	*30 %*	-	*30%*	-
	Total	100 %		100 %		100 %		100 %		100 %	

CLA – 4 can be from any combination of these: Assignments, Seminars, Tech Talks, Mini-Projects, Case-Studies, Self-Study, MOOCs, Certifications, Conf. Paper etc.,

Course Designers		
Experts from Industry	Experts from Higher Technical Institutions	Internal Experts
1. Dr. R. Kalimuthu, ISRO, Mahendragiri, r_kalimuthu@vssc.gov.in, rkpearls@yahoo.com	*1. Dr. Rajendran C , IITM*	*1. Mr. S. Oliver Nesa Raj, SRMIST*
2. Dr. A. Velayutham, DRDO, Avadi, velayudham.a@cvrde.drdo.in	*2. Dr. Srinivasan G , , IITM*	*2. Dr. P. Godhandaraman, SRMIST*

Course Code	18MEO105T	Course Name	MATERIALS MANAGEMENT	Course Category	O	Open Elective	L	T	P	C
							3	0	0	3

Pre-requisite Courses	NIL	Co-requisite Courses	NIL	Progressive Courses	NIL
Course Offering Department	Mechanical Engineering	Data Book / Codes/Standards	NIL		

Course Learning Rationale (CLR):	*The purpose of learning this course is to:*
CLR-1 :	*To Understand the principles of materials Management*
CLR-2 :	*To Acquire knowledge on Inventory control and materials forecasting*
CLR-3 :	*Be familiar with the Material planning and control*
CLR-4 :	*Be familiar with the Storage and distribution*
CLR-5 :	*To attain the knowledge about material accounting and budgeting*
CLR-6 :	*Be familiar with the basic aspects of Material Management, Inventory control procedures, Codification of materials, Online material management system.*

		Learning			Program Learning Outcomes (PLO)														
		1	2	3	1	2	3	4	5	6	7	8	9	10	11	12	13	14	15
Course Learning Outcomes (CLO):	*At the end of this course, learners will be able to:*	Level of Thinking (Bloom)	Expected Proficiency (%)	Expected Attainment (%)	Engineering Knowledge	Problem Analysis	Design & Development	Analysis, Design, Research	Modern Tool Usage	Society & Culture	Environment & Sustainability	Ethics	Individual & Team Work	Communication	Project Mgt. & Finance	Life Long Learning	PSO - 1	PSO - 2	PSO – 3
CLO-1 :	*Understand the Materials management and to recognize the relationship with other functional areas and acquire the knowledge on inventory control and material forecasting*	*1&2*	*90*	*85*	*H*						*M*								
CLO-2 :	*Acquire knowledge on Inventory control and materials forecasting*	*1*	*90*	*85*	*H*						*M*								
CLO-3 :	*Appreciate the Job evaluation and understand the need of scheduling*	*1*	*90*	*85*	*H*						*M*					*L*			
CLO-4 :	*Understand the theory behind the Project management and acquire the knowledge about MRP, Storage design and storage system and layout*	*1&2*	*90*	*85*	*H*										*L*				
CLO-5 :	*Obtained the knowledge about Materials management controls, Budgetary control*	*1&2*	*90*	*85*	*M*									*L*					
CLO-6 :	*Recognize the use of materials management, acquire knowledge on the inventory management and control procedures, Codification of materials, Online material management system,Purchasing policies and procedures*	*1&2*	*90*	*85*	*M*						*M*								

Duration (hour)		9	9	9	9	9
S-1	SLO-1	*History and development of material management, Policy manual: A to Z items*	*Materials forecasting, Selection of inventory control, BOM*	*Codification of materials Storage systems and equipment*	*Purchasing policies and procedures*	*Performance indicators*
S-2	SLO-1	*Concept and details of integrated materials and management systems*	*Spare parts managements and techniques*	*Storage design, Stores layout*	*Legal aspects of purchasing*	*Materials management controls*
S-3	SLO-1	*Important and scope of materials management*	*Inventory control systems, Lead time analysis, Optimum order quantity*	*Storage systems and equipments*	*Selection of sources of supply*	*Budgetary control*
S-4	SLO-1	*Materials purchase policy and economic ordered quantity*	*Types of Lead time; Administrative lead time, Supplier lead time, Transport lead time*	*Stores preservation*	*Vendor evaluation and rating*	*Computer in materials management, Computer revolution, Software and hardware, Materials information system*
S-5	SLO-1	*Purchasing cycle, A to Z purchase order*	*Flow charting techniques to reduce various types of lead time*	*Stores procedures Stock valuation and verification*	*Vendor development, Price and Cost analysis*	*Reports and information needs, Application and limitations of computers in materials management*
S-6	SLO-1	*Functions of Materials Intelligence (MIS)*	*Aggregate inventory management*	*Ware housing Distribution management*	*Ethical buying, Ethical concept in buying*	*Store functions, types of Sores, sore identification systems*
S-7	SLO-1	*Specification and Standardization in Materials Management*	*Problems in Inventory control*	*Store accounting*	*Purchasing organisations, Purchasing cycle and contracts*	*Store accounting, sore records, Legal aspects of sore keeping*
S-8	SLO-1	*Make or buy decision, buying process*	*Materials requirement planning*	*Material handling system and equipments*	*Sourcing supplier evaluation*	*Online material management system*
S-9	SLO-1	*Purchasing cycle and economic ordered quantity*	*Supply chain Management*	*Need for inventory, Inventory cost, Inventory control measures(ABC, XYZ analysis)*	*Legal aspects of purchasing*	*Coding of materials, material purchasing policies and procedures*

Learning Resources	1. *"Operations and Supply Chain Management" Ann K. Gatewood, Publisher: Pearson 8 editions, January 2016.* 2. *"Introduction to Materials Management" , Tony K. Arnold, 8th Edition by Steve Chapman, , Publisher Pearson edition, 2017* 3. *"Inventory Accuracy: People, Processes, & Technology, OPS Publishing; 1 edition, March 2003.* 4. *"Operations Management, Mahadevan B, Publisher: Pearson 3rd edition,2017.*	5. *"Purchasing and Materials Management", Gopalakrishnan.P, Tata McGraw Hill Education, 01-Mar-2001.* 6. *"Materials Management: An Integrated Systems Approach" Publisher: Springer original 1st edition, 2014.* 7. *"Material Management an integrated approach" Publisher, PHL Learning Private Limited, 3rd edition,2011* 8. *"Production and operations management", SN.Chary, Tata McGraw Hill Education, 5th edition, 2012.*

Learning Assessment											
	Bloom's Level of Thinking	Continuous Learning Assessment (50% weightage)								Final Examination (50% weightage)	
		CLA – 1 (10%)		CLA – 2 (15%)		CLA – 3 (15%)		CLA – 4 (10%)#			
		Theory	Practice	Theory	Practice	Theory	Practice	Theory	Practice	Theory	Practice
Level 1	Remember Understand	*40 %*	-	*30 %*	-	*30 %*	-	*30 %*	-	*30%*	-
Level 2	Apply Analyze	*40 %*	-	*40 %*	-	*40 %*	-	*40 %*	-	*40%*	-
Level 3	Evaluate Create	*20 %*	-	*30 %*	-	*30 %*	-	*30 %*	-	*30%*	-
	Total	100 %		100 %		100 %		100 %		100 %	

CLA – 4 can be from any combination of these: Assignments, Seminars, Tech Talks, Mini-Projects, Case-Studies, Self-Study, MOOCs, Certifications, Conf. Paper etc.,

Course Designers		
Experts from Industry	Experts from Higher Technical Institutions	Internal Experts
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Dr.A.Velayutham, DRDO, Avadi, velayudham.a@cvrde.drdo.in	*Dr.K.G.Pradeep-IIT MADRAS*	*Mr. Selwyn Jebadurai*

Course Code	18MEO106T	Course Name	ENVIRONMENTAL POLLUTION AND ABATEMENT	Course Category	O	Open Elective	L	T	P	C
							3	0	0	3

Pre-requisite Courses	NIL	Co-requisite Courses	NIL	Progressive Courses	NIL
Course Offering Department	Mechanical Engineering	Data Book / Codes/Standards	NIL		

Course Learning Rationale (CLR):	*The purpose of learning this course is to:*	Learning			Program Learning Outcomes (PLO)														
		1	2	3	1	2	3	4	5	6	7	8	9	10	11	12	13	14	15
CLR-1 :	*Be Familiar the principles and methods of controlling various types of pollution.*	Level of Thinking (Bloom)	Expected Proficiency (%)	Expected Attainment (%)	Engineering Knowledge	Problem Analysis	Design & Development	Analysis, Design, Research	Modern Tool Usage	Society & Culture	Environment & Sustainability	Ethics	Individual & Team Work	Communication	Project Mgt. & Finance	Life Long Learning	PSO - 1	PSO - 2	PSO – 3
CLR-2 :	*Understand the emission control techniques.*																		
CLR-3 :	*understand water treatment and solid removal methods*																		
CLR-4 :	*Be Familiar with aerobic and anaerobic treatments.*																		
CLR-5:	*Be Familiar with the nature of solid waste and their disposal.*																		
CLR-6	*understand the environmental pollutants and theircontrol*																		
Course Learning Outcomes (CLO):	*At the end of this course, learners will be able to:*																		
CLO-1 :	*Understand the basics of pollution and the control methods*	*1,2*	*90*	*80*	*H*						*L*								
CLO-2 :	*Acquire knowledge aboutvarious air pollutants and emission control techniques.*	*1,2*	*90*	*80*	*H*					*M*	*H*								
CLO-3 :	*Understand the water treatment methods and solid removal*	*1,2*	*90*	*80*	*H*						*H*								
CLO-4 :	*Acquire knowledge about the Aerobic and anaerobic treatments*	*1,2*	*90*	*80*	*H*						*H*								
CLO-5 :	*Acquire knowledge about the variousSolid waste disposal methods.*	*1,2*	*90*	*80*	*H*					*M*	*H*								
CLO-6 :	*Acquire knowledge about the environmental pollution and control*	*1,2*	*90*	*80*	*H*					*M*	*H*								

		Basics of Pollution and Prevention	Air Pollution	Water Pollution	Biological Treatment	Solids disposal
Duration (hour)		09	09	09	09	09
S-1	SLO-1	*Environment and environmental pollution from chemical process industries, characterization of emission and effluents*	*Sources and formation of Sulfur oxides (SOx); nitrogen oxides (NOx), carbon monoxide*	*Biological uptake of pollutants*	*Anaerobic degradation of organic matter*	*Solids waste disposal – composting process and its phases*
	SLO-2	-	*total suspended particulate matter, respirable particulates*			
S-2	SLO-1	*environmental Laws, rules and standards for ambient air*	*photo-chemical oxidants. Other pollutants*	*effect of pollutants on land, vegetation, animals and human health*	*Trickling filter – Process description*	*Sanitary landfill- Principle and process*
S-3	SLO-1	*noise pollution- effects, control*	*Green house effect,green house gases: CO_2, CH_4, N_2O, CFCs,*	*bio-deterioration, bioaccumulation*	*aerobic treatment – aeration units*	*gasification process.*
	SLO-2	-	*water vapor concentration, alternatives for CFCs, global warming and climate change*	-		
S-4	SLO-1	*Process modification: alternative raw material, recovery of by product*	*ozone layer depletion- ozone depleting processes, ozone hole,*	*bio-magnification and eutrophication*	*biochemical kinetics: Hydraulic detention time, Mean residence time*	*Upward, Downward, cross draft gasifier*
	SLO-2		*environmental effects and strategies for ozone layer protection,*			
S-5	SLO-1	*recycle and reuse of waste, energy recovery and waste utilization*	*acid rain-sources and impact*	*infectious microbial agents in water system*	*Types of activated sludge process*	*Incineration and Pyrolysis*
	SLO-2					
S-6	SLO-1	*Material and energy balance for pollution minimization.*	*wet gas scrubbing techniques*	*consequences on human health.*	*Tapered aeration*	*Quantum and nature of solid waste*
	SLO-2					
S-7	SLO-1	*Water use minimization*	*gaseous emission control by absorption and adsorption methods*	*Physical treatment- pre-treatment*	*Stepped aeration*	*bio methanation -phases involved and factors*
	SLO-2					

S-8	SLO-1	*Fugitive emission, effluents and leakages*	*Design of cyclones, Electrostatic Precipitation*	*solids removal by settling and sedimentation*	*sludge separation*	*Pelletization, landfill and gas recovery*
	SLO-2					
S-9	SLO-1	*Pollution control through housekeeping and maintenance..*	*fabric filters and absorbers*	*filtration and centrifugation*	*Aerobic treatment units (ponds,lagoons, oxidation ditch)*	*municipal solid waste disposal- Best management practices for containers*
	SLO-2			*coagulation and flocculation.*		

Learning Resources	*1. Vallero D; "Fundamentals of Air Pollution", 4 th Ed; Academic Press, 2008* *2. Eckenfelder W.W; "Industrial Water Pollution Control", 2 Ed; McGraw Hill, 2000* *3. Kreith F. and Tchobanoglous G., "Handbook of Solid Waste Management", 2 Ed; Mc Graw Hill, 2002*	*4. Pichtel J; "Waste Management Practices: Municipal,Hazardous and Industrial", CRC, 2005* *5. Tchobanoglous G., Burton F. L. and Stensel H.D., "Waste Water Engineering: Treatment and Reuse", 4th Ed; Tata McGraw Hill,2010*

Learning Assessment

	Bloom's Level of Thinking	Continuous Learning Assessment (50% weightage)								Final Examination (50% weightage)	
		CLA – 1 (10%)		CLA – 2 (15%)		CLA – 3 (15%)		CLA – 4 (10%)#			
		Theory	Practice	Theory	Practice	Theory	Practice	Theory	Practice	Theory	Practice
Level 1	Remember Understand	*20%*	*20%*	*15%*	*15%*	*15%*	*15%*	*15%*	*15%*	*15%*	*15%*
Level 2	Apply Analyze	*20%*	*20%*	*20%*	*20%*	*20%*	*20%*	*20%*	*20%*	*20%*	*20%*
Level 3	Evaluate Create	*10%*	*10%*	*15%*	*15%*	*15%*	*15%*	*15%*	*15%*	*15%*	*15%*
	Total	100 %		100 %		100 %		100 %		100 %	

CLA – 4 can be from any combination of these: Assignments, Seminars, Tech Talks, Mini-Projects, Case-Studies, Self-Study, MOOCs, Certifications, Conf. Paper etc.,

Course Designers

Experts from Industry	Experts from Higher Technical Institutions	Internal Experts
1. Dr.R.Kalimuthu, ISRO, Mahendragiri, r_kalimuthu@vssc.gov.in	*Dr. S.K. Rani* *Professor & Dean (SP & CS)* *Crescent Institute of Science and Technology*	*V. Praveena* *Assistant Professor*
2. Dr.A.Velayutham, DRDO, Avadi, velayudham.a@cvrde.drdo.in	*M Malathi* *Manager R &D, IP Rings*	*Dr. P. Chandrashekaran* *SRMIST*

Course Code	18MEO107T	Course Name	NANO ROBOTICS	Course Category	O	Open Elective	L	T	P	C
							3	0	0	3

Pre-requisite Courses	NIL	Co-requisite Courses	NIL	Progressive Courses	NIL
Course Offering Department	Mechanical Engineering	Data Book / Codes/Standards	NIL		

Course Learning Rationale (CLR):	*The purpose of learning this course is to:*
CLR-1 :	*Be familiar with the basics of Robotics and Nano Technology*
CLR-2 :	*Be familiar with the Micro/Nano Sensors*
CLR-3 :	*Be familiar with the Micro/Nano Actuators*
CLR-4 :	*Be familiar with the Micro/Nano Manipulators*
CLR-5 :	*Be familiar with the Micro/Nano Robotics manufacturing and control techniques*
CLR-6 :	*Familiar with the Micro/Nano Sensors, Actuators, Manipulators and Manufacturing Techniques*

		Learning			Program Learning Outcomes (PLO)														
		1	2	3	1	2	3	4	5	6	7	8	9	10	11	12	13	14	15
Course Learning Outcomes (CLO):	*At the end of this course, learners will be able to:*	Level of Thinking (Bloom)	Expected Proficiency (%)	Expected Attainment (%)	Engineering Knowledge	Problem Analysis	Design & Development	Analysis, Design, Research	Modern Tool Usage	Society & Culture	Environment & Sustainability	Ethics	Individual & Team Work	Communication	Project Mgt. & Finance	Life Long Learning	PSO - 1	PSO - 2	PSO – 3
CLO-1 :	*Acquire knowledge on Basics of Robotics and Nano Technology*	*1*	*90*	*85*	*H*	*L*	*L*	*L*	*L*							*M*	*H*	*L*	*H*
CLO-2 :	*Understand the various Micro/Nano Sensors*	*1&2*	*90*	*85*	*H*	*L*	*M*	*M*	*H*							*M*	*H*	*L*	*H*
CLO-3 :	*Understand the Micro/Nano Actuators*	*1&2*	*90*	*85*	*H*	*L*	*M*	*M*	*H*							*M*	*H*	*L*	*H*
CLO-4 :	*Understand the Micro/Nano Manipulators*	*1&2*	*90*	*85*	*H*	*L*	*M*	*M*	*H*							*M*	*H*	*L*	*H*
CLO-5 :	*Acquire knowledge on Micro/Nano Robotics manufacturing and control techniques*	*1*	*90*	*85*	*H*	*L*	*M*	*M*	*H*							*M*	*H*	*L*	*H*
CLO-6 :	*Learn Micro/Nano Sensors, Actuators, Manipulators and Manufacturing Techniques*	*1&2*	*90*	*85*	*H*	*L*	*M*	*M*	*H*							*M*	*H*	*L*	*H*

		Fundamentals of Robotics and Nanotechnology	Micro/Nano Sensors	Micro/Nano Actuators	Micro/Nano Manipulators	Micro/Nano Robotics manufacturing and control techniques
Duration (hour)		9	9	9	9	9
S-1	SLO-1	*Introduction-History of Robotics*	*Far field and Near filed Imaging sensors*	*Bending type Piezoelectric actuators*	*SPM Probes and Micro nano grippers*	*CAD models and CAD models of nanostructures*
S-2	SLO-1	*Robot Anatomy and Work Volume*	*Position and Capacitive sensors*	*Unimorph, Bimorph and stack type actuators*	*Atomic manipulation using STM*	*Micro nano assembly and Self assembly*
S-3	SLO-1	*Robot Drive Systems*	*Linear Variable Differential Transformer*	*Piezo tube and Thin film types ZnO*	*Optical Tweezers*	*Precision micro/nanoparticle assembly using SEM*
S-4	SLO-1	*End Effectors and Robotic Sensors*	*Interferometric sensors*	*Surface acoustic waves and Elecrostatic actuators*	*Dielectrophoresis*	*Guided Self Assembly*
S-5	SLO-1	*Actuators and Power transmission system*	*Accelerometers and Gyroscopes*	*Thermal and Ultrasonic actuators*	*Bio manipulation*	*Automated manipulation of nanoparticles*
S-6	SLO-1	*Importance of Nanotechnology-History of Nanotechnology*	*Force, Pressure Sensors*	*Electro and Magnetostrictive based actuators*	*Slip motion (nanomanipulation)*	*Micro Mechanical Flying robot*
S-7	SLO-1	*Opportunity at the nano scale-length and time scale in structures*	*Chemical and Flow sensors*	*Shape memory alloy actuators*	*Carbon nanotube manipulation using nanoprobes*	*Kinematics and Dynamics of Robot*
S-8	SLO-1	*Nano device structures*	*Strain gauge and Deflection based AFM*	*Polymer actuators, Dielectric elastomers*	*High density data storage using nanoprobes*	*Kinematics and Dynamics of Robot*
S-9	SLO-1	*Overview of Nano robotics system Components*	*Visual force sensing, Bending imaging and Tactile sensors*	*CNT actuators and Bimolecular Motors*	*Simple case study*	*Teleoperation based, Task based and automatic control robot*

Learning Resources	1. *Norio Taniguchi, "Nanotechnology", Oxford university press, Cambridge, 1996.* 2. *Ning Xi, Guangyoung Li, "Introduction to Nanorobotic Manipulation & Assembly" Artech House press 2012* 3. *Elwenspoek.M and Wiegerink.R., "Mechanical Microsensors", Springer-Verlag Berlin, 2001.*	4. *Fatikow.S. Rembold.U., "Microsystem Technology and Microrobotics", Springer Verlag, 1997* 5. *Bhushan.B., "Handbook of Micro/Nanotribology", CRC Press, 2nd Ed., 1999.*

Learning Assessment											
	Bloom's Level of Thinking	Continuous Learning Assessment (50% weightage)								Final Examination (50% weightage)	
		CLA – 1 (10%)		CLA – 2 (15%)		CLA – 3 (15%)		CLA – 4 (10%)			
		Theory	Practice	Theory	Practice	Theory	Practice	Theory	Practice	Theory	Practice
Level 1	Remember Understand	*40 %*	-	*30 %*	-	*30 %*	-	*30 %*	-	*30%*	-
Level 2	Apply Analyze	*40 %*	-	*40 %*	-	*40 %*	-	*40 %*	-	*40%*	-
Level 3	Evaluate Create	*20 %*	-	*30 %*	-	*30 %*	-	*30 %*	-	*30%*	-
	Total	100 %		100 %		100 %		100 %		100 %	

CLA – 4 can be from any combination of these: Assignments, Seminars, Tech Talks, Mini-Projects, Case-Studies, Self-Study, MOOCs, Certifications, Conf. Paper etc.,

Course Designers		
Experts from Industry	Experts from Higher Technical Institutions	Internal Experts
1. Mr. R. Dinesh kumar, TAFE India Pvt Ltd, Chennai	*1. Dr. V.Srinivasan,Annamalai University, srinivraghavan@yahoo.com*	*Mr.S.Dinesh,SRM IST*
2. Mr. K.Nivasraj, Vedanta ltd, Goa	*2. Dr.Assaithambi, Govn. Col.of. Eng,sengipatti,Thanjavur, basaithambi@gcetj.edu.in*	*Mr.N.Karthikeyan, SRM IST*

Course Code	18MEO108T	Course Name	AUTOMATIC CONTROL SYSTEMS	Course Category	O	Open Elective	L	T	P	C
							3	0	0	3

Pre-requisite Courses	NIL	Co-requisite Courses	NIL	Progressive Courses	NIL
Course Offering Department		Mechanical Engineering	Data Book / Codes/Standards		NIL

Course Learning Rationale (CLR):	The purpose of learning this course is to:
CLR-1 :	*Understand the history of control systems, relevance of input and output transfer function.*
CLR-2 :	*Impart the knowledge on principles involved in modeling various mechanical and state space representations of systems.*
CLR-3 :	*Gain knowledge on steady state and transient state response and stability criterion*
CLR-4 :	*Know application of various tools used for stability analysis of various systems*
CLR-5 :	*Understand upon Discrete control systems and Z transformations*
CLR-6 :	*Impart knowledge on developing a system and studying on the stability of the system using various tools*

Course Learning Outcomes (CLO):	At the end of this course, learners will be able to:	Learning 1: Level of Thinking (Bloom)	Learning 2: Expected Proficiency (%)	Learning 3: Expected Attainment (%)	PLO 1: Engineering Knowledge	PLO 2: Problem Analysis	PLO 3: Design & Development	PLO 4: Analysis, Design, Research	PLO 5: Modern Tool Usage	PLO 6: Society & Culture	PLO 7: Environment & Sustainability	PLO 8: Ethics	PLO 9: Individual & Team Work	PLO 10: Communication	PLO 11: Project Mgt. & Finance	PLO 12: Life Long Learning	PLO 13: PSO - 1	PLO 14: PSO - 2	PLO 15: PSO – 3
CLO-1 :	*model systems that are applied to the reality*	1& 2	80	85	H	H	H	M	-	-	-	-	-	-	-	-	-	-	-
CLO-2 :	*understand response analysis*	1	80	85	H	M	H			-	-	-	-	-	-	-	-	-	-
CLO-3 :	*understand the basic tools of analysis and stability*	1	80	85	H	H	H	M	M	-	-	-	-	-	-	-	-	-	-
CLO-4 :	*understand the basic tools of analysis and stability*	1&2	80	85	H	M	-	-	M	-	-	-	-	-	-	-	-	-	-
CLO-5 :	*understand basic concepts in digital controls*	1&2	80	85	H	H	-	M		-	-	-	-	-	-	-	-	-	-
CLO-6 :	*Understand the systems and their model creation and utilization of various tools in analyzing the responses of various realistic systems*	1&2	80	85	H	M	M	M	-	-	-	-	-	-	-	-	-	-	-

		Introduction	Modeling systems	Analysis of system status - stability	Tools for Analysis of stability	Discrete Control systems
Duration (hour)		9	9	9	9	9
S-1	SLO-1	*Controls – definition – need for control – examples*	*Principles of modeling – common aspects of all mechanical systems – components – common features*	*Transient analysis*	*Routh criteria for stability*	*Discrete control systems – concepts – back ground - introduction*
S-2	SLO-1	*necessity of controls for engineers*	*Development of model – Mechanical systems*		*Root locus – background*	
S-3	SLO-1	*History of control systems*	*Development of model – Electrical systems*	*Steady state analysis*	*Root locus – construction – simple systems*	*Basic components of discrete systems – quantization and errors*
S-4	SLO-1	*Theory, design and engineering*	*Development of model – Electrical systems*		*Root locus – complex systems*	
S-5	SLO-1	*Basic open loop system,*	*Linearization of nonlinear systems*	*Error identification – analysis*	*Bode plots – concept – simple systems*	*Concepts behind Z-transforms – basic functions -*
S-6	SLO-1	*Concept of feedback, closed loop system*	*State space representation – relationship to transfer function*			
S-7	SLO-1	*Relevance of relationship between input – output – transfer function*	*Use of state space representation*	*Position – velocity – acceleration error constants*	*Construction of bode plots*	*Impulse sampling and data hold In Discrete Control systems*
S-8	SLO-1	*Block diagram - drawing handling - components*	*Summarizing system modeling*			
S-9	SLO-1	*Historical examples of control systems*		*Routh criteria for stability*	*Introduction to compensation and design of control systems*	

Learning Resources	1. *Automatic control systems , Benjamin kuo, Wiley publication , Ninth edition ,2014* 2. *Modern control engineering, Ogata.K, Prentice Hall, Fifth Edition, 2010* 3. *Discrete time control systems, Ogata.K, Prentice Hall, 1995*	4. *Control Systems, Gopal, Tata McGraw-Hill 3rdedition , 2007.* 5. *Modern Control Engineering, Nagrath& Gopal, New Age International,2014* 6. *Control Systems, A. Ambikapathy, Khanna Publishing House,2018.* 7. *V.I. Goerge, Digital Control Systems, Cengage, 2014.*

Learning Assessment

	Bloom's Level of Thinking	Continuous Learning Assessment (50% weightage)								Final Examination (50% weightage)	
		CLA – 1 (10%)		CLA – 2 (15%)		CLA – 3 (15%)		CLA – 4 (10%)			
		Theory	Practice	Theory	Practice	Theory	Practice	Theory	Practice	Theory	Practice
Level 1	Remember Understand	*40 %*	-	*30 %*	-	*30 %*	-	*30 %*	-	*30%*	-
Level 2	Apply Analyze	*40 %*	-	*40 %*	-	*40 %*	-	*40 %*	-	*40%*	-
Level 3	Evaluate Create	*20 %*	-	*30 %*	-	*30 %*	-	*30 %*	-	*30%*	-
	Total	100 %		100 %		100 %		100 %		100 %	

CLA – 4 can be from any combination of these: Assignments, Seminars, Tech Talks, Mini-Projects, Case-Studies, Self-Study, MOOCs, Certifications, Conf. Paper etc.

INDUSTRIAL EXPERT	ACADEMIC EXPERT	INTERNAL EXPERT
SELVA KUMAR .S, FORD INDIA LIMITED, Chennai	*Dr. BIJAY KUMAR ROUT, BITS, Pilani*	*VASANTHKUMAR.CH , SRMIST*
Dr.R.Kalimuthu, ISRO, Mahendragiri, r_kalimuthu@vssc.gov.in	*Dr.R.Prabhusekar, rprabhusekar@mnnit.ac.in, MNNIT Allahabad*	*Dr. S. Prabhu, SRMIST*

Course Code	18MEO109T	Course Name	NEURAL NETWORK AND FUZZY SYSTEMS	Course Category	O	Open Elective	L	T	P	C
							3	0	0	3

Pre-requisite Courses	Nil	Co-requisite Courses	Nil	Progressive Courses	Nil
Course Offering Department	Mechanical Engineering	Data Book / Codes/Standards	Nil		

Course Learning Rationale (CLR):	The purpose of learning this course is to:
CLR-1 :	*Impart the knowledge of neural network and fuzzy systems*
CLR-2 :	*Understand the various neural network algorithms*
CLR-3 :	*Initialize fuzzy logic and neuro fuzzy logic techniques*
CLR-4 :	*Familiarize with fuzzy algorithms*
CLR-5 :	*Enhance the knowledge of fuzzy & neural in various applications*
CLR-6 :	*Familiarize with genetic algorithm*

Course Learning Outcomes (CLO):	At the end of this course, learners will be able to:	Learning 1 Level of Thinking (Bloom)	2 Expected Proficiency (%)	3 Expected Attainment (%)	PLO 1 Engineering Knowledge	2 Problem Analysis	3 Design & Development	4 Analysis, Design, Research	5 Modern Tool Usage	6 Society & Culture	7 Environment & Sustainability	8 Ethics	9 Individual & Team Work	10 Communication	11 Project Mgt. & Finance	12 Life Long Learning	13 PSO - 1	14 PSO - 2	15 PSO – 3
CLO-1 :	*Acquire basic understanding of the various algorithms involved in Neural Networks & Fuzzy Systems*	1,2	90	85	H	L	M	H	M						L	H	H	H	-
CLO-2 :	*Acquire basic understanding of the various learning methods and methodologies*	1,2	90	85	H	L	H	H	H						M	M	H	H	-
CLO-3 :	*Understand various fuzzy algorithms*	1,2	90	85	H	M	H	H	H						L	H	H	H	-
CLO-4 :	*Analyze how to apply the concept of fuzzy & neural in mechanical applications*	2,3	90	85	H	H	H	H	H	M		M	M			H	H	H	-
CLO-5 :	*Application of neural and neuro fuzzy concepts*	2	90	85	H	H	H	M	M			M			M	H	H	H	-
CLO-6 :	*Acquire knowledge of Genetic Algorithm*	1,3	90	85	H	L	H	H	H				M		M	H	H	H	-

Duration (hour)		9	9	9	9	9
S-1	SLO-1	*Introduction to Neural networks - Biological foundations*	*Learning Algorithms:Learning process – Supervised and unsupervised learning*	*Introduction to Fuzzy Logic: Fuzzy sets – Definition, Basic set – Theoretic operations for fuzzy sets*	*Fuzzy Logic and Control System: Fuzzy logic controller logic*	*Neuro-Fuzzy Logic Control –Optimization of membership function*
S-2	SLO-1	*ANN models, Types of activation functions*	*Error-correction learning*	*Fuzzy Relations on sets and fuzzy sets, Compositions of fuzzy relations*	*Fuzzification interface*	*Rules base of fuzzy logic controller using neural networks*
S-3	SLO-1	*Introduction to network architectures*	*Hebbian learning & Boltzmann learning*	*Properties of the Min-max Composition*	*Knowledge base and Decision making*	*Type A - Membership Model*
S-4	SLO-1	*Single layered systems*	*Single layer and multilayer preceptors*	*Fuzzy conditional statements*	*Defuzzification interface*	*Type A - Membership Model*
S-5	SLO-1	*Multilayer feed forward network(MLFFN)*	*Least mean square algorithm*	*Fuzzy rules*	*Fuzzy controller - Types*	*Type B – Membership Model*
S-6	SLO-1	*Radial basis function network(RBFN)*	*Back propagation algorithm*	*Fuzzy analysis – Fuzzy functions on fuzzy sets*	*The Mamdani Controller*	*Type B – Membership Model*
S-7	SLO-1	*Recurring neural network(RNN)*	*Applications in forecasting*	*Integration of fuzzy functions*	*The Sugeno Controller*	*Adaptive fuzzy systems*
S-8	SLO-1	*Advanced neural network – Hopfield nets algorithm*	*Applications in pattern recognition*	*Fuzzy Graphs*	*Application of fuzzy logic – Crane control*	*Adaptive neuron-fuzzy inference system (ANFIS)*
S-9	SLO-1	*Bumptree network algorithm*	*Applications in other engineering problems*	*Fuzzy Differentiation*	*Application of fuzzy logic – Control of a Model Car*	*Empirical research on aggregators*

Learning Resources

1. *Patricia Melin, "Modular Neural Networks and Type-2 Fuzzy systems for pattern recognition" Springer, 2012.*
2. *James M. Keller, Derong Liu, David B. Fogel, "Fundamentals of computational intelligence. Neural Networks, Fuzzy systems, and evolutionary computation" IEEE Press, John Wiley & Sons, Inc., New Jersey, 2016.*
3. *Cornelius T. Leondes, "Fuzzy logic and Expert systems applications" Academic Press, USA, 1998.*
4. *Jacek.M.Zurada, "Introduction to artificial Neural Systems" Jaico Publishing House, Mumbai, 2007.*
5. *Simon Haykins, "Neural Networks – A comprehensive foundation" Macmillan College, Pro.Con.Inc. New York, 2005.*
6. *Zimmermann.H.J. "Fuzzy set theory and its applications" Allied Publication Ltd., Chennai, 2001.*
7. *Tsoukalas.L.H and Robert E. Uhrig, "Fuzzy and Neural approach in Engineering" John Wiley and Sons, New York, 1997.*
8. *Klir.G.J and Yuan.B.B. "Fuzzy sets and fuzzy logic" Prentice Hall of India, New Delhi, 1997.*
9. *Driankov.D, Hellendron.H and Reinfrank.M, "An introduction to fuzzy control" Narosa Publishing House, New Delhi, 1996.*

Learning Assessment											
	Bloom's Level of Thinking	Continuous Learning Assessment (50% weightage)								Final Examination (50% weightage)	
		CLA – 1 (10%)		CLA – 2 (15%)		CLA – 3 (15%)		CLA – 4 (10%)			
		Theory	Practice	Theory	Practice	Theory	Practice	Theory	Practice	Theory	Practice
Level 1	Remember Understand	*40 %*	-	*30 %*	-	*30 %*	-	*30 %*	-	*30%*	-
Level 2	Apply Analyze	*40 %*	-	*40 %*	-	*40 %*	-	*40 %*	-	*40%*	-
Level 3	Evaluate Create	*20 %*	-	*30 %*	-	*30 %*	-	*30 %*	-	*30%*	-
	Total	100 %		100 %		100 %		100 %		100 %	

CLA – 4 can be from any combination of these: Assignments, Seminars, Tech Talks, Mini-Projects, Case-Studies, Self-Study, MOOCs, Certifications, Conf. Paper etc.,

Course Designers		
Experts from Industry	Experts from Higher Technical Institutions	Internal Experts
1. Dr. R. Kalimuthu, ISRO, Mahendragiri, r_kalimuthu@vssc.gov.in, rkpearls@yahoo.com	*1. Dr. P. Hariharan, Anna University, hari@annauniv.edu, hariharan2311@gmail.com*	*1. Dr. M. R. Stalin John, SRMIST*
2. Dr. A. Velayutham, DRDO, Avadi, velayudham.a@cvrde.drdo.in	*2.Dr.N.Arunachalam, IIT Madras, chalam@iitm.ac.in*	*2. Mrs. I. Infanta Mary Priya, SRMIST*

Course Code	18MEO110T	Course Name	ROBOTIC SENSORS	Course Category	O	Open Elective	L	T	P	C
							3	0	0	3

Pre-requisite Courses	NIL	Co-requisite Courses	NIL	Progressive Courses	NIL
Course Offering Department	Mechanical Engineering	Data Book / Codes/Standards	NIL		

Course Learning Rationale (CLR):	The purpose of learning this course is to:
CLR-1 :	*Understand the basis of latest technology of sensors used in robots*
CLR-2 :	*Be familiar with the concept Different sensing variables that are used as input to robots for sensing*
CLR-3 :	*Impart the knowledge on various vision sensors applied in robots , vision systems and their overview*
CLR-4 :	*Various methods used in robot programming*
CLR-5 :	*Different types of grippers and gripping methods*
CLR-6 :	*Understand various sensors used in robots and various programming methods in robotics, application of various grippers and their design concepts*

Course Learning Outcomes (CLO):	At the end of this course, learners will be able to:	Learning 1: Level of Thinking (Bloom)	Learning 2: Expected Proficiency (%)	Learning 3: Expected Attainment (%)	PLO 1: Engineering Knowledge	PLO 2: Problem Analysis	PLO 3: Design & Development	PLO 4: Analysis, Design, Research	PLO 5: Modern Tool Usage	PLO 6: Society & Culture	PLO 7: Environment & Sustainability	PLO 8: Ethics	PLO 9: Individual & Team Work	PLO 10: Communication	PLO 11: Project Mgt. & Finance	PLO 12: Life Long Learning	PLO 13: PSO - 1	PLO 14: PSO - 2	PLO 15: PSO – 3
CLO-1 :	*Understand the application of sensors in robotics*	1& 2	80	70	H	M	-	-	-	-	-	-	-	-	-	-	-	-	-
CLO-2 :	*Recognize the application of various inertial sensors, displacement measurement sensors, force and touch sensors in robotic applications*	1	80	70	H	L	M	-	-	-	-	-	-	-	-	-	-	-	-
CLO-3 :	*Understand various miscellaneous sensors and recognize the importance of telepresence and related technologies*	1	80	70	H	-	-	-	-	-	-	-	-	-	-	-	-	-	-
CLO-4 :	*Understand the controlling methodologies for a robot using vision sensor modules, and be able to understand robot vision locating position. Application of End effector camera sensor in robotics.*	1&2	80	70	H	M	-	-	-	-	-	-	-	-	-	-	-	-	-
CLO-5 :	*Recognize the various Control Computer configurations, Vision Sensor modules, Software Structure, Vision Sensor software structures and integration of all together for specific applications*	1&2	80	70	H	-	-	-	-	-	-	-	-	-	-	-	-	-	-
CLO-6 :	*Various sensors and their working principles in various robotic application, especially inertial sensors, force and other touch related sensors, miscellaneous sensors, vision sensors, telepresence and related technologies*	1&2	80	70	H	-	-	-	-	-	-	-	-	-	-	-	-	-	-

Duration (hour)		10	10	10	10	10
S-1	SLO-1	*An Introduction to sensors and Transducers, History and definitions*	*Position sensors – Optical, non-Optical*	*Different sensing variables*	*Introduction to vision sensor, working and principles of vision sensing*	*Control Computer for robot, Speciation's, Hardware requirements*
S-2	SLO-1	*Smart Sensing, working of a smart sensor, networking of smart sensors*	*Contact, non-contact type sensors position sensing*	*Smell and smart e-nose sensors*	*classification of vision sensors*	*Vision Sensor modules*
S-3	SLO-1	*AI sensing, Need of sensors in Robotics*	*Range Sensing, types and classification based on the Distance measurement technique*	*Heat or Temperature Humidity classification of RTD and Thermocouples Non-contact-based temperature measurement Pyrometry and Active, passive type of IR devices*	*Considerations for camera , and camera specifications*	*Software Structure,*
S-4	SLO-1	*Case study on AI*	*Touch and Slip sensors application in grippers as a feedback device*	*Light sensors and application of light sensors in robotic interlocks eg (as an interlock switch during power failure)*	*Integration of vision sensors to robot controller*	*Vision Sensor software,*
S-5	SLO-1	*Classification of various sensors*	*Sensors types of touch and slip sensors , tactile sensors*	*Speech or Voice recognition Systems,*	*End effector camera Sensor.*	*Robot programming,*
S-6	SLO-1	*Based on operation principle*	*Force sensors and their application in fixed robots*	*Speaker dependent voice recognition systems Speaker independent voice recognition system*	*Calibration of vision sensors*	*Handling, Gripper, classification of grippers based on operation*
S-7	SLO-1	*Based on application*	*Torque Sensors and associated circuitry used for torque sensors*	*Discrete speech recognition, Continuous speech recognition, Natural language processing system*	*Robot Control through Vision sensors*	*Gripping methods, accuracy*

S-8	SLO-1	*Sensors in mobile and fixed robot configurations*	*Velocity sensors*	*Case study on voice recognition system (eg. siri, Google talk)*	*Robot vision locating position,*	*A Case study-01*
S-9	SLO-1	*Application of sensors in various robots*	*Accelerometers*	*Need for telepresence*	*Robot guidance with vision system*	*A Case study-02*
S-10	SLO-1	*Case study on fixed robot configurations and mobile robot configurations*	*Proximity Sensors*	*Telepresence and related technologies.*	*End effector camera Sensor*	*A Case study-03*

Learning Resources	1. *Richard D. Klafter, Thomas .A, Chri Elewski, Michael Negin, Robotics Engineering an Integrated Approach, Phi Learning., 2009.* 2. *John Iovice, "Robots, Androids and Animatrons", Mc Graw Hill, 2003.* 3. *K.S. Fu, R.C. Gonzalez, C.S.G. Lee, "Robotics – Control Sensing, Vision and Intelligence", Tata McGraw-Hill Education, 2008.* 4. *Mikell P Groover & Nicholas G Odrey, Mitchel Weiss, Roger N Nagel, Ashish Dutta, Industrial Robotics, Technology programming and Applications, Tata McGraw-Hill Education, 2012.*	5. *Sabrie Soloman, Sensors and Control Systems in Manufacturing, McGraw-Hill Professional Publishing, 2nd Edition, 2009.* 6. *7. Julian W Gardner, Micro Sensor MEMS and Smart Devices, John Wiley & Sons, 2001.* 7. *John Iovice, "Robots, Androids and Animatrons", Mc Graw Hill, 2003.*

Learning Assessment

	Bloom's Level of Thinking	Continuous Learning Assessment (50% weightage)								Final Examination (50% weightage)	
		CLA – 1 (10%)		CLA – 2 (15%)		CLA – 3 (15%)		CLA – 4 (10%)#			
		Theory	Practice	Theory	Practice	Theory	Practice	Theory	Practice	Theory	Practice
Level 1	Remember Understand	*40 %*	-	*30 %*	-	*30 %*	-	*30 %*	-	*30%*	-
Level 2	Apply Analyze	*40 %*	-	*40 %*	-	*40 %*	-	*40 %*	-	*40%*	-
Level 3	Evaluate Create	*20 %*	-	*30 %*	-	*30 %*	-	*30 %*	-	*30%*	-
	Total	100 %		100 %		100 %		100 %		100 %	

CLA – 4 can be from any combination of these: Assignments, Seminars, Tech Talks, Mini-Projects, Case-Studies, Self-Study, MOOCs, Certifications, Conf. Paper etc.,

Course Designers		
Experts from Industry	Experts from Higher Technical Institutions	Internal Experts
SELVA KUMAR .S	*Dr. BIJAY KUMAR ROUT*	*VASANTHKUMAR.CH*
SENIOR ANALYST, FORD INDIA LIMITED CHENNAI.	*Birla Institute of Technology and Science (BITS), Pilani, Rajasthan, Professor in the Department of Mechanical Engineering*	*Assistant Professor, Mechanical Engineering Department, SRMIST, KTR Campus.*

Course Code	18MEO111T	Course Name	INDUSTRIAL ENGINEERING	Course Category	O	Open Elective	L	T	P	C
							3	0	0	3

Pre-requisite Courses	Nil	Co-requisite Courses	Nil	Progressive Courses	Nil
Course Offering Department	Mechanical Engineering	Data Book / Codes/Standards	Nil		

Course Learning Rationale (CLR):	The purpose of learning this course is to:
CLR-1 :	*Be familiar with the techniques and procedures of work study*
CLR-2 :	*Know about various plant layout and material handling systems*
CLR-3 :	*Understand the ergonomics, production and productivity measurement*
CLR-4 :	*Impart the concept of production planning and control*
CLR-5 :	*Be familiar with methods of wage payment*
CLR-6 :	*Improve the efficiency, productivity and quality of products manufactured.*

Course Learning Outcomes (CLO):	At the end of this course, learners will be able to:	Learning 1: Level of Thinking (Bloom)	Learning 2: Expected Proficiency (%)	Learning 3: Expected Attainment (%)	PLO 1: Engineering Knowledge	PLO 2: Problem Analysis	PLO 3: Design & Development	PLO 4: Analysis, Design, Research	PLO 5: Modern Tool Usage	PLO 6: Society & Culture	PLO 7: Environment & Sustainability	PLO 8: Ethics	PLO 9: Individual & Team Work	PLO 10: Communication	PLO 11: Project Mgt. & Finance	PLO 12: Life Long Learning	PLO 13: PSO - 1	PLO 14: PSO - 2	PLO 15: PSO – 3
CLO-1 :	*Acquire knowledge on different techniques and procedures of work study*	1	90	85	H	M	-	-	-	-	-	-	-	-	-	-	M	-	-
CLO-2 :	*Recognize the various plant layouts, need for site selection and about material handling*	1&2	90	85	H	-	-	-	H	-	-	-	-	-	-	-	M	-	-
CLO-3 :	*Acquire knowledge on ergonomics of work design, types and function of production and productivity measurement*	1&2	90	85	H	M	H	-	-	-	-	-	-	-	-	-	H	M	-
CLO-4 :	*Understand inventory management and resource utilization.*	1&2	90	85	H	H	-	-	-	-	-	-	-	-	-	-	M	-	-
CLO-5 :	*Acquire knowledge on job evaluation, incentive schemes and method of wage payment*	1	90	85	H	M	-	-	-	-	-	L	-	-	-	-	-	-	M
CLO-6 :	*Analysis and improve the efficiency and productivity in the industries*	1&2	90	85	H	M	-	-	-	-	-	-	-	-	-	-	M	M	-

Duration (hour)		9	9	9	9	9
S-1	SLO-1	*Introduction to Work measurement and its Techniques*	*Plant location and site selection.*	*Introduction to work design, Work design for increased productivity*	*Objectives and Functions of PPC*	*Types of Wages and salary administration*
S-2	SLO-1	*Production study and Time study.*	*Types, need, factors influencing the plant layout.*	*The work system, design Introduction to job design.*	*Aspects of product development and design*	*Meaning principles in wage fixation, Techniques used of wage fixation*
S-3	SLO-1	*Standard time, Rating factors and Work sampling.*	*Tools and techniques for developing layout, process chart, flow diagram, string diagram, Template and Scale models.*	*Environmental factors and organizational factors*	*Introduction to Process Planning and types, Principles of Standardization*	*Method of Job evaluation*
S-4	SLO-1	*Techniques of Work study*	*Layout Planning and procedure involved in creating layout*	*Behavioral factors influencing effective job design.*	*Break even analysis*	*Steps involved in merit rating of employee*
S-5	SLO-1	*Human factors of Work study*	*Construction and Improvement algorithms-Automated Layout Design Program (ALDEP)*	*Ergonomics, Objectives system approach of ergonomic model*	*Introduction to Group Technology. and various types*	*Various Methods of wage payment*
S-6	SLO-1	*Method study, Techniques and procedures of improving Productivity.*	*Construction and Improvement algorithms-Computerized Relative Allocation of Facilities Techniques(CRAFT)*	*Man machine system, Production and Productivity*	*Method of finding optimum Batch size. Equipment.*	*Types, Advantages and disadvantages of Incentive scheme*
S-7	SLO-1	*Motion economy principles.*	*Introduction and procedure on Assembly and line balancing*	*Definition of production and function*	*ABC analysis.*	*Productivity base incentives*
S-8	SLO-1	*Charging Techniques*	*Material Handling, scope and importance. Types of material handling systems.*	*Type of production systems*	*Introduction to Value Engineering and its importance, Case studies*	*Case Example of Evaluation of incentive scheme*
S-9	SLO-1	*SIMO chart, Ergonomics and Industrial design.*	*Methods of material handling*	*Definition of productivity and productivity measurement.*	*Types of cost-Cost of production and Labour cost-Simple problems*	*Importance of Environmental pollution and control*

Learning Resources	1. *SC Sharma, TR Banga "Industrial Engineering and Management", Khanna Publications Pvt,2017* 2. *Khanna.O.P, "Industrial Engineering and Management", Dhanpat Rai Publications Pvt Ltd, 2014* 3. *Buffa E.S,"Modern Production / Operational Management", John Wiley & Sons, 2013* 4. *Samuel Eilon, "Elements of Production Planning and Control", McMillan and Co., Digitized, 2012*	5. *Kumar.B, "Industrial Engineering and Management", 9th edition, Khanna Publishers, New Delhi, 2009* 6. *James M. Apple, "Principles of Layout and Material Handling", Ronald press,2012* 7. *Maynard.H, "Industrial Engineering Hand Book", McGraw Hill Book Co. NewYork, 2010*

Learning Assessment

	Bloom's Level of Thinking	Continuous Learning Assessment (50% weightage)								Final Examination (50% weightage)	
		CLA – 1 (10%)		CLA – 2 (15%)		CLA – 3 (15%)		CLA – 4 (10%)#			
		Theory	Practice	Theory	Practice	Theory	Practice	Theory	Practice	Theory	Practice
Level 1	Remember / Understand	*40 %*	-	*30 %*	-	*30 %*	-	*30 %*	-	*30%*	-
Level 2	Apply / Analyze	*40 %*	-	*40 %*	-	*40 %*	-	*40 %*	-	*40%*	-
Level 3	Evaluate / Create	*20 %*	-	*30 %*	-	*30 %*	-	*30 %*	-	*30%*	-
	Total	100 %		100 %		100 %		100 %		100 %	

CLA – 4 can be from any combination of these: Assignments, Seminars, Tech Talks, Mini-Projects, Case-Studies, Self-Study, MOOCs, Certifications, Conf. Paper etc.,

Course Designers

Experts from Industry	Experts from Higher Technical Institutions	Internal Experts
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2. Dr. A. Velayutham, DRDO, Avadi, velayudham.a@cvrde.drdo.in	*Dr. Vimal KEK, National Institute of Technology, Patna, vimalkek@nitp.ac.in*	*2. Thirugnanam. A, SRMIST*

Course Code	18MEO112T	Course Name	PRODUCTION MANAGEMENT	Course Category	O	Open Elective	L	T	P	C
							3	0	0	3

Pre-requisite Courses	Nil	Co-requisite Courses	Nil	Progressive Courses	Nil
Course Offering Department	Mechanical Engineering	Data Book / Codes/Standards	Nil		

Course Learning Rationale (CLR):	*The purpose of learning this course is to:*
CLR-1 :	*Understand the principles of Production Management*
CLR-2 :	*Acquire knowledge on Inventory Management and Work study*
CLR-3 :	*Be familiar with the Job evaluation and Scheduling*
CLR-4 :	*Be familiar with the Plan and execute of the Project*
CLR-5 :	*Attain the knowledge about Implementation and Quality Assurance in Management*
CLR-6 :	*Be familiar with the basic aspects of Production Management like Inventory Management, Work study, Job evaluation, Scheduling, project management, MRP and TQM.*

		Learning			Program Learning Outcomes (PLO)														
		1	2	3	1	2	3	4	5	6	7	8	9	10	11	12	13	14	15
Course Learning Outcomes (CLO):	*At the end of this course, learners will be able to:*	Level of Thinking (Bloom)	Expected Proficiency (%)	Expected Attainment (%)	Engineering Knowledge	Problem Analysis	Design & Development	Analysis, Design, Research	Modern Tool Usage	Society & Culture	Environment & Sustainability	Ethics	Individual & Team Work	Communication	Project Mgt. & Finance	Life Long Learning	PSO - 1	PSO - 2	PSO – 3
CLO-1 :	*Understand the production management and to recognize the relationship with other functional areas and acquire the knowledge about capacity, location and layout planning.*	*1 & 2*	*90*	*85*	*H*	*M*	-	-	-	-	-	-	*M*	-	-	-	-	-	*M*
CLO-2 :	*Acquire knowledge on Inventory management and Work study*	*1*	*90*	*85*	*H*	*M*	-	-	-	-	-	-		-	-	-	-	-	*M*
CLO-3 :	*Appreciate the Job evaluation and understand the need of scheduling*	*1*	*90*	*85*	*H*		-	-	-	-	-	-	*M*	-	-	-	-	-	*M*
CLO-4 :	*Understand the theory behind the Project management and acquire the knowledge about MRP, ERP and Supply chain management.*	*1 & 2*	*90*	*85*	*H*	*M*	-	-	-	-	-	-		-	-	-	-	-	*M*
CLO-5 :	*Obtain the knowledge about Total Quality Management*	*1 & 2*	*90*	*85*	*H*		-	-	-	-	-	-	*M*	-	-	-	-	-	*M*
CLO-6 :	*Recognize the use of production management, acquire knowledge on the inventory management and work study, job evaluation and scheduling, study the total quality management on production process.*	*1*	*90*	*85*	*H*	*M*	-	-	-	-	-	-	*M*	-	-	-	-	-	*M*

		Introduction to Production Management	Inventory Management and Work Study	Job Evaluation and Scheduling	Project Management and MRP	Total Quality Management
Duration (hour)		9	9	9	9	9
S-1	SLO-1	*History and development of production management*	*Inventory Control and cost, procurement and purchasing methods*	*Job evaluation: objectives, methods and factors affecting wage structure.*	*Project Management Phases and Project Appraisal*	*Quality management systems and Factors controlling quality*
S-2	SLO-1	*Functions and scope of different types of production processes*	*Warehousing Procedure and records in stock control, stores management*	*Types of wages, methods of wage system and characteristics*	*PERT and CPM*	*Impact of poor quality, challenges and Quality cost*
S-3	SLO-1	*Relationship of production management with other functional areas*	*Method Study and Means of increasing productivity*	*Value analysis and value engineering*	*Material requirement Planning (MRP)*	*Quality Assurance and Quality Circle*
S-4	SLO-1	*Capacity planning and its types*	*Charts and diagrams used in method study*	*Aggregate planning and strategies*	*Manufacturing resources Planning (MRP II)*	*Statistical Process Control and Control Charts with examples*
S-5	SLO-1	*Capacity decisions and their importance, Capacity planning strategies: types*	*Role of work study and human factors in work study*	*Forecasting and its methods*	*Enterprise Resource Planning (ERP)*	*Total Quality Management*
S-6	SLO-1	*Rooting, Techniques of rooting*	*Objectives and basic procedure for work study*	*MPS and Scheduling, Related Problems*	*Logistics: types and strategies*	*Just in Time with Case Study*
S-7	SLO-1	*Location planning: factors, types of planning, location models*	*Factors affecting work study*	*Scheduling principles, inputs, strategies, sequence and Assumptions, Case study*	*Supply chain Management*	*Six Sigma*
S-8	SLO-1	*Layout planning: factors and types*	*work measurement, objectives and techniques of work measurement*	*Gantt chart and Johnson's algorithm*	*Objectives and Decision Phases of Supply chain Management*	*Maintenance management and its types*
S-9	SLO-1	*Productivity management: definition, productivity index*	*Problems in Inventory control & work study*	*Problems in Gantt chart and Johnson's algorithms*	*Roles and Development in Supply chain Management*	*Effects of maintenance, Reliability and Replacement Techniques*

Learning Resources	1. *S.K. HajraChoudhury et al, "Production Management", MP publishers, New Delhi, 1990.* 2. *Heizer.,"Operations Management", Pearson, New Delhi, 2016.* 3. *Ahuja, K.K., "Production Management", CBS Publishers, New Delhi, 2013.* 4. *Agarwal and Jain, "Production Management", Khanna publishers, New Delhi, 1998*	5. *S N.Chary, "Production and operation management", Tata Mcgraw Hill publications, New Delhi, 2009* 6. *Goel, B.S., "Production Management", Pragathi&prakasan publishers, Mererut, 1984.* 7. *S.Anil and N.Suresh, "Production and operation Management", New Age International publishers, New Delhi, 2008*

Learning Assessment											
	Bloom's Level of Thinking	Continuous Learning Assessment (50% weightage)								Final Examination (50% weightage)	
		CLA – 1 (10%)		CLA – 2 (15%)		CLA – 3 (15%)		CLA – 4 (10%)#			
		Theory	Practice	Theory	Practice	Theory	Practice	Theory	Practice	Theory	Practice
Level 1	Remember Understand	*40 %*	-	*30 %*	-	*30 %*	-	*30 %*	-	*30%*	-
Level 2	Apply Analyze	*40 %*	-	*40 %*	-	*40 %*	-	*40 %*	-	*40%*	-
Level 3	Evaluate Create	*20 %*	-	*30 %*	-	*30 %*	-	*30 %*	-	*30%*	-
	Total	100 %		100 %		100 %		100 %		100 %	

CLA – 4 can be from any combination of these: Assignments, Seminars, Tech Talks, Mini-Projects, Case-Studies, Self-Study, MOOCs, Certifications, Conf. Paper etc.,

Course Designers		
Experts from Industry	Experts from Higher Technical Institutions	Internal Experts
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2. Dr. Muthumanikkam, Jt. Director, CVRDE, DRDO,Avadi,Chennai.	*2.Dr.Assaithambi, Govt. Col. of. Engg, sengipatti,Thanjavur, basaithambi@gcetj.edu.in*	*2. Dr.A.Arul Jeya Kumar, SRMIST*

Course Code	18MEO113T	Course Name	DESIGN OF EXPERIMENTS	Course Category	O	Open Elective	L	T	P	C
							3	0	0	3

Pre-requisite Courses	NIL	Co-requisite Courses	NIL	Progressive Courses	NIL
Course Offering Department	Mechanical Engineering	Data Book / Codes/Standards		Statistical data books	

Course Learning Rationale (CLR):	The purpose of learning this course is to:
CLR-1 :	*Be familiar with necessity, fundamentals and potential practical problemsin design of experiments*
CLR-2 :	*Be familiar with methodology used for design of experiments*
CLR-3 :	*Be familiar with robust design concepts with case studies*
CLR-4 :	*Be familiar with the concept of response surface design*
CLR-5 :	*Be familiar with the concepts of confounding and analysis of variance (ANOVA)*
CLR-6 :	*Be familiar with how the analysis of the data from the experiment should be carried out.*

Course Learning Outcomes (CLO):	At the end of this course, learners will be able to:	Learning 1: Level of Thinking (Bloom)	Learning 2: Expected Proficiency (%)	Learning 3: Expected Attainment (%)
CLO-1 :	*Understand the basics and potential practical problems in design of experiments*	*1, 2*	*90*	*85*
CLO-2 :	*Understand and apply various methodology for design of experiment to evaluate case studies*	*1, 2 & 3*	*85*	*80*
CLO-3 :	*Apply the concept of robust design to evaluate case studies*	*1, 2 & 3*	*85*	*80*
CLO-4 :	*Expose the concepts of response surface design to evaluate experimental problems*	*1, 2 & 3*	*85*	*80*
CLO-5 :	*Apply the concept of confounding and ANOVA to evaluate case studies*	*1, 2 & 3*	*90*	*85*
CLO-6 :	*Construct optimal or good designs for a range of practical experiments and describe how the analysis of the data from the experiment should be carried out*	*1, 2 & 3*	*90*	*85*

Program Learning Outcomes (PLO)

	1 Engineering Knowledge	2 Problem Analysis	3 Design & Development	4 Analysis, Design, Research	5 Modern Tool Usage	6 Society & Culture	7 Environment & Sustainability	8 Ethics	9 Individual & Team Work	10 Communication	11 Project Mgt. & Finance	12 Life Long Learning	13 PSO - 1	14 PSO - 2	15 PSO – 3
CLO-1	H	H	H	H	L	M	M	L	L	L	M	M	H	H	H
CLO-2	H	H	H	H	H	M	M	L	L	L	M	M	H	H	H
CLO-3	H	H	H	H	H	M	M	L	L	L	M	M	H	H	H
CLO-4	H	H	H	H	H	M	M	L	L	L	M	M	H	H	H
CLO-5	H	H	H	H	H	M	M	L	L	L	M	M	H	H	H
CLO-6	H	H	H	H	H	M	M	L	L	L	M	M	H	H	H

Duration (hour)		9	9	9	9	9
S-1	SLO-1	*Introduction in Design of experiments (DOE)*	*Need for DOE methodology*	*Introduction to Robust design, Loss functions*	*Background of response surface design*	*Introduction and uses of confounding*
S-2	SLO-1	*The fundamental and potential practical problems in experimentation*	*Barriers in the successful application of DOE*	*Eight steps in Taguchi methodology*	*Multiple Responses and Contour profile of response surface plot*	*2^3 factorial experiment with complete confounding*
S-3	SLO-1	*Statistical thinking and its role within DOE*	*Practical methodology of DOE and Analytical tools for DOE*	*Orthogonal array, Selecting the interaction, Linear graphs*	*Creation of response surface designs*	*2^3 factorial experiment with partial confounding*
S-4	SLO-1	*Basic principles of DOE and Degrees of freedom*	*The confidence interval for the mean response*	*S/N ratio: Larger-the-better, Smaller-the-better, Nominal-the-best*	*Central composite designs (Rotatable central composite design)*	*Confounding in the 2^n series and examples*
S-5	SLO-1	*Selection of quality characteristics for experiments*	*Introduction to Screening design*	*Analyze the data, factor effect diagram*	*Central composite designs (Rotatable central composite design)*	*Confounding of 3^n factorial and examples*
S-6	SLO-1	*Understanding key interaction in processes*	*Geometric and non-geometric P-B design*	*Levels of parameters*	*Box-Behnken design with case studies*	*ANOVA (One-way and two-way, higher-way ANOVA)*
S-7	SLO-1	*An alternative method for calculating two-order interaction effect*	*Introduction of full factorial design, Basic concepts of 2^2, 2^3 and 2^k designs*	*Confirmation test*	*Random factor models and its industrial application , Random Effects Models*	*MANOVA and ANCOVA overview*
S-8	SLO-1	*Synergistic interaction, Antagonistic interaction*	*Solving Case studies on Full factorial design with statistics software*	*Augmented design with simple case studies*	*Two Factor Factorial with Random Factors*	*Solving Case studies on ANOVA with statistics software*
S-9	SLO-1	*Synergistic interaction versus Antagonistic interaction*	*Solving Case studies on Full factorial design with statistics software*	*Solving case studies on robust design with statistics software*	*Two Factor Mixed Models with random factors*	*Regression Models and Regression Analysis*

Learning Resources	1. *Douglas C Montgomery, " Design and Analysis of Experiments" , Eighth Edition, John Wiley & Sons Ltd., 2012* 2. *Box, G.E.P. and Draper N.R, “Empirical Model-Building and Response Surfaces", John Wiley &sons 2007.* 3. *Jijuantony, "Design of Experiments for Engineers and Scientists", Second Edition, Elsevier, 2014.* 4. *M N Das, N C Giri, “Design and Analysis of Experiments", New Age International (P) Limited, Publishers, 2003.*	5. *Russell R. Barton, “Graphical Methods for the Design of Experiments", Springer, 2012.* 6. *Larry B. Barrentine, “An introduction to Design of Experiments A simplified approach”, New Age International Publishers, 2014.* 7. *William G. Cochran, Gertrude M. Cox, “Experimental Design", John Wiley and sons, Inc, 2003.* 8. *Myres R.H, Montgomery D. C, Anderson-Cook C. M “Response Surface Methodology", Wiley, 2016.* 9. *Cox D.R, Reid N, “The theory of Design of Experiments", Chapman and Hall, CRC Press, 2000.* 10. *John, P.W.M, “Statistical Design and Analysis of Experiments", Society for Industrial and Applied Mathematics, 1998.*

Learning Assessment											
	Bloom’s Level of Thinking	Continuous Learning Assessment (50% weightage)								Final Examination (50% weightage)	
		CLA – 1 (10%)		CLA – 2 (15%)		CLA – 3 (15%)		CLA – 4 (10%)#			
		Theory	Practice	Theory	Practice	Theory	Practice	Theory	Practice	Theory	Practice
Level 1	Remember Understand	*25%*	-	*20 %*	-	*20 %*	-	*20%*	-	*20 %*	-
Level 2	Apply Analyze	*50 %*	-	*60 %*	-	*50 %*	-	*50%*	-	*60 %*	-
Level 3	Evaluate Create	*25 %*		*20 %*		*30 %*	-	*30%*	-	*20 %*	-
Total		100%		100%		100%		100%		100%	

CLA – 4 can be from any combination of these: Assignments, Seminars, Tech Talks, Mini-Projects, Case-Studies, Self-Study, MOOCs, Certifications, Conf. Paper etc.

Course Designers		
Experts from Industry	Experts from Higher Technical Institutions	Internal Experts
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Dr.A.Velayutham, DRDO, Avadi	*Dr.N.Arunachalam, IIT Madras, chalam@iitm.ac.in*	*Dr. S. Prabhu, SRMIST*

Course Code	18MEO114T	Course Name	MODERN CONTROL THEORY	Course Category	O	Open Elective	L	T	P	C
							3	0	0	3

Pre-requisite Courses	NIL	Co-requisite Courses	NIL	Progressive Courses	NIL
Course Offering Department	Mechanical Engineering	Data Book / Codes/Standards		Statistical data books	

Course Learning Rationale (CLR):	*The purpose of learning this course is to:*
CLR-1 :	*Understand and remember the fundamentals of modern control theory including basic controller actions*
CLR-2 :	*Create mathematical models for dynamic systems and Apply transfer function and state space models*
CLR-3 :	*Upon learning the students shall Analyze the transient and steady state system response of control systems*
CLR-4 :	*Upon learning the students shall Analyze the stability of control system by different methods*
CLR-5 :	*Upon learning the students shall Analyze multiple input multiple output systems using state space approach*

Course Learning Outcomes (CLO):	*At the end of this course, learners will be able to:*	Learning 1: Level of Thinking (Bloom)	Learning 2: Expected Proficiency (%)	Learning 3: Expected Attainment (%)	PLO 1: Engineering Knowledge	PLO 2: Problem Analysis	PLO 3: Design & Development	PLO 4: Analysis, Design, Research	PLO 5: Modern Tool Usage	PLO 6: Society & Culture	PLO 7: Environment & Sustainability	PLO 8: Ethics	PLO 9: Individual & Team Work	PLO 10: Communication	PLO 11: Project Mgt. & Finance	PLO 12: Life Long Learning	PLO 13: PSO - 1	PLO 14: PSO - 2	PLO 15: PSO – 3
CLO-1 :	*understand basic terminologies, concepts of feedback, dynamic system modeling using linear differential equations, applytransfer functions for control system*	*1,2*	*90*	*85*	*H*	*H*													
CLO-2 :	*Understand modeling in state space, apply state space model and evaluate different mechanical systems*	*1,2*	*85*	*80*	*H*	*H*	*H*												
CLO-3 :	*understandstandard test signals, apply and evaluate system response for first and second order systems*	*1,2,3*	*85*	*80*	*H*	*H*	*H*												
CLO-4 :	*understand, apply, and create optimal control systems based on stability analysis by different approaches*	*1,2,3*	*85*	*80*	*H*	*H*	*H*												
CLO-5 :	Analyze the multiple input multiple output dynamic systems based on state space approach, apply Kalman and Gilbert test	1,2,3	90	85	H	H		H								H			

		Introduction to control systems	System Modeling	System response	Stability Analysis	State space analysis of MIMO systems
Duration (hour)		9	9	9	9	9
S-1	SLO-1	*Brief Review, Basic terminologies and examples, Classical-Modern-Robust-Automatic control systems, Concepts of Feedback: Closed-loop and open-loop control systems, Design and compensation of control systems (Design procedure)*	*Modeling in state space: State, State variables, State vector, State space, State equations for a MIMO system*	*Transient and steady state response, Standard test signals- Mathematical expressions- type and order of a system*	*Complex s-plane, Routh's stability criterion*	*MIMO System analysis: state-space approach*
S-2	SLO-1	*Brief Review, Basic terminologies and examples, Classical-Modern-Robust-Automatic control systems, Concepts of Feedback: Closed-loop and open-loop control systems, Design and compensation of control systems (Design procedure)*	*Modeling in state space: State, State variables, State vector, State space, State equations for a MIMO system*	*First order Systems: Unit step response and Unit ramp response, Concepts of time constant and its importance in speed of response*	*Complex s-plane, Routh's stability criterion*	*MIMO System analysis: state-space approach*
S-3	SLO-1	*Modeling of control systems using linear differential equations, Transfer function expressions (with note on convolution integral), Block diagrams*	*State space representation of dynamic systems – nth order systems of linear differential equations, State space models for mechanical systems: Examples from mechanical, electrical, liquid-level, thermal systems*	*First order Systems: Unit step response and Unit ramp response, Concepts of time constant and its importance in speed of response*	*Analysis of control systems by Root-Locus method: concepts and procedure, Design of Lead-Lag compensation based on Root-Locus approach*	*State space representation in controllable, observable, diagonal and jordan canonical forms, order reduction and solution of state equations*
S-4	SLO-1	*Modeling of control systems using linear differential equations, Transfer function expressions (with note on convolution integral), Block diagrams*	*State space representation of dynamic systems – nth order systems of linear differential equations, State space models for mechanical systems: Examples from mechanical, electrical, liquid-level, thermal systems*	*Second order systems: Servo system and Servo system with velocity feedback*	*Analysis of control systems by Root-Locus method: concepts and procedure, Design of Lead-Lag compensation based on Root-Locus approach*	*State space representation in controllable, observable, diagonal and jordan canonical forms, order reduction and solution of state equations*

S-5	SLO-1	*Basic Control action: Types of controllers, Principles of pneumatic, hydraulic and electronic controllers*	*State space representation of dynamic systems – nth order systems of linear differential equations, State space models for mechanical systems: Examples from mechanical, electrical, liquid-level, thermal systems*	*Second order systems: Servo system and Servo system with velocity feedback*	*Analysis of control systems by Root-Locus method: concepts and procedure, Design of Lead-Lag compensation based on Root-Locus approach*	*Controllability and observability, Kalman and Gilbert test*
S-6	SLO-1	*Basic Control action: Types of controllers, Principles of pneumatic, hydraulic and electronic controllers*	*State space representation of dynamic systems – nth order systems of linear differential equations, State space models for mechanical systems: Examples from mechanical, electrical, liquid-level, thermal systems*	*Second order systems: Servo system and Servo system with velocity feedback*	*Stability: Polar, Bode and Nyquistplots*	*Controllability and observability, Kalman and Gilbert test*
S-7	SLO-1	*Basic Control action: Types of controllers, Principles of pneumatic, hydraulic and electronic controllers*	*State space representation of transfer function systems*	*Controller errors, Higher order systems, Effects of proportional-integral-derivative control actions on the system response*	*Stability: Polar, Bode and Nyquistplots*	*Pole placement approach to the design of control systems, State observers, Design of servo systems*
S-8	SLO-1	*Tuning of PID controller: Ziegler-Nichols rules*	*State space representation of transfer function systems*	*Controller errors, Higher order systems, Effects of proportional-integral-derivative control actions on the system response*	*Lead-Lag compensation based on frequency response approach*	*Pole placement approach to the design of control systems, State observers, Design of servo systems*
S-9	SLO-1	*Tuning of PID controller: Ziegler-Nichols rules*	*Linearisation of a non-linear system*	*Controller errors, Higher order systems, Effects of proportional-integral-derivative control actions on the system response*	*Lead-Lag compensation based on frequency response approach*	*Pole placement approach to the design of control systems, State observers, Design of servo systems*

Learning Resources	1. *K. Ogata - 'Modern Control Engineering - Prentice Hall (India) - Pearson Education - 2009 - 5th Edition* 2. *Francis. H. Raven - 'Automatic Control Systems' – McGraw Hill - 1995 - 5th Edition*	1. *B. C. Kuo - 'Automatic Control Systems' - Wiley - 2009 - 9th Edition* 2. *Schaum's Series - 'Feedback and Control Systems' – McGraw Hill Education - 2013 - 2nd Edition* 3. *I. J. Nagarath& M. Gopal - 'Control Systems' - New age International Publishers.* 4. *Norman Nise- 'Control Systems Engineering' - Wiley and Sons - 2015 - 7thEdition* 5. *Rihard C. Drof and Robert. H. Bishop Addison - 'Modern Control Systems' – Wesley – 2010 - 12th Edition*

Learning Assessment

	Level of Thinking	Continuous Learning Assessment (50%)				Final Examination (50%)
		CLA – 1 (10%)	CLA – 2 (15%)	CLA – 3 (15%)	CLA – 4 (10%) #	
Level 1	Remember Understand	*40 %*	*30 %*	*30 %*	*30 %*	*30 %*
Level 2	Apply Analyze	*40 %*	*40 %*	*40 %*	*40 %*	*40 %*
Level 3	Evaluate Create	*20 %*	*30 %*	*30 %*	*30 %*	*30 %*
	Total	100%	100%	100%	100%	100%

CLA – 4 can be from any combination of these: Assignments, Seminars, Tech Talks, Mini-Projects, Case-Studies, Self-Study, MOOCs, Certifications, Conf. Paper etc.,

Course Designers

Experts from Industry	Experts from Higher Technical Institutions	Internal Experts
1. Dr.R.Kalimuthu, ISRO, Mahendragiri, r_kalimuthu@vssc.gov.in	*1. Dr. BIJAY KUMAR ROUT, BITS, Pilani*	*Dr C. Shravankumar, SRMIST*
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Course Code	18MEO115T	Course Name	FACILITIES PLANNING	Course Category	O	Open Elective	L	T	P	C
							3	0	0	3

Pre-requisite Courses	NIL	Co-requisite Courses	NIL	Progressive Courses	NIL
Course Offering Department	Mechanical Engineering	Data Book / Codes/Standards	NIL		

Course Learning Rationale (CLR):	*The purpose of learning this course is to:*
CLR-1 :	*Understand the purpose of facilities planning process*
CLR-2 :	*Acquire knowledge on requirements and relationships of facilities planning*
CLR-3 :	*Be familiar with the facility design*
CLR-4 :	*Acquire knowledge on strategies adopted for designing a facility*
CLR-5 :	*Attain the knowledge about material handling and facility layout design*
CLR-6 :	*Be familiar with the basic aspects of evaluating, selecting maintaining in facilities planning and Industrial Acts and safety*

Course Learning Outcomes (CLO):	*At the end of this course, learners will be able to:*	Learning 1: Level of Thinking (Bloom)	Learning 2: Expected Proficiency (%)	Learning 3: Expected Attainment (%)	1 Engineering Knowledge	2 Problem Analysis	3 Design & Development	4 Analysis, Design, Research	5 Modern Tool Usage	6 Society & Culture	7 Environment & Sustainability	8 Ethics	9 Individual & Team Work	10 Communication	11 Project Mgt. & Finance	12 Life Long Learning	13 PSO - 1	14 PSO - 2	15 PSO – 3
CLO-1 :	*Understand the basic concepts in facilities planning process*	*1&2*	*90*	*85*	*H*					*M*						*L*			
CLO-2 :	*Acquire knowledge on requirements and relationships of facilities planning*	*1*	*90*	*85*	*M*														
CLO-3 :	*Understand facility design for various functions and acquire knowledge about strategies adopted for designing a facility*	*1*	*90*	*85*	*H*		*H*	*M*										*L*	
CLO-4 :	*Acquire knowledge on material handling and facility layout design*	*1&2*	*90*	*85*	*H*		*H*	*M*		*M*						*L*		*L*	
CLO-5 :	*Recognize the basic aspects of evaluating, selecting and maintaining in facilities planning*	*1&2*	*90*	*85*	*M*			*M*		*M*									
CLO-6 :	*Evaluate the existing facility, modify to meet the requirements and understand Industrial Acts and safety.*	*1*	*90*	*85*	*M*					*M*						*M*			

Duration (hour)		9	9	9	9	9
S-1	SLO-1	*Definition, Significance and objectives of facilities planning*	*Department planning*	*Material Handling, Principles and classification*	*Facility design for various functions*	*Introduction to Facilities plan Evaluating. Facilities plan evaluation procedure, Factors to evaluate facility planning*
S-2	SLO-1	*Facilities planning process*	*Activity relationship*	*Designing material handling systems, Estimating material handling costs, Safety consideration*	*Warehouse operation and location problems*	*Qualitative Evaluation Techniques*
S-3	SLO-1	*Strategic Facilities Planning*	*Flow patterns*	*Layout Planning Models and Basic layout types*	*Nature of Location Decision, Need for facility location planning*	*Efficiency indices, Cost of Evaluation of Layout*
S-4	SLO-1	*Developing facilities planning strategies*	*Planning and measuring*	*Layout procedures, Algorithmic approaches and Pair-wise exchange method*	*General procedures and actors influencing location decisions, Facility Location Models*	*Facilities plan selection, Steps and involved in Facilities plan selection*
S-5	SLO-1	*Nature of Location Decision, Need for facility location planning*	*Space requirements*	*graph based approaches blocplan, logic, multiple approach*	*Economics and cost analysis, Rural and urban location pattern*	*Facility plan preparing, Importance of facility preparing*
S-6	SLO-1	*General procedures and Factors influencing location decisions, Facility Location Models*	*Personnel requirements*	*Multi floor facility layout, Developing layout alternatives*	*Manufacturing systems and Services*	*Facilities plan implementing and facility plan maintaining*
S-7	SLO-1	*Influence of product*	*Employee, facility interface, Multi-facility location problem, Euclidean-distance location problem, Minimax location probem.*	*Computer assisted layout planning*	*Fixed automation system and Flexible manufacturing system*	*Necessity of Industrial acts, The Indian Factories Act 1948, The industrial Dispute act1947, The minimum Wage Act 1948.*
S-8	SLO-1	*Process and schedule design*	*Restrooms, food services, health services*	*ALDEP, CORE LAP, CRAFT , PLANET , MAT*	*Reduction in work in process, Just-in-time manufacturing*	*Introduction to Industrial safety, Investigation and analysis of accidents, Safety devices Causes and sources of accidents.*

S-9	SLO-1	*Facilities design and procedure*	*Office facility planning*	*Commercial facility layout packages*	*Facilities planning trends*	*Safety devices, Causes and sources of accidents.*

Learning Resources	*1. Tompkins.J.A, White.J.A, Bozer.Y.A, and Tan Choco.J.M.A, "Facilities Planning", 4th Edition, John Wiley & sons, India, 2010.* *2. James M. Apple, "Principles of layout and material handling", Ronald press, 1977.* *3. Francis.R.L, McGinnis.L.F, and White J.A, "Facility Layout and Location: An analytical approach", Prentice Hall, New Jersey, 1992.*	*4. Gupta and Patel, "Work study", Khanna Publishers, New Delhi.* *5. Kanna.O.P, "Industrial Engineering and management", Khanna Publishers,New Delhi , 2018* *6. Sharma SC & Banga TR, "Industrial Engineering & Management", Khanna Publishers ,2017*

Learning Assessment

	Bloom's Level of Thinking	Continuous Learning Assessment (50% weightage)								Final Examination (50% weightage)	
		CLA – 1 (10%)		CLA – 2 (15%)		CLA – 3 (15%)		CLA – 4 (10%)#			
		Theory	Practice	Theory	Practice	Theory	Practice	Theory	Practice	Theory	Practice
Level 1	Remember Understand	*40 %*	-	*30 %*	-	*30 %*	-	*30 %*	-	*30%*	-
Level 2	Apply Analyze	*40 %*	-	*40 %*	-	*40 %*	-	*40 %*	-	*40%*	-
Level 3	Evaluate Create	*20 %*	-	*30 %*	-	*30 %*	-	*30 %*	-	*30%*	-
	Total	100 %		100 %		100 %		100 %		100 %	

CLA – 4 can be from any combination of these: Assignments, Seminars, Tech Talks, Mini-Projects, Case-Studies, Self-Study, MOOCs, Certifications, Conf. Paper etc.,

Course Designers

Experts from Industry	Experts from Higher Technical Institutions	Internal Experts
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2. Mr. S.Arun kumar, Executive Engineer, ONGC borntough18@gmail.com	*Dr. K.E.K Vimal , Assistant Professor, NIT, Patna*	*Dr. S.Murali*

Course Code	18MEO116T	Course Name	INDUSTRIAL SAFETY AND ENVIRONMENT	Course Category	O	Open Elective	L	T	P	C
							3	0	0	3

Pre-requisite Courses	NIL	Co-requisite Courses	NIL	Progressive Courses	NIL
Course Offering Department	Mechanical Engineering	Data Book / Codes/Standards	NIL		

Course Learning Rationale (CLR):	*The purpose of learning this course is to:*
CLR-1 :	*Be familiar with the safety issues in design, handling and industrial environment*
CLR-2 :	*Be familiar with the accident prevention and motivating factors of safety suggestion schemes*
CLR-3 :	*Know the various safety measures followed in material handling system*
CLR-4 :	*Be familiar with the safety measures followed in chemical industries and chemical laboratories*
CLR-5 :	*Be familiar with the environmental impact Assessment*
CLR-6 :	*Be familiar with the regulations for health, safety and environment*

		Learning			Program Learning Outcomes (PLO)														
		1	2	3	1	2	3	4	5	6	7	8	9	10	11	12	13	14	15
Course Learning Outcomes (CLO):	*At the end of this course, learners will be able to:*	Level of Thinking (Bloom)	Expected Proficiency (%)	Expected Attainment (%)	Engineering Knowledge	Problem Analysis	Design & Development	Analysis, Design, Research	Modern Tool Usage	Society & Culture	Environment & Sustainability	Ethics	Individual & Team Work	Communication	Project Mgt. & Finance	Life Long Learning	PSO - 1	PSO - 2	PSO – 3
CLO-1 :	*Conduct basic safety inspections using strategies that they have developed*	*1&2*	*90*	*85*	*L*		*H*		*H*	*M*	*H*	*L*	*H*	*M*	*L*	*H*			
CLO-2 :	*Understand the motivating factors of safety suggestion schemes, thereby preventing accidents*	*1*	*90*	*85*	*H*	*M*	*H*		*H*	*M*	*H*	*L*	*H*	*H*	*M*	*H*			
CLO-3 :	*Understand the various safety measures to be followed in material handling system*	*1&2*	*90*	*85*	*H*	*L*	*H*		*H*	*L*	*H*	*L*	*M*	*H*		*H*			
CLO-4 :	*Understand the various safety measures followed in chemical industries and chemical laboratories*	*1&2*	*90*	*85*	*H*	*L*	*H*		*H*	*L*	*H*	*L*	*M*	*H*		*H*			
CLO-5 :	*Gain knowledge in basic environmental impact Assessment*	*1&2*	*90*	*85*	*L*		*H*		*M*		*H*		*M*			*H*			
CLO-6 :	*Create a document addressing the principles for developing and implementing a successful occupational health and safety program and evaluation of a work site*	*1&2*	*90*	*85*	*H*	*M*	*H*		*H*	*M*	*H*	*L*	*H*	*H*	*M*	*H*			

		Accident Prevention	Safety in Material Handling	Safety in Chemical Industries	Environmental Impact Assessment	Regulations for Health, Safety and Environment
Duration (hour)		9	9	9	9	9
S-1	SLO-1	*Definitions and theories of accident, reportable and non-reportable accidents, unsafe act,unsafe condition and dangerous occurrence*	*General safety consideration in material handling*	*Safety in the design process of chemical plants*	*Evolution, Concepts, Methodologies, Screening, Scoping and Checklist of EIA*	*Factories act and rules, Workmen compensation act*
S-2	SLO-1	*Theories and principles of accident causation*	*Ropes, Chains, Sling, Hoops, Clamps*	*Safety in operational and maintenance of chemical plants*	*Rapid and Comprehensive EIA*	*Indian explosive act*
S-3	SLO-1	*Cost of accidents, Accident reporting and investigations, accident reports- Class exercise with case study.*	*Arresting gears and Prime movers*	*Exposure of personnel*	*Legislative and environmental clearance procedure in India*	*Gas cylinder rules*
S-4	SLO-1	*Safety committees and their need, types and advantages*	*Ergonomic consideration in material handling*	*Operational activities and hazards*	*Prediction tools for EIA*	*Environmental pollution act*
S-5	SLO-1	*Safety education and training and their importance*	*Design, installation, operation andmaintenance of Conveying equipment.*	*Safety in storage and handling of chemicals and gases*	*Assessment of Impact of air, water and soil*	*Indian petroleum act and rules*
S-6	SLO-1	*Various training methods*	*Hoisting, traveling and slewing mechanisms*	*Hazards during transportation and Pipeline transport*	*Assessment of Impact of noise, biological and Socio cultural environment*	*Oil industry safety directorate (OISD)*
S-7	SLO-1	*Accident prevention and Motivating factors of safety suggestion schemes*	*Selection, operation and maintenance of industrial trucks*	*Safety in chemical laboratories*	*Public participation*	*Indian Electricity act and rules*
S-8	SLO-1	*Safety performance*	*Selection, operation and maintenance of Mobile cranes and Tower crane*	*Specific safety consideration for cement, paper and pharmaceutical*	*Resettlement and Rehabilitation*	*Mines act and rules, Manufacture, Storage and Import of Hazardous Chemical rules 1989*
S-9	SLO-1	*Definitions connected with measuring safety performance as per Indian and International standards*	*Storage and Retrieval of common goods of various shapes and sizes in a general store of a big industry.*	*Specific safety consideration for petroleum, petro -chemical, rubber, fertilizer and distilleries*	*Documentation of EIA*	*Indian motor vehicles act and rules*

Learning Resources	1. *Thomas J.Anton, "Occupational safety and health management", (2nd Edition). New York, McGraw Hill1989.* 2. *Rieske, David W., Asfahl and C. Ray, "Industrial Safety and Health Management", 6th Edition, Prentice Hall Professional Technical Ref. 2009.* 3. *Heinrich.H.W, "Industrial Accident Prevention", McGraw-Hill, 1980.* 4. *Alexandrov.M.P,"Material Handling Equipment",Mir Publishers, Moscow, 1981.* 5. *Lees.F.P, Loss "Prevention in Process Industries", Butterworths, NewDelhi, 1986.*	6. *Handlin.W, "Industrial Hand Book", McGraw-Hill, 2000.* 7. *Canter.R.L, "Environmental Impact Assessment", (2nd Edition), McGraw Hill, 1996.* 8. *IS CODES: IS 5903, IS 807, IS 2760, IS 14469, IS 13367-1, IS 5324, IS 7167, IS 7155, IS 1800.1, IS 3521 of Oil Industry Safety Directorate, Govt. of India.* 9. *The manufacture, storage and import of hazardous chemical rules 1989, Madras BookAgency, Chennai.*

Learning Assessment											
	Bloom's Level of Thinking	Continuous Learning Assessment (50% weightage)								Final Examination (50% weightage)	
		CLA – 1 (10%)		CLA – 2 (15%)		CLA – 3 (15%)		CLA – 4 (10%)#			
		Theory	Practice	Theory	Practice	Theory	Practice	Theory	Practice	Theory	Practice
Level 1	Remember Understand	*40 %*	-	*30 %*	-	*30 %*	-	*30 %*	-	*30%*	-
Level 2	Apply Analyze	*40 %*	-	*40 %*	-	*40 %*	-	*40 %*	-	*40%*	-
Level 3	Evaluate Create	*20 %*	-	*30 %*	-	*30 %*	-	*30 %*	-	*30%*	-
	Total	100 %		100 %		100 %		100 %		100 %	

CLA – 4 can be from any combination of these: Assignments, Seminars, Tech Talks, Mini-Projects, Case-Studies, Self-Study, MOOCs, Certifications, Conf. Paper etc.

Course Designers		
Experts from Industry	Experts from Higher Technical Institutions	Internal Experts
1. Mr. S.Bhargav, GM,Rane Brake, Trichy	*1. Dr. R. Raju, Anna university, Chennai.*	*1. Mr. A. C. Arun Raj, SRMIST*
2. Dr. Muthumanikkam, Jt. Director, CVRDE, DRDO,Avadi,Chennai.	*2. Dr. T. Paul Robert, Anna university, Chennai.*	*2. Mr. A. Thirugnanam, SRMIST*

Course Code	18MEO117T	Course Name	ARTIFICIAL INTELLIGENCE AND EXPERT SYSTEMS	Course Category	O	Open elective	L	T	P	C
							3	0	0	3

Pre-requisite Courses	Nil	Co-requisite Courses	Nil	Progressive Courses	Nil
Course Offering Department		Department of Mechanical Engineering		Data Book / Codes/Standards	Nil

Course Learning Rationale (CLR):	*The purpose of learning this course is to:*
CLR-1 :	*Be familiar with the basic concepts of artificial intelligence*
CLR-2 :	*Be familiar with various search techniques used in artificial intelligence*
CLR-3 :	*Be familiar with various Matching techniques used in artificial intelligence*
CLR-4 :	*Be familiar with the concept of knowledge management*
CLR-5 :	*Be familiar with the programming language*
CLR-6 :	*Be familiar with basic concepts of expert system*

Course Learning Outcomes (CLO):	*At the end of this course, learners will be able to:*	Learning 1 Level of Thinking (Bloom)	2 Expected Proficiency (%)	3 Expected Attainment (%)	PLO 1 Engineering Knowledge	2 Problem Analysis	3 Design & Development	4 Analysis, Design, Research	5 Modern Tool Usage	6 Society & Culture	7 Environment & Sustainability	8 Ethics	9 Individual & Team Work	10 Communication	11 Project Mgt. & Finance	12 Life Long Learning	13 PSO - 1	14 PSO - 2	15 PSO – 3
CLO-1 :	*Understand the basic concepts of artificial intelligence*	*1&2*	*90*	*85*	*H*	*L*	*H*	*H*	*H*	-	-	-	-	-	-	*H*	-	-	-
CLO-2 :	*Identify and use various search techniques*	*1&2*	*90*	*85*	*H*	*H*	*H*	*H*	*H*	-	-	-		-	-	*M*	-	-	-
CLO-3 :	*Understand the concept of matching techniques*	*1&2*	*90*	*85*	*H*	*L*	*M*	*M*	*H*	-	-	-	-	-	-	*M*	-	-	-
CLO-4 :	*Gain knowledge on the concept of knowledge management*	*1&2*	*90*	*85*	*H*	*L*	*M*	*M*	*H*	-	-	-	-	-	-	*M*	-	-	-
CLO-5 :	*Do coding in python language*	*1*	*90*	*85*	*L*	*H*	*H*	*M*	*H*	-	-	-	-	-	-	*M*	-	-	-
CLO-6 :	*Understand basic concepts of expert system*	*1&2*	*90*	*85*	*H*	*H*	*M*	*H*	*H*	-	-	-	-	-	-	*M*	-	-	-

		Introduction To Ai	Problem Solving Agents	Knowledge Organisation, Communication	Programming Language	Expert Systems
Duration (hour)		9	9	9	9	9
S-1	SLO-1	*History, Definition of AI*	*Problem Definition, formulating problems and Searching for solutions*	*Knowledge organization, manipulation and knowledge acquisition*	*Introduction to python its syntax*	*Introduction to Expert Systems*
S-2	SLO-1	*Emulation of human cognitive process*	*Measuring problem, solving performance with examples*	*Indexing and Retrieval techniques*	*Input, output statements*	*Basic Activities of an expert system*
S-3	SLO-1	*Semantic nets*	*Search /Strategies: Uninformed or Blinded search Breadth first search.*	*Integration of knowledge in memory organization systems*	*Numeric functions*	*Interpretation, Prediction and Diagnosis*
S-4	SLO-1	*An abstract view of modeling*	*Uniform cost search: Depth first search, Depth limited search*	*Matching Techniques: Need for matching and Matching problem*	*Input statements for declaration of variables, Output statements for declaration of variables*	*Design, Planning and Monitoring*
S-5	SLO-1	*Elementary knowledge*	*Iterative deepening, Depth first search and Bi-directional search*	*Partial matching, Fuzzy matching and RETE matching algorithm*		*Debugging, Repair, Instruction and Control*
S-6	SLO-1	*Computational logic*	*Comparing uniformed search strategies and Informed search strategies*	*Natural language processing: Overview of linguistics*	*Interaction functions*	*Basic aspect of expert system*
S-7	SLO-1	*Analysis of compound statements using simple logic connectives*	*Heuristic information and Hill climbing methods*	*Basic semantic analysis and Representation structures*	*recursion functions*	*Acquisition module frames of expert systems, Knowledge base*
S-8	SLO-1	*Predicate logic*	*Best First Search; Greedy Best First Search, Branch-and- Bound Search*	*Natural language generation.*	*Property list and arrays*	*Production rules , Semantic net and Inference engine*
S-9	SLO-1	Simple exercises	Optimal search and A* algorithm and iterative deepening A*	Bayesian Networks and Bayesian Inference		Backward chaining and forward chaining

Learning Resources	*1.Schalkoff, R.J., "Artificial Intelligence: An Engineering Approach", McGraw-Hill, 1990* *2. Elaine Rich and Kelvin Knight, "Artificial Intelligence", Tata McGraw Hill, New Delhi, 2009* *3. Russell , " Artificial intelligence :A modern Approach , Pearson Education ,3rd edition,2013* *4. Donald A. Waterman, "A Guide to Expert Systems", Addison-Wesley Longman Publishing Co., Inc. Boston, MA, USA ©1985 ISBN:0-201-08313-2*	*5. Nils J. Nilsson,"Principles of Artificial Intelligence", Narosa Publishing House, 2000.* *6. Eugene Charniak and Drew McDermot, "Introduction to Artificial Intelligence", Addison Wesley Longman Inc., 1998* *7. Patterson, "Introduction to Artificial Intelligence and Expert systems", Prentice Hall of India, New Delhi, 1990*

Learning Assessment											
	Bloom's Level of Thinking	Continuous Learning Assessment (50% weightage)								Final Examination (50% weightage)	
		CLA – 1 (10%)		CLA – 2 (15%)		CLA – 3 (15%)		CLA – 4 (10%)#			
		Theory	Practice	Theory	Practice	Theory	Practice	Theory	Practice	Theory	Practice
Level 1	Remember Understand	*40 %*	-	*30 %*	-	*30 %*	-	*30 %*	-	*30%*	-
Level 2	Apply Analyze	*40 %*	-	*40 %*	-	*40 %*	-	*40 %*	-	*40%*	-
Level 3	Evaluate Create	*20 %*	-	*30 %*	-	*30 %*	-	*30 %*	-	*30%*	-
	Total	100 %		100 %		100 %		100 %		100 %	

CLA – 4 can be from any combination of these: Assignments, Seminars, Tech Talks, Mini-Projects, Case-Studies, Self-Study, MOOCs, Certifications, Conf. Paper etc.,

Course Designers		
Experts from Industry	Experts from Higher Technical Institutions	Internal Experts
1. Dr. R. Kalimuthu, ISRO, Mahendragiri, r_kalimuthu@vssc.gov.in, rkpearls@yahoo.com	*1. Dr. P. Hariharan, Anna University, hari@annauniv.edu, hariharan2311@gmail.com*	*1. Mr Gujjari Bala Siva Krishna*
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Course Code	18MEO118T	Course Name	MICROCONTROLLER AND ITS APPLICATIONS IN ROBOTICS	Course Category	O	Open Elective	L	T	P	C
							3	0	0	3

Pre-requisite Courses	Nil	Co-requisite Courses	Nil	Progressive Courses	Nil
Course Offering Department	Mechanical Engineering			Data Book / Codes/Standards	Nil

Course Learning Rationale (CLR):	The purpose of learning this course is to:
CLR-1 :	*Acquire the fundamental concepts of microcontroller.*
CLR-2 :	*Learn to program the microcontroller using assembly language.*
CLR-3 :	*To expose interfacing of microcontroller with the external world using a high level language.*
CLR-4 :	*To introduce students to an open source microcontroller and its programming.*
CLR-5 :	*To enable students with the Design of Microcontroller based circuits based on applications on robotics.*
CLR-6 :	*Impart the Knowledge about the concepts and selection of microcontroller to its application.*

Course Learning Outcomes (CLO):	At the end of this course, learners will be able to:	Learning 1: Level of Thinking (Bloom)	Learning 2: Expected Proficiency (%)	Learning 3: Expected Attainment (%)	PLO 1: Engineering Knowledge	PLO 2: Problem Analysis	PLO 3: Design & Development	PLO 4: Analysis, Design, Research	PLO 5: Modern Tool Usage	PLO 6: Society & Culture	PLO 7: Environment & Sustainability	PLO 8: Ethics	PLO 9: Individual & Team Work	PLO 10: Communication	PLO 11: Project Mgt. & Finance	PLO 12: Life Long Learning	PLO 13: PSO - 1	PLO 14: PSO - 2	PLO 15: PSO – 3
CLO-1 :	*Understand the fundamental concepts of microcontroller.*	1	90	85	M	-	M	-	-	-	-	-	-	-	-	-	L	L	L
CLO-2 :	*Program the microcontroller using assembly language.*	1	90	85	H	M	M	L	L	-	-	-	-	-	-	-	H	H	L
CLO-3 :	*Interface I/O modules with microcontroller from external world.*	1	90	85	H	M	M	M	M	-	-	-	-	-	-	-	H	M	L
CLO-4 :	*Demonstrate a fundamental knowledge of open source microcontroller and learnt to program it.*	2	90	85	H	H	M	M	H	-	-	-	M	-	-	-	H	H	L
CLO-5 :	*Demonstrate microcontroller based circuit for engineering applications.*	3	90	85	H	M	H	H	H	-	-	-	H	-	-	-	H	M	L
CLO-6 :	*Select suitable microcontroller to meet specific requirements.*	3	90	85	H	M	H	M	L	-	-	-	L	-	-	-	H	M	L

Duration (hour)		9	9	9	9	9
S-1	SLO-1	*Data representation and Numbering system and its types are binary, decimal, hexadecimal systems*	*Introduction to Assembly language*	*Introduction to External world interfacing with microcontroller, Analog signals and Digital signals*	*Introduction to open source microcontroller*	*Application of Microcontroller in various fields*
S-2	SLO-1	*Data conversion from hexadecimal to decimal and decimal to binary, binary addition and subtraction*	*Instruction sets with syntax and examples.*	*Analog to digital conversion and its types*	*Open Hardware platform basic knowledge of its hardware and its software environments*	*Advancement in Microcontroller*
S-3	SLO-1	*Introduction and history description about microcontrollers*	*Timers and its types*	*Digital to Analog conversion and its types*	*Variables ,Digital inputs with programs*	*Study and Design a Home security system using microcontroller*
S-4	SLO-1	*Specification and Internal architecture of 8051*	*TCON,TMOD*	*Analog inputs are mechanical switches ,relays*	*Digital Outputs with programs*	*Study and Design a Elevator system*
S-5	SLO-1	*Pin description of 8051*	*Delay program with and without timer*	*Digital outputs are LED,7 segment display and LCD interfacing*	*Reading analog signals and PWM signal generation with programs*	*Study and Design a Sensor guided mobile robot using ultrasonic sensor*
S-6	SLO-1	*Various Addressing modes of 8051 are immediate, register, direct*	*Interrupts and its Types*	*DC Motor Interfacing*	*Conditional statements are if ,else and nested if with programs*	*Study and Design a Tic Tac Toe playing robot*
S-7	SLO-1	*Indirect, Relative, Indexed and Absolute addressing modes*	*Programming using Interrupts*	*Stepper Motor Interfacing*	*Looping statements are for ,while and Do while with programs*	*Study and Design a Line following robot as a maze solver using microcontroller*
S-8	SLO-1	*Difference between microcontroller with microprocessor*	*I/O Ports and its 3 modes of operation*	*Servo Motor Interfacing*	*Functions and recursive function with programs*	*Study and Design a Unmanned Aerial Vehicle using microcontroller*
S-9	SLO-1	*Selection criterion for choosing microcontroller*	*Serial communication and its modes, SCON*	*Digital inputs -Keypad and its interfacing*	*Continuous Serial monitoring and hardware interrupt with programs*	*Study and Design a Soccer playing robot using microcontroller*

Learning Resources	1. *Muhammad Ali Mazidi,"8051 Microcontroller and Embedded Systems", Pearson New International Edition, 2014.* 2. *Simon Monk, "Programming Arduino Next Steps: Going Further with Sketches", Second Edition, McGraw Hill Professional, 2018.* 3. *MacKenzie I. Scott, "The 8051 Microcontroller", Pearson Education India, 2011.*	1. *Donald Norris,"Python for Microcontrollers: Getting Started with MicroPython", McGraw Hill Professional, 2016.* 2. *Jeff Cicolani," Beginning Robotics with Raspberry Pi and Arduino: Using Python and OpenCV,Apress,2017*

Learning Assessment

	Bloom's Level of Thinking	Continuous Learning Assessment (50% weightage)								Final Examination (50% weightage)	
		CLA – 1 (10%)		CLA – 2 (15%)		CLA – 3 (15%)		CLA – 4 (10%)#			
		Theory	Practice	Theory	Practice	Theory	Practice	Theory	Practice	Theory	Practice
Level 1	Remember Understand	*40 %*	-	*30 %*	-	*30 %*	-	*30 %*	-	*30%*	-
Level 2	Apply Analyze	*40 %*	-	*40 %*	-	*40 %*	-	*40 %*	-	*40%*	-
Level 3	Evaluate Create	*20 %*	-	*30 %*	-	*30 %*	-	*30 %*	-	*30%*	-
	Total	100 %		100 %		100 %		100 %		100 %	

CLA – 4 can be from any combination of these: Assignments, Seminars, Tech Talks, Mini-Projects, Case-Studies, Self-Study, MOOCs, Certifications, Conf. Paper etc.,
SLO – Session Learning Outcome

Course Designers		
Experts from Industry	Experts from Higher Technical Institutions	Internal Experts
Sreejith Balachandran, Senior Engineer,COMAU ROBOTICS	*Hushein Rasheeth, Vel Tech - Technical University*	*1. Mr.V.Manojkumar, SRMIST*
Dr. R. Kalimuthu, ISRO, Mahendragiri, r_kalimuthu@vssc.gov.in, rkpearls@yahoo.com	*Dr. P. Hariharan, Anna University, hari@annauniv.edu, hariharan2311@gmail.com*	*2. Mr.N. Karthikeyan, SRMIST*
Dr. A. Velayutham, DRDO, Avadi, velayudham.a@cvrde.drdo.in	*Dr.N.Arunachalam, IIT Madras, chalam@iitm.ac.in*	

Course Code	18MEO119T	Course Name	MACHINERY FAULT DIAGNOSTICS AND SIGNAL PROCESSING	Course Category	O	Open Elective	L	T	P	C
							3	0	0	3

Pre-requisite Courses	Nil	Co-requisite Courses	Nil	Progressive Courses	Nil
Course Offering Department	Mechanical Engineering	Data Book / Codes/Standards	Nil		

Course Learning Rationale (CLR):	*The purpose of learning this course is to:*
CLR-1 :	*Be familiar with the working of a machinery and need for machine maintenance*
CLR-2 :	*Be familiar with the reason for Failure and capable of doing failure analysis*
CLR-3 :	*Be familiar with the basics of Signal analysis and Machinery condition monitoring*
CLR-4 :	*Be familiar with Instrumentation systems*
CLR-5 :	*Be capable of Machine Testing and Analysis*
CLR-6 :	*Be familiar of industrial practices in machine troubleshooting*

Course Learning Outcomes (CLO):	*At the end of this course, learners will be able to:*	Learning 1: Level of Thinking (Bloom)	Learning 2: Expected Proficiency (%)	Learning 3: Expected Attainment (%)	PLO 1: Engineering Knowledge	2: Problem Analysis	3: Design & Development	4: Analysis, Design, Research	5: Modern Tool Usage	6: Society & Culture	7: Environment & Sustainability	8: Ethics	9: Individual & Team Work	10: Communication	11: Project Mgt. & Finance	12: Life Long Learning	13: PSO - 1	14: PSO - 2	15: PSO – 3
CLO-1 :	*Acquire knowledge on basic components and working of a machine*	*1& 2*	*90*	*85*	*H*	-	-	-	-	-	-	-	-	-	-	*H*	*M*	-	-
CLO-2 :	*Appreciate the process of monitoring the conditions of a machine*	*1*	*90*	*85*	*H*	-	*H*	-	*H*	-	-	-	*M*	-	-	-	-	*H*	*H*
CLO-3 :	*Understand the techniques in wear and debris analysis, vibration analysis and signal analysis*	*1*	*90*	*85*	*H*	*M*	*H*	*H*	*M*	-	-	-	-	-	-	-	-	*H*	*H*
CLO-4 :	*Understand the various tools used for monitoring the condition of machine*	*1&2*	*90*	*85*	*H*	-	*H*	-	*H*	-	-	-	-	-	-	-	*H*	*H*	-
CLO-5 :	*Understand the process of thermography and non- destructive techniques*	*1&2*	*90*	*85*	*H*	-	-	-	*M*	-	-	-	-	-	-	-	*H*	-	*H*
CLO-6 :	*Acquire skills in fault finding and diagnosis*	*1&2*	*90*	*85*	*H*	*M*	-	*M*	-	-	-	-	*H*	-	-	*H*	*H*	*H*	-

Duration (hour)		9	9	9	9	9
S-1	SLO-1	*Failures and failure analysis*	*Principles of Maintenance*	*Time Domain Signal Analysis*	*Data Recording and Transmission*	*Fans, Blowers, Compressors, Pumps and Turbines*
S-2	SLO-1	*Failure concepts and characteristics*	*Failure Modes Effects*	*Frequency Domain Signal Analysis*	*Vibration Transducers, Vibration Monitoring*	*Contaminant Analysis, Oil Analysis*
S-3	SLO-2	*Fault detection sensors*	*Criticality Analysis*	*Computer Aided Data Acquisition - Basics*	*Basics of Noise and Noise Monitoring*	*Fault Detection in Motors and Transformers*
S-4	SLO-1	*Data processing*	*Fault Diagnostics*	*FFT Analysis*	*Numerical problems in Noise Vibration*	*Motor Current Signature Analysis*
S-5	SLO-1	*signal analysis*	*Fault Prognostics*	*Modulation and Sidebands*	*Numerical problems in Data Acquisition*	*wear and debris Analysis*
S-6	SLO-1	*Condition based maintenance principles*	*Basics of Machinery Vibration*	*Envelope Analysis*	*Unbalance Detection, Field Balancing*	*Thermography and Ultrasonics*
S-7	SLO-2	*Fault analysis planning and system availability*	*Engineering Applications of Vibration*	*Cepstrum Analysis*	*Misalignment Detection, Cracked Shaft Detection*	*Acoustic Emission and Eddy Current Testing*
S-8	SLO-2	*Reliability/failure concepts*	*Rotor dynamics*	*Order Analysis*	*Looseness and Rub Detection, Ball and Journal Bearings*	*Radiography,Dye Penetrant Test, Visual Inspection*
S-9	SLO-1	*Application of diagnostic maintenance to specific industrial machinery and plants*	*Fault findings in rotor machines*	*Examples on signal processing in MATLAB*	*Gear Fault Detection*	*Case studies on failure and fault detection*

Learning Resources	*1. A. R. Mohanty , "Machinery Condition Monitoring: Principles and Practices" , CRC Press, 2014.* *2. William T. Thomson, Chandramouli Padmnabhan," Theory of Vibration with Applications", Pearson, V edition, 2008.* *3. PareshGirdhar, Cornelius Scheffer, "Practical machinery vibration analysis and predictive maintenance", Elsevier, 2004.*	*4. J Prasad, C G K Nair, "Non-Destructive Testing and Evaluation of Materials", Tata McGraw Hill, Education Private Limited, 2011* *5. S.S. Rao, "Vibration of Continuous systems", Wiley, 2006*

Learning Assessment											
	Bloom's Level of Thinking	Continuous Learning Assessment (50% weightage)								Final Examination (50% weightage)	
		CLA – 1 (10%)		CLA – 2 (15%)		CLA – 3 (15%)		CLA – 4 (10%)#			
		Theory	Practice	Theory	Practice	Theory	Practice	Theory	Practice	Theory	Practice
Level 1	Remember Understand	*40 %*	-	*30 %*	-	*30 %*	-	*30 %*	-	*30%*	-
Level 2	Apply Analyze	*40 %*	-	*40 %*	-	*40 %*	-	*40 %*	-	*40%*	-
Level 3	Evaluate Create	*20 %*	-	*30 %*	-	*30 %*	-	*30 %*	-	*30%*	-
	Total	100 %		100 %		100 %		100 %		100 %	

CLA – 4 can be from any combination of these: Assignments, Seminars, Tech Talks, Mini-Projects, Case-Studies, Self-Study, MOOCs, Certifications, Conf. Paper etc.,

SLO – Session Learning Outcome

Course Designers		
Experts from Industry	Experts from Higher Technical Institutions	Internal Experts
1. Mr. Senthil Kumar. K, Divisional Manager, Global Bus – Operations, Ashok Leyland Ltd senthilkumar.k3@ashokleyland.com	*1. Dr.A.R. Mohanty, Professor, IIT Kharagpur amohanty@mech.iitkgp.ac.in*	*1. Mr.M, Dhanasekaran, SRMIST*
2. Mr.Sumit Bose, Zonal Manager, Man Trucks and Buses, smtbs69@rediffmail.com	*2. Prof. N. Ramesh Babu, IIT Madras, nrbabu@iitm.ac.in*	*2. Mr.V. Manoj Kumar, SRMIST*

Course Code	18MEO120T	Course Name	DIGITAL IMAGE PROCESSING AND MACHINE VISION	Course Category	O	Open Elective	L	T	P	C
							3	0	0	3

Pre-requisite Courses	NIL	Co-requisite Courses	NIL	Progressive Courses	NIL
Course Offering Department	Mechanical Engineering		Data Book / Codes/Standards		NIL

Course Learning Rationale (CLR):	The purpose of learning this course is to:
CLR-1 :	*Be familiar with the sensors and Image acquisition system*
CLR-2 :	*Be familiar with the basics of image processing in Frequency domain*
CLR-3 :	*Be familiar with the image enhancement and compression*
CLR-4 :	*Know the existing vision systems*
CLR-5 :	*Practice the tasks inany one of image processing software like MATLAB or OpenCV*
CLR-6:	*Be Familiar with components of machine vision, image processing and its applications in industries*

Course Learning Outcomes (CLO):	At the end of this course, learners will be able to:	Learning 1: Level of Thinking (Bloom)	Learning 2: Expected Proficiency (%)	Learning 3: Expected Attainment (%)	PLO 1: Engineering Knowledge	PLO 2: Problem Analysis	PLO 3: Design & Development	PLO 4: Analysis, Design, Research	PLO 5: Modern Tool Usage	PLO 6: Society & Culture	PLO 7: Environment & Sustainability	PLO 8: Ethics	PLO 9: Individual & Team Work	PLO 10: Communication	PLO 11: Project Mgt. & Finance	PLO 12: Life Long Learning	PLO 13: PSO - 1	PLO 14: PSO - 2	PLO 15: PSO – 3
CLO-1 :	*Understand the basic concepts of digital image processing.*	1&2	90	85	H	L	M	M	H	L	-	-	L	M	-	-	H	H	M
CLO-2 :	*Learn the image fundamentals and mathematical transforms necessaryfor image processing*	1&2	90	85	H	H	M	M	H	-	-	-	-	M	-	-	H	H	M
CLO-3 :	*Study the various image enhancement and compression techniques*	1	90	85	H	L	L	M	H	-	-	-	-	M	-	-	H	H	M
CLO-4 :	*Understand the existing machine vision systems and technique for template matching and feature extraction*	1&2	90	85	H	L	L	M	H	-	-	-	-	-	-	M	H	H	M
CLO-5 :	*Application of Machine Vision in experimental mechanics and basics of 3D Vision*	1&2	90	85	H	L	M	M	H	M	M	-	-	-	-	M	H	H	M
CLO 6:	*Learn machine vision components and basics of Image Processing*	1&2	90	85	H	L	M	M	H	M	-	-	-	M	-	-	H	H	M

		IMAGE ACQUISITION AND FUNDAMENTALS OF IMAGEPROCESSING	IMAGE TRANSFORMS AND EDGE DETECTION	IMAGE ENHANCEMENT AND COMPRESSION	MACHINE VISION AND 3D VISION	MACHINE VISION APPLICATIONS
Duration (hour)		9	9	9	9	9
S-1	SLO-1	*Elements of visual perception, structure of eye*	*The Basics of Intensity Transformations and Spatial Filtering*	*Histogram modification and specification techniques*	*Review of existing vision systems*	*Digital Image Correlation DIC*
S-2	SLO-1	*Introduction to image processing, classification of image,*	*One-dimensional discrete fourier transform (DFT)*	*Image smoothing, Low pass filtering, Ideal low pass filter,*	*Binary and Gray vision system Vision system*	*DIC in sheet metal forming, experimental mechanics*
S-3	SLO-1	*Fundamental steps involved in image processing, sourceof image*	*Two- dimensional discrete fourier transform (DFT)*	*Butterworth low pass filter*	*Image Analysis methods, Feature extraction*	*Stereo vision in experimental mechanics*
S-4	SLO-1	*Image acquisition and digitization ,sensing*	*Cosine and Sine transform and their properties*	*Image sharpening, Butterworth filters*	*Image interpretation Segmentation*	*Electronic and automotive Industrial Applications*
S-5	SLO-1	*Illumination and its types*	*Hadamard and Haar transform and their properties*	*Generation of spatial masks from frequency domain specification,*	*Template Matching*	*Camera Calibration*
S-6	SLO-1	*CCD and CMOS Cameras*	*Slant, KL, SVD transforms and their properties*	*Basic steps in frequency domain filtering*	*Classification of 3-D Vision Techniques*	*Dimensional measurements in machine vision*
S-7	SLO-1	*Representing Digital Images, Spatial and IntensityResolution, Image Interpolation*	*Edge detection and their techniques, Roberts operator,*	*Nonlinear filters, function, Max filter, Min filter*	*Photometric stereo*	*Assembly Inspection*
S-8	SLO-1	*Problems on quantization and sampling*	*Problems based on FFT,DFT*	*Run length coding*	*Structured Light Reconstruction*	*Food processing Industrial applictaions*
S-9	SLO-1	*Practice on reading image and exercise on spatial resolution and sampling in MATLAB or Open CV*	*Practice on image transformation in MATLAB or Open CV*	*Practice on image filtering in MATLAB or Open CV*	*Assignments on feature extraction in MATLAB/Open CV*	*Practice on photometric stereo MATLAB Or Open CV*

Learning Resources	1. *Anil K. Jain, "Fundamentals of Digital Image Processing", Prentice Hall of India, New Delhi, 2007.* 2. *Rafel.C.Gonzalez and Richard E.Woods, "Digital Image Processing", Addison Wesley, New York,2009.* 3. *Vernon, D., "Machine Vision - Automated Visual Inspection and Robot Vision", Prentice Hall International Ltd., New York, 1991.* 4. *William K. Pratt, "Digital Image Processing", John Wiley, New York, 2007.*	5. *Sid Ahmed M. A., "Image Processing Theory, Algorithms and Architectures", McGraw-Hill, New York,1995.* 6. *Umbaugh.S.E, "Computer Vision and image processing - Practical approach using CVIP tools, Prentice Hall of India, New Delhi, 1998.* 7. *Ramesh Jain, RangacharKasturi and Brain G. Schunk, "Machine Vision", McGraw Hill International Editions, Computer Science Series, Singapore, 1995.* 8. *Emanuele Trucco, Alessandro Verri, "Introductory Techniques For 3D Computer Vision", 1998 Edition, Prentice Hall*

Learning Assessment

	Bloom's Level of Thinking	Continuous Learning Assessment (50% weightage)								Final Examination (50% weightage)	
		CLA – 1 (10%)		CLA – 2 (15%)		CLA – 3 (15%)		CLA – 4 (10%)#			
		Theory	Practice	Theory	Practice	Theory	Practice	Theory	Practice	Theory	Practice
Level 1	Remember Understand	*40 %*	-	*30 %*	-	*30 %*	-	*30 %*	-	*30%*	-
Level 2	Apply Analyze	*40 %*	-	*40 %*	-	*40 %*	-	*40 %*	-	*40%*	-
Level 3	Evaluate Create	*20 %*	-	*30 %*	-	*30 %*	-	*30 %*	-	*30%*	-
	Total	100 %		100 %		100 %		100 %		100 %	

CLA – 4 can be from any combination of these: Assignments, Seminars, Tech Talks, Mini-Projects, Case-Studies, Self-Study, MOOCs, Certifications, Conf. Paper etc.,
SLO – Session Learning Outcome

Course Designers		
Experts from Industry	Experts from Higher Technical Institutions	Internal Experts
Mr.S.A.Krishnan, IGCAR,kalpakkam	*Dr.N.Arunachallam, IITM*	*Dr. A.Vijaya, SRMIST*
Mr. Narasimhan Sridhar, TESA Engg, Chennai	*Dr.A.Jothilingam, Visiting Faculty, MIT, Anna University*	*Dr. R. Senthilnathan , SRMIST*

Course Code	18MEO121T	Course Name	MULTIDISCIPLINARY DESIGN	Course Category	O	Open Elective	L	T	P	C
							3	0	0	3

Pre-requisite Courses	Nil	Co-requisite Courses	Nil	Progressive Courses	Nil
Course Offering Department	Department of Mechanical Engineering	Data Book / Codes/Standards	Nil		

Course Learning Rationale (CLR):	The purpose of learning this course is to:
CLR-1 :	*develop appropriate skills on systemic thinking on how to identify and formulate a problem, evaluate the conceptual design by using scientific, engineering and managerial tools, and to understand the current trend for the problem.*
CLR-2 :	*rationalize the product design problem by selecting appropriate design variables, parameters and constraints from the published article*
CLR-3 :	*subdivide a complex system into smaller disciplinary models, analyze the output and reintegrate them into an overall system model and optimize the output*
CLR-4 :	*apply Multi objective optimization for the output to reintegrate them into an overall efficient system model*
CLR-5 :	*take on the challenges of team work, prepare a presentation in a professional manner.*
CLR-6 :	*understand how the various multi-disciplinary fields interact and integrate in real life situations. Develop appropriate skills on systemic thinking , evaluate the conceptual design by using scientific, engineering and managerial tools, analyze and interpret the data, considering safety, socio-politico-cultural, risks and hazards, disposal, regional and national laws, costing and financial model and undertake documentation with a presentation.*

Course Learning Outcomes (CLO):	At the end of this course, learners will be able to:	Learning 1 Level of Thinking (Bloom)	2 Expected Proficiency (%)	3 Expected Attainment (%)	Program Learning Outcomes (PLO) 1 Engineering Knowledge	2 Problem Analysis	3 Design & Development	4 Analysis, Design, Research	5 Modern Tool Usage	6 Society & Culture	7 Environment & Sustainability	8 Ethics	9 Individual & Team Work	10 Communication	11 Project Mgt. & Finance	12 Life Long Learning	13 PSO - 1	14 PSO - 2	15 PSO – 3
CLO-1 :	*develop appropriate skills on systemic thinking on how to identify and formulate a problem, evaluate the conceptual design by using scientific, engineering and managerial tools, and to understand the current trend for the problem.*	*2*	*80*	*70*	*H*	*H*	*M*	*M*	*M*	-	-	-	-	-	-	-	*H*	*H*	*H*
CLO-2 :	*rationalize the product design problem by selecting appropriate design variables, parameters and constraints from the published article*	*2*	*85*	*75*	*H*	*H*	*M*	*M*	*M*	-	-	-	-	-	-	-	*H*	*H*	*H*
CLO-3 :	*subdivide a complex system into smaller disciplinary models, manage the output and reintegrate them into an overall system model and optimize the output*	*2*	*75*	*70*	*H*	*H*	*M*	*H*	*M*	-	-	-	-	-	-	-	*H*	*H*	*H*
CLO-4 :	*apply Multi objective optimization for the output to reintegrate them into an overall efficient system model*	*2*	*85*	*80*	*H*	*H*	*M*	*M*	*M*	-	-	-		-	-	-	*H*	*H*	*H*
CLO-5 :	*take on the challenges of teamwork, prepare a presentation in a professional manner*	*2*	*85*	*75*	*H*	*H*	*H*	*H*	*H*	-	-	-	*H*	-	-	-	*H*	*H*	*H*
CLO-6 :	*develop appropriate skills on systemic thinking on how to identify and formulate a problem, decompose the problem into smaller elements, conceptualize the design, evaluate the conceptual design by using scientific, engineering and managerial tools, select, analyze and interpret the data, consideration of safety, socio-politico-cultural, risks and hazards, disposal, regional and national laws, costing and financial model and undertake documentation and finally with a presentation.*	*2*	*80*	*70*	*H*	*H*	*H*	*H*	*H*	*H*	*H*	*H*	*H*	*H*	*H*	-	*H*	*H*	*H*

Duration (hour)		9	9	9	9	9
S-1	SLO-1	*Identifying and Formulating research problem*	*Student presentation on literature review*	*Design of experiments -Optimization of variables to get optimized output*	*Multi objective Optimization to get optimized output and Grey relational analysis*	*Student presentation on Entropy Method*
S-2	SLO-1	*Research Process, Research Types, Research and Scientific Method*	*Student presentation on literature review*	*Response surface methodology*	*Student presentation on Grey relational analysis*	*Student presentation on Entropy Method*
S-3	SLO-1	*Problem Solving in Engineering*	*Student presentation on literature review*	*Analysis of variance (ANOVA)*	*Student presentation on Grey relational analysis*	*Student presentation on Entropy Method*
S-4	SLO-1	*Identification of Research Topic*	*Report preparation about Literature survey*	*Students presentation on Response surface methodology and Analysis of variance (ANOVA)*	*Student presentation on Grey relational analysis*	*Introduction to TOPSIS Method*
S-5	SLO-1	*Problem Definition*	*Student presentation on literature survey*	*Students presentation on Response surface methodology and Analysis of variance (ANOVA)*	*Student presentation on Grey relational analysis*	*Student presentation on TOPSIS Method*

S-6	SLO-1	*Problem Solving in Engineering*	*Student presentation on literature survey*	*Students presentation on Response surface methodology and Analysis of variance (ANOVA)*	*Student presentation on Grey relational analysis*	*Student presentation on TOPSIS Method*
S-7	SLO-1	*Collect primary data and secondary data*	*Student presentation on literature survey*	*Students presentation on Response surface methodology and Analysis of variance (ANOVA)*	*Introduction to Entropy Method to calculate weights of the TOPSIS Method*	*Student presentation on TOPSIS Method*
S-8	SLO-1	*Student presentation on literature review*	*Student presentation on literature survey*	*Students presentation on Response surface methodology and Analysis of variance (ANOVA)*	*Student presentation on Entropy Method*	*Student presentation on TOPSIS Method*
S-9	SLO-1	*Student presentation on literature review*	*Student presentation on literature survey*	*Students presentation on Response surface methodology and Analysis of variance (ANOVA)*	*Student presentation on Entropy Method*	*Student presentation on TOPSIS Method*

Learning Resources	1. *Douglas C Montgomery, " Design and Analysis of Experiments" , John Wiley & Sons Ltd., 2005* 2. *Ganesan R, "Research Methodology for Engineers" , MJP Publishers., 2011* 3. *Rao Singaresu.S, "Engineering Optimization – Theory & Practice", New Age International (P) Limited,New Delhi, 2009.* 4. *P.C.Tewaria, Ujjwal Prakash, Dinesh Khanduja, Sandeep,"Ranking of Sintered Material for High Loaded Automobile Application using Entropy-Topsis method", Materials Today: Proceedings, 2015,Pp.2375 – 2379*	5. *Suneesh. E,Multi-response optimisation of micro-milling parameters through GRA, TOPSIS and Taguchi techniques to increase production rate while reducing energy consumption, Measurement, https://doi.org/10.1016/j.measurement.2019.04.090.* 6. *Rom Kim, "A study on competitiveness analysis of ports in Korea and China by Entropy weight TOPSIS", The Asian Journal of Shipping and Logistics, 2016,32(4), Pp.187-194.* 7. *Statistical software-Minitab*

Learning Assessment

	Bloom's Level of Thinking	Continuous Learning Assessment (50% weightage)								Final Examination (50% weightage)	
		CLA – 1 (15%)		CLA – 2 (15%)		CLA – 3 (20%)		CLA – 4 (50%)#			
		Theory	Practice/ Presentation	Theory	Practice/ Presentation	Theory	Practice/ Presentation	Theory	Practice/ Presentation	Theory	Practice/ Presentation
Level 1	Remember / Understand	-	*20%*	-	*15%*	-	*15%*	-	*15%*	-	*30%*
Level 2	Apply / Analyze	-	*20%*	-	*20%*	-	*20%*	-	*20%*	-	*40%*
Level 3	Evaluate / Create	-	*10%*	-	*15%*	-	*15%*	-	*15%*	-	*30%*
	Total	100 %		100 %		100 %		100 %		-	

Course Designers		
Experts from Industry	Experts from Higher Technical Institutions	Internal Experts
1. Dr. R. Kalimuthu, ISRO, Mahendragiri, r_kalimuthu@vssc.gov.in, rkpearls@yahoo.com	*Dr.P.Sathiya, Professor, NIT, Trichy. psathiya@nitt.edu*	*Mrs. R.Ambigai,SRMIST*
2. Dr. A. Velayutham, DRDO, Avadi, velayudham.a@cvrde.drdo.in		*Dr. M. R..Stalin John,SRMIST*

Course Code	18MHO101T	Course Name	Mechatronics	Course Category	O	Open Elective	L	T	P	C
							3	0	0	3

Pre-requisite Courses	Nil	Co-requisite Courses	Nil	Progressive Courses	Nil
Course Offering Department	Mechatronics Engineering	Data Book / Codes/Standards	Nil		

Course Learning Rationale (CLR):	The purpose of learning this course is to:
CLR-1 :	*To get an overview of Mechatronics as a design philosophy*
CLR-2 :	*To get an insight into multi-disciplinary systems*
CLR-3 :	*Familiarize the mechanical engineering aspects of mechatronics systems*
CLR-4 :	*Understand the concepts related to data acquisition and control*
CLR-5 :	*Understand the importance of modeling and model based design*
CLR-6 :	*To have a detailed idea of applying mechatronics design concepts in real world systems*

		Learning			Program Learning Outcomes (PLO)														
		1	2	3	1	2	3	4	5	6	7	8	9	10	11	12	13	14	15
Course Learning Outcomes (CLO):	At the end of this course, learners will be able to:	Level of Thinking (Bloom)	Expected Proficiency (%)	Expected Attainment (%)	Engineering Knowledge	Problem Analysis	Design & Development	Analysis, Design, Research	Modern Tool Usage	Society & Culture	Environment & Sustainability	Ethics	Individual & Team Work	Communication	Project Mgt. & Finance	Life Long Learning	PSO - 1	PSO - 2	PSO – 3
CLO-1 :	*Conversant in mechatronics design philosophy*	3	80	75	H	H	M	L	L	-	-	-	L	L	-	L	H	M	-
CLO-2 :	*Ability to resolve the sub-systems and challenges involved in a larger mechatroncis system*	3	85	80	H	H	M	M	L	-	-	-	M	L	-	L	H	M	-
CLO-3 :	*Understand the concepts related to data acquisition and control*	2	75	70	H	M	L	M	L	-	-	-	M	L	-	L	H	M	-
CLO-4 :	*Ability to model and simulate physics based mechatronics systems*	2	75	70	H	M	M	M	M	-	-	-	M	L	-	L	H	M	-
CLO-5 :	*Ability to understand the challenges in integration of a multi-disciplinary system*	2	85	80	H	M	M	M	M	-	-	-	M	L	-	L	H	M	-
CLO-6 :	*Analyze the functionality of a multi-disciplinary system from the perspective of integration*	2	80	75	H	M	M	M	M	-	-	-	L	L	-	L	H	M	-

		Introduction to Mechatronics	Mechanical and Actuation Systems	Data Acquisition and Control	Modelling and Simulation	Case Studies
Duration (hour)		7	10	10	8	10
S-1	SLO-1	*Definition of mechatronics*	*Fundamental laws governing mechanical systems*	*Sensors in mechatronics systems*	*Significance of modeling*	*Modelling of a serial robot manipulator*
	SLO-2	*Evolution of mechatronics systems*	*Actuation subsystem in Mechatronics systems*	*Sensor characteristics*	*Example*	*Need of model based design for the system under consideration*
S-2	SLO-1	*Multidisciplinary nature of modern machines and their design challenges*	*Kinematic chains, transmission elements*	*Sensor signal types*	*Model-In-Loop(MIL) simulation*	*Benefits of model based design*
	SLO-2	*Example*	*Types, purpose and examples*	*Analog and digital signals*	*Example*	*Understanding the system under consideration*
S-3	SLO-1	*Traditional vs mechatronics approaches*	*Gears*	*Motion encoder, types*	*Software-In-Loop(SIL) simulations*	*Mechanical and electronics description*
	SLO-2	*Example*	*Types, selection criteria, nomenclature*	*Specifications and selection criteria*	*Example*	*Mathematical description of the model*
S-4	SLO-1	*Mechatronics design process*	*Lead screws and belt drives*	*Incremental optical encoder*	*Virtual Prototyping- a critical aspect of mechatronics approach*	*Mathematical modeling- derivation*
	SLO-2	*Need for design tools integration*	*Types, selection criteria, nomenclature*	*Quadrature decoding - Hardware method*	*Example*	*Control strategy*
S-5	SLO-1	*Review of key elements of mechatronics systems*	*Mechanical aspects of actuator selection*	*Quadrature decoding - Software method*	*Real-time (RT) simulations*	*Analysis of performance*
	SLO-2	*Example*	*Types of actuators*	*Absolute encoder decoding*	*Example*	*Analysis of performance*
S-6	SLO-1	*Role of mechatronics engineer.*	*Comparison of electrical, pneumatic and hydraulic actuators*	*Elements of a data acquisition system*	*concurrent development of subsystems*	*Modelling of a active suspension*
	SLO-2	*Various steps for design*	*Special purpose actuators*	*Signal conditioning systems*	*Example*	*Need of model based design for the system under consideration*
S-7	SLO-1	*Various Mechatronics systems*	*Example circuit design of a servo pneumatic actuation system*	*Analog to digital conversion*	*Real-time Hardware-In-Loop simulation (HIL)*	*Benefits of model based design*

	SLO-2	*Various Mechatronics systems*	*Case study*	*Computer hardware aspects of data acquisition*	*Example*	*Understanding the system under consideration*
S-8	SLO-1		*Step motors, types*	*Introduction to state space modelling*	*Running the controller model and plant model on real-time target*	*Mechanical and electronics description*
	SLO-2		*Construction and selection criteria*	*Modelling of a DC motor*	*V&V using HIL RT model.*	*Mathematical description of the model*
S-9	SLO-1		*Electronic drives for electrical actuators*	*Introduction to PID Control*		*Mathematical modeling- derivation*
	SLO-2		*Types, pupose and selection criteria*	*Derivation*		*Control strategy*
S-10	SLO-1		*DC motor drives - any one type*	*State space model of a speed control of a DC motor*		*Analysis of performance*
	SLO-2		*AC motor drives - any one type*	*Derivation*		*Analysis of performance*

Learning Resources	1. *Devdasshetty, Richard A.Kolk "Mechatronics Systems Design", 2nd Edition, Cengage Learning, 2011.* 2. *W. Bolton, "Mechatronics", 5th Edition, Pearson Education, 2011.*

Learning Assessment

	Bloom's Level of Thinking	Continuous Learning Assessment (50% weightage)								Final Examination (50% weightage)	
		CLA – 1 (10%)		CLA – 2 (15%)		CLA – 3 (15%)		CLA – 4 (10%)#			
		Theory	Practice	Theory	Practice	Theory	Practice	Theory	Practice	Theory	Practice
Level 1	Remember Understand	*30 %*	-	*30 %*	-	*30 %*	-	*20 %*	-	*40%*	-
Level 2	Apply Analyze	*40 %*	-	*40 %*	-	*40 %*	-	*40 %*	-	*30%*	-
Level 3	Evaluate Create	*30 %*	-	*30 %*	-	*30 %*	-	*40 %*	-	*30%*	-
	Total	100 %		100 %		100 %		100 %		100 %	

CLA – 4 can be from any combination of these: Assignments, Seminars, Tech Talks, Mini-Projects, Case-Studies, Self-Study, MOOCs, Certifications, Conf. Paper etc.,

Course Designers

Experts from Industry	Experts from Higher Technical Institutions	Internal Experts
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Course Code	18MHO102T	Course Name	Model Based System Design	Course Category	E	Professional Elective	L	T	P	C
							3	0	0	3

Pre-requisite Courses	Nil	Co-requisite Courses	Nil	Progressive Courses	Nil
Course Offering Department	Mechatronics Engineering	Data Book / Codes/Standards	Nil		

Course Learning Rationale (CLR):	*The purpose of learning this course is to:*
CLR-1 :	*Understand the processes, methods, and practices of model-based systems engineering(MSBE)*
CLR-2 :	*Comprehend the conflicting requirements of complex engineering systems and their life cycle stages through some relevant case studies and relate the need for model based system engineering*
CLR-3 :	*Define and develop requirements, architectures, behavior, specifications, verifications, and tests that represent engineering systems using model-based systems engineering.*
CLR-4 :	*Analyze systems using model-based systems engineering approaches that lead to better and increased design metrics of systems*
CLR-5 :	*Apply the knowledge of model based system engineering for creating models using SysML diagrams that accurately represent views of engineering systems and analyze the same for improving the performance.*

Course Learning Outcomes (CLO):	*At the end of this course, learners will be able to:*	Learning 1: Level of Thinking (Bloom)	2: Expected Proficiency (%)	3: Expected Attainment (%)	PLO 1: Engineering Knowledge	2: Problem Analysis	3: Design & Development	4: Analysis, Design, Research	5: Modern Tool Usage	6: Society & Culture	7: Environment & Sustainability	8: Ethics	9: Individual & Team Work	10: Communication	11: Project Mgt. & Finance	12: Life Long Learning	13: PSO - 1	14: PSO - 2	15: PSO – 3
CLO-1 :	*Ability to describe the processes, methods, and practices of model-based systems engineering*	2	75	70	H	H	M	H	M	-	-	-	-	-	-	H	H	H	H
CLO-2 :	*Recognize the conflicting requirements of complex engineering systems and their life cycle stages through some relevant case studies and relate the need for model based system engineering*	3	75	70	H	H	M	H	M	-	M	-	-	-	-	H	M	M	M
CLO-3 :	*Develop and relate requirements, architectures, behavior, specifications, verifications, and tests that represent cyber-physical systems using model-based systems engineering methods.*	3	75	70	H	H	M	H	M	-	M	M	-	-	M	H	M	M	M
CLO-4 :	*Demonstrate analysis of systems using model-based systems engineering approaches that lead to better and increased design metrics of systems*	3	75	70	H	H	M	H	M	-	M	M	-	-	M	H	M	M	M
CLO-5 :	*Apply the knowledge of model based system engineering to create effective models using SysML diagrams that accurately represent views of engineering systems and analyze the same for improving the performance.*	3	75	70	H	H	M	H	H	-	M	M	-	-	M	H	M	M	M

		Foundations to Model Based System Engineering(MSBE)	Modeling, Analysis and Management of System Requirements	Modeling and Simulation of Structures and Behaviors of Systems	Definition of Cyber Physical Systems and Components	Verification and Validation
Duration (hour)		9	9	9	9	9
S-1	SLO-1	*Overview of complex engineering systems*	*Requirement of engineering artifact modeling*	*Multidisciplinary design modeling requirements*	*Definition of components and systems*	*V&V techniques overview*
	SLO-2	*Motivation for system engineering/ model based system engineering (MBSE)*	*Requirement of engineering artifact modeling*	*Multidisciplinary design modeling requirements*	*Definition of components and systems*	*V&V techniques overview*
S-2	SLO-1	*The system engineering process*	*Eliciting Requirements*	*Structural modeling*	*Assigning behaviors to components*	*Verification techniques: software engineering techniques*
	SLO-2	*Typical application of system engineering process*	*Eliciting Requirements*	*Structural modeling*	*Assigning behaviors to components*	*Formal verification technique*
S-3	SLO-1	*Multidisciplinary systems engineering team*	*Requirement modeling*	*Structural modeling using SysML*	*Incorporating images in to the model*	*Program analysis technique*
	SLO-2	*System engineering practice through standards*	*Requirement modeling*	*Structural modeling using SysML*	*Incorporating images in to the model*	*V&V of engineering design models*
S-4	SLO-1	*Contrasting document based approach and model based approach*	*Requirements management*	*Behavioral model using states and transitions*	*Allocation*	*V&V of engineering design models- Tool support*
	SLO-2	*Contrasting document based approach and model based approach- introduce SysML diagrams and MSBE tool*	*Requirements management*	*Behavioral model using states and transitions*	*Allocate activity partition*	*Automatic approach for synergistic verification and validation*
S-5	SLO-1	*Modeling principles- Model and MSBE method definition*	*Requirements Diagram, Traceability Hierarchy Diagram*	*Behavioral model in SysML*	*Unit, dimension and data types*	*Synergistic verification and validation methodology*

	SLO-2	*The purpose for modeling a system*	*Requirements Diagram, Traceability Hierarchy Diagram*	*Behavioral model in SysML*	*Adding constraints*	*Dedicated V&V approach for system engineering*
S-6	SLO-1	*Model validation*	*Hazard analysis and threat modeling*	*Ensuring consistency*	*Activity diagrams*	*Verification and validation of behavioral diagrams*
	SLO-2	*Model metrics*	*Hazard analysis and threat modeling*	*Solving inconsistency*	*Interaction diagrams*	*Verification and validation of behavioral diagrams*
S-7	SLO-1	*Introducing the concept of architectures*	*Creating requirements models of systems using SysML in different contexts and views*	*The relationship between behavioral diagrams and structure level*	*Case study: MBSE approach for Elevator*	*Probability model checking of SysML activity diagrams*
	SLO-2	*Requirements*	*Creating requirements models of systems using SysML*	*The relationship between behavioral diagrams and structure level*	*Case study: MBSE approach for Elevator*	*Probability model checking of SysML activity diagrams*
S-8	SLO-1	*System's life cycle*	*Creating requirements models of systems using SysML in different contexts and views*	*Identifying complexity through different levels of abstraction and refinement*	*Case study: MBSE approach for ATM*	*Performance analysis of time-constrained activity diagrams*
	SLO-2	*System's life cycle*	*Creating requirements models of systems using SysML in different contexts and views*	*Identifying complexity through different levels of abstraction and refinement*	*Case study: MBSE approach for ATM*	*Performance analysis of time-constrained activity diagrams*
S-9	SLO-1	*Design and integration process*	*The SysML Use Case Diagram*	*Independent views of the same system*	*Case study: MBSE approach for automobile*	*Case study –Demonstration of V&V*
	SLO-2	*Types of systems*	*SysML Blocks and Block definition diagram*	*Concluding remarks*	*Case study: MBSE approach for automobile*	*Case study –Demonstration of V&V*

Learning Resources	1. *Dennis M.Buede & William D.Miller., "The Engineering Design of Systems Models and Methods" 3rd Edition, Wiley, 2016* 2. *Jon Hold and Simon Perry., "SysML for System Engineering", The Institution of Engineering and Technology, 2nd Edition, Wiley,2013* 3. *Kossiakoff, A. Sweet, Seymour, S., W.N., Biemer, S.M., "Systems Engineering Principles and Practice", John Wiley & Sons, 2nd Edition, 2011.* 4. *Mourad Debbabi, Fawzy Hassaine., "Verification and validation in Systems Engineering", 1st Edition, Springer, 2010.*	5. *Brian Berenbach & Daniel Paulish., "Software and Systems Requirements Engineering in Practice", 1st edition McGraw Hill, 2009* 6. *David D.Walden, Garry J.Roelder, Kevin J.Forsberg, R.Douglas Hamelin, Thomas M.Shortell., "INCOSE Systems Engineering Handbook- A Guide for System Life Cycle Processes and Activities" Wiley, 4th Edition, 2015* 7. *Sanford Friedenthal, Alan Moore ,Rick Steiner., "A Practical Guide to SysML The Systems Modeling Language", 3rd Edition, Elsevier, 2015*

Learning Assessment											
	Bloom's Level of Thinking	Continuous Learning Assessment (50% weightage)								Final Examination (50% weightage)	
		CLA – 1 (10%)		CLA – 2 (15%)		CLA – 3 (15%)		CLA – 4 (10%)#			
		Theory	Practice	Theory	Practice	Theory	Practice	Theory	Practice	Theory	Practice
Level 1	Remember Understand	*30 %*	-	*30 %*	-	*30 %*	-	*30 %*	-	*30%*	-
Level 2	Apply Analyze	*40 %*	-	*40 %*	-	*40 %*	-	*40 %*	-	*40%*	-
Level 3	Evaluate Create	*30 %*	-	*30 %*	-	*30 %*	-	*30 %*	-	*30%*	-
	Total	100 %		100 %		100 %		100 %		100 %	

CLA – 4 can be from any combination of these: Assignments, Seminars, Tech Talks, Mini-Projects, Case-Studies, Self-Study, MOOCs, Certifications, Conf. Paper etc.

Course Designers		
Experts from Industry	Experts from Higher Technical Institutions	Internal Experts
1. Mr. Elayara Sivarajj, Tesla, California, elayaraj@hotmail.com	*1. Dr. Manivannan P V, Indian Institute of Techonology, Chennai, pvm@iitm.ac.in*	*1. Mr. K.Sivanathan, SRMIST*
2. Dr. Guna Surendra, Gossamsetti, Hitachi, Japan. surendra.gossamsetti.bu@hitachi.com	*2. Dr. D. Sathia Narayanan, National Institute of Ocean Technology, Chennai, sathianarayanan@niot.res.in.*	*2. Dr.R.Senthilnathan, SRMIST*

Course Code	18MHO103T	Course Name	INTRODUCTION TO ROBOTICS	Course Category	O	Open Elective	L	T	P	C
							3	0	0	3

Pre-requisite Courses	Nil	Co-requisite Courses	Nil	Progressive Courses	Nil
Course Offering Department		Mechatronics Engineering	Data Book / Codes/Standards	Nil	

Course Learning Rationale (CLR):	The purpose of learning this course is to:
CLR-1 :	*Introduce the various architectures of industrial robot*
CLR-2 :	*Introduce the vector transformation applied to robotics*
CLR-3 :	*Introduce the forward and inverse kinematics applied to serial manipulator robot*
CLR-4 :	*Emphasize on the various actuators and transmission element used in robot.*
CLR-5 :	*Introduce the parallel configuration of robot and its kinematics computation.*
CLR-6 :	*To define various control strategy used in manipulator robotics*

Course Learning Outcomes (CLO):	At the end of this course, learners will be able to:	Learning 1: Level of Thinking (Bloom)	2: Expected Proficiency (%)	3: Expected Attainment (%)	PLO 1: Engineering Knowledge	2: Problem Analysis	3: Design & Development	4: Analysis, Design, Research	5: Modern Tool Usage	6: Society & Culture	7: Environment & Sustainability	8: Ethics	9: Individual & Team Work	10: Communication	11: Project Mgt. & Finance	12: Life Long Learning	13: PSO - 1	14: PSO - 2	15: PSO – 3
CLO-1 :	*Understand the architecture and basic technical terms used in robotics*	2	80	70	H	M	M	H	M	-	-	-	-	-	-	H	H	-	-
CLO-2 :	*Apply vector transformation in robotics*	2	80	70	H	H	M	H	M	-	-	-	-	-	-	H	H	-	-
CLO-3 :	*Abilityto compute the forward and inverse kinematics of serial manipulator*	2	80	70	H	H	M	H	M	-	-	-	H	-	-	H	H	-	-
CLO-4 :	*Understand the various actuators and transmission elements used in robot.*	2	80	70	H	H	H	H	M	-	-	-	M	-	-	H	H	-	-
CLO-5 :	*Understand the parallel configuration of robot, their kinematics computation.*	2	80	70	H	H	M	H	M	-	-	-	M	-	-	H	H	-	-
CLO-6 :	*Implement various control and trajectory planning algorithm*	2	80	70	H	H	M	H	M	-	-	-	M	-	-	H	H	-	-

		Introduction to Robotics	Transformations	Kinematics	Introduction to robot sensors and control	Parallel Manipulator and industrial work cell
Duration (hour)		7	7	11	10	10
S-1	SLO-1	*Definition of Robot, Laws of Robotics,*	*Description of point in space*	*Introduction to manipulator kinematics*	*Basic actuators and transmission elements*	*Introduction to parallel manipulator*
	SLO-2	*Basic terminologies used in robotics*	*Description of body in space*	*Forward and inverse kinematics*	*Mathematical model of DC motor*	*Advantage of parallel manipulator over serial manipulator*
S-2	SLO-1	*Classification based on application*	*Translation and Rotation*	*Forward Kinematics of RR planar manipulator- geometric approach*	*Harmonic Drives*	*Degree of freedom of parallel manipulator using Gruebler equation*
	SLO-2	*Classification based on work volume*	*Derivation of rotation matrix to represent frame orientation in XYZ axes*	*Inverse Kinematics of RR planar manipulator- geometric approach*	*Computation of reduction ratio of harmonic drive and its advantage*	*Problem on finding degree of freedom of planar and spatial mechanism*
S-3	SLO-1	*Definition – precision, repeatability and accuracy*	*various rotation representation and their difference*	*DH formulation*	*Force sensor*	*Types of parallel manipulator*
	SLO-2	*Co-ordinate systems used in robotics, Degree of freedom with examples*	*Euler angle, fixed angle , arbitrary axis representation*	*Difference between modified and standard DH convention with example of RR planar manipulator*	*Various tactile sensors- principle and working*	*Examples*
S-4	SLO-1	*Links and various joints in robotics*	*Properties of rotation matrix*	*Forward kinematics of 3R spatial articulated arm*	*Slip sensor*	*Kinematics of parallel manipulator*
	SLO-2	*Anatomy of Robot*	*Homogeneous transformation*	*Derivation of final DH matrix for 3R spatial articulated arm*	*Slip sensor*	*Concept of inverse and forward kinematics*
S-5	SLO-1	*RPY wrist*	*Case study- problems on pure rotation (current and fixed axis)*	*Forward kinematics of 4 DOF SCARA robot*	*Vision system for robot*	*Inverse kinematics of planar parallel manipulator*
	SLO-2	*Configuration space and operational space*	*Case study –problem on rotation and translation*	*Derivation of final DH matrix for 4 DOF SCARA robot*	*Vision architecture block diagram*	*Derivation*
S-6	SLO-1	*Robot data sheet interpretation*	*Operators and mapping*	*Forward kinematics of RPY wrist*	*Introduction-trajectory planning. joint space and Cartesian space planning*	*Inverse kinematics of spatial parallel manipulator*

	SLO-2	*Important terms and finding in datasheet of manufacturer*	*Case study - operators and mapping*	*Derivation of final DH matrix for RPY wrist*	*Choice of joint space and Cartesian space trajectory planning*	*Derivation*
S-7	SLO-1	*Robot End-effector*	*Compound transformation*	*Inverse Kinematics - closed loop form*	*Cubic polynomial trajectory planning*	*Robot work cell layout*
	SLO-2	*Types of gripper*	*Case Study – compound Transformation*	*Computation method and issues*	*Problem on cubic polynomial trajectory planning*	*Classification of robot work cell*
S-8	SLO-1			*Inverse kinematics of a 3 DOF spatial articulated arm*	*Robot position control*	*Multiple robot*
	SLO-2			*Numerical*	*Position control of one DOF link*	*Work cell control*
S-9	SLO-1			*Velocity kinematics introduction and Jacobian*	*Robot force control*	*Safety monitoring*
	SLO-2			*Understanding and deriving Jacobian matrix elements*	*Case study- force control (peg in a hole)*	*Error detection and recovery*
S-10	SLO-1			*Derivation of Jacobian matrix for RR planar manipulator*	*Hybrid force/position control*	*Robot Cycle time analysis*
	SLO-2			*Concept of singularity for manipulator*	*Case Study of hybrid force/position control*	*Criteria for selection of robot work cell*
S-11	SLO-1			*Computing Jacobian for RRR spatial manipulator*		
	SLO-2			*Computing singularity for a RRR spatial manipulator*		

Learning Resources	1. *Mikell P. Groover, "Industrial Robotics", McGraw Hill, 2nd edition, 2012* 2. *John J. Craig, "Introduction to Robotics", 3rd Edition, Addison Wesley, ISE 2008.* 3. *Deb S.R., "Robotics Technology and Flexible Automation", 2nd edition, Tata McGraw - Hill Publishing Company Limited, 2012.*	4. *Arthor Critchlow, "Introduction to Robotics",1st edition, Macmillan, 2009.* 5. *Mohsen Shahinpoor, "A Robot Engineering Text Book", 1st edition, Harper and Row, 2004* 6. *Sterling Kinney J, "Indeterminate Structural Analysis", 1st edition, Narosa Publishing House, 1987.*

Learning Assessment

	Bloom's Level of Thinking	Continuous Learning Assessment (50% weightage)								Final Examination (50% weightage)	
		CLA – 1 (10%)		CLA – 2 (15%)		CLA – 3 (15%)		CLA – 4 (10%)#			
		Theory	Practice	Theory	Practice	Theory	Practice	Theory	Practice	Theory	Practice
Level 1	Remember Understand	*40 %*	-	*30 %*	-	*30 %*	-	*30 %*	-	*30%*	-
Level 2	Apply Analyze	*40 %*	-	*40 %*	-	*40 %*	-	*40 %*	-	*40%*	-
Level 3	Evaluate Create	*20 %*	-	*30 %*	-	*30 %*	-	*30 %*	-	*30%*	-
	Total	100 %		100 %		100 %		100 %		100 %	

CLA – 4 can be from any combination of these: Assignments, Seminars, Tech Talks, Mini-Projects, Case-Studies, Self-Study, MOOCs, Certifications, Conf. Paper etc.,

Course Designers		
Experts from Industry	Experts from Higher Technical Institutions	Internal Experts
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Course Code	18NTO301T	Course Name	APPLICATIONS OF NANOTECHNOLOGY	Course Category	O	Open Elective	L	T	P	C
							3	0	0	3

Pre-requisite Courses	Nil	Co-requisite Courses	Nil	Progressive Courses	Nil
Course Offering Department	Nanotechnology	Data Book / Codes/Standards	Nil		

Course Learning Rationale (CLR):	*The purpose of learning this course is to:*
CLR-1 :	*Acquire knowledge on environmental applications of nanotechnology*
CLR-2 :	*Understand the theory of nanotechnology in agriculture and food technology*
CLR-3 :	*Familiarize electrical, electronics and energy applications of nanotechnology*
CLR-4 :	*Know nanotechnology in textiles and cosmetics*
CLR-5 :	*Explore the concept of biomedical applications of nanotechnology*
CLR-6:	*Understand the current developments and future prospects of nanotechnology*

Course Learning Outcomes (CLO):	*At the end of this course, learners will be able to:*	Learning 1 Level of Thinking (Bloom)	2 Expected Proficiency (%)	3 Expected Attainment (%)	PLO 1 Engineering Knowledge	2 Problem Analysis	3 Design & Development	4 Analysis, Design, Research	5 Modern Tool Usage	6 Society & Culture	7 Environment & Sustainability	8 Ethics	9 Individual & Team Work	10 Communication	11 Project Mgt. & Finance	12 Life Long Learning	13 PSO - 1	14 PSO - 2	15 PSO – 3
CLO-1 :	*Apply skills to identify new materials for environmental applications*	2	80	75	H	H	H	H	H	H	H	H	H	H	M	H	H	H	H
CLO-2 :	*Analyze the role of nanotechnology in agriculture and food technology*	2	80	70	H	M	M	H	M	H	H	H	M	H	M	H	M	M	M
CLO-3 :	*Discriminate electrical, electronic and energy applications of nanotechnology*	2	75	70	H	M	H	H	H	H	H	M	H	H	H	H	H	H	H
CLO-4 :	*Apply the techniques of nanotechnology in textile and cosmetics*	2	80	75	M	H	H	M	H	H	H	H	H	H	M	H	H	H	H
CLO-5 :	*Appreciate the role of nanotechnology in advancing the biomedical industry*	2	80	70	H	H	H	H	H	M	H	H	M	H	M	H	H	H	H
CLO-6:	*Utilize the concept of biosensor to analyze the material nature.*	2	80	75	H	M	M	H	H	H	H	H	H	H	M	H	H	M	H

Duration (hour)		9	9	9	9	9
S-1	SLO-1	*Environmental pollutants in air*	*Nanotechnology in Agriculture*	*Electronic circuit chips*	*Nanofibre production in Textiles*	*Introduction to biomedical applications*
	SLO-2	*Environmental pollutants in water*	*Precision farming*	*Nanosensors and actuators*	*Electrospinning*	*Bioreceptors and their properties*
S-2	SLO-1	*Environmental pollutants in soil*	*Smart delivery system*	*Optical switches*	*Controlling morphologies of nanofibers*	*Biochips*
	SLO-2	*Types of toxic and hazards wastes*	*Nanofertilizers and types*	*Diodes*	*Nano-fillers embedded polypropylene fibers*	*Integrated nanosensor*
S-3	SLO-1	*Application of nanotechnology - Introduction*	*Nanourea and mixed fertilizers*	*Nano-wire transistors*	*Bionics*	*DNA based biosensors*
	SLO-2	*Application of nanotechnology in industrial waste*	*Nanofertigation*	*Advantages of nano electrical and electronic devices*	*Swim-suits with shark-skin effect*	*Natural nanocomposite systems*
S-4	SLO-1	*Application of nanotechnology in waste water treatment*	*Nanopesticides*	*Memory storage*	*Soil repellence*	*Nanomaterials in bone substitutes and dentistry*
	SLO-2	*Drinking water purifications*	*Nanoseed Science*	*Lighting displays and filters*	*Lotus effect*	*Implants and Prosthesis*
S-5	SLO-1	*Air purifications*	*Nanotechnology in Food industry*	*Quantum computers*	*Nano finishing in textile*	*Tissue Engineering*
	SLO-2	*Gas purifications*	*Nanopackaging for enhanced shelf life*	*Medical diagnosis and conductive additives*	*Modern textiles Nanopolymers in medical textiles*	*Neuroscience*
S-6	SLO-1	*Nanomonitoring*	*Smart packaging*	*Lead-free solder*	*Introduction to cosmetics*	*Neuro-electronic Interfaces*
	SLO-2	*Nano Biosensors - Overview*	*Intelligent packaging*	*Nanocoatings and EMI shielding.*	*Formulation of Gels*	*Nanorobotics*
S-7	SLO-1	*Nano Biosensors for Pesticide Detection*	*Food processing*	*Energy devices*	*Shampoos*	*Photodynamic Therapy*
	SLO-2	*Nano Biosensors for Plant Pathogen Detection*	*Food safety*	*Fuel cells*	*Hair-conditioners*	*Protein Engineering*
S-8	SLO-1	*Nano Bioremediation*	*bio-security*	*role of nanomaterials in fuel cell applications*	*Introduction to Sun-screen dispersions*	*Nanosensors in Diagnosis*
	SLO-2	*Pesticide Degradation*	*Electrochemical sensors*	*Photovoltaic cells*	*Sun-screen dispersions for UV protection*	*Drug delivery*
S-9	SLO-1	*Soil Structure*	*sensors for food analysis*	*Application of nanotechnology in solar cells*	*Colour cosmetics*	*Cancer therapy*
	SLO-2	*Soil structure Remediation*	*contaminant detection*	*Application of power in transportation*	*Types of Colour cosmetics*	*Other therapeutic applications*

Learning Resources	1. *Environmental Nanotechnology, by M. H. Fulekar, Bhawana Pathak* 2. *Lynn J. Frewer, Willehm Norde, R. H. Fischer and W. H. Kampers, Nanotechnology in the Agri-food sector, Wiley-VCH Verlag, (2011).* 3. *Jennifer Kuzma and Peter VerHage, Nanotechnology in agriculture and food production, Woodrow Wilson International Center, (2006).*	4. *P. J. Brown and K. Stevens, Nanofibers and Nanotechnology in Textiles, Woodhead Publishing Limited,Cambridge, (2007).* 5. *Neelina. H, Malsch (Ed.), "Biomedical Nanotechnology", CRC Press 2005.*

Learning Assessment											
	Bloom's Level of Thinking	Continuous Learning Assessment (50% weightage)								Final Examination (50% weightage)	
		CLA – 1 (10%)		CLA – 2 (15%)		CLA – 3 (15%)		CLA – 4 (10%)#			
		Theory	Practice	Theory	Practice	Theory	Practice	Theory	Practice	Theory	Practice
Level 1	Remember Understand	*30 %*	-	*30 %*	-	*30 %*	-	*30 %*	-	*30%*	-
Level 2	Apply Analyze	*40 %*	-	*40 %*	-	*40 %*	-	*40 %*	-	*40%*	-
Level 3	Evaluate Create	*30 %*	-	*30 %*	-	*30 %*	-	*30 %*	-	*30%*	-
	Total	100 %		100 %		100 %		100 %		100 %	

CLA – 4 can be from any combination of these: Assignments, Seminars, Tech Talks, Mini-Projects, Case-Studies, Self-Study, MOOCs, Certifications, Conf. Paper etc.,

Course Designers		
Experts from Industry	Experts from Higher Technical Institutions	Internal Experts
1. Dr. N. Vijayan, CSIR-NPL, nvijayan@nplindia.org	*1. Prof. S. Balakumar, University of Madras, balakumar@unom.ac.in*	*Dr.J.Archana, SRMIST*
2. Dr. Krishna SurendraMuvvala, Saint Gobain Research India, India, Krishna.muvvala@saintgobain.com	*2. Prof. V. Subramaniyam, IIT Madras, vsubbu@iitm.ac.in*	*Dr.S.Harish, SRMIST*

Course Code	18NTO302T	Course Name	SOLID STATE ELECTRONIC DEVICES	Course Category	O	Open Elective	L	T	P	C
							3	0	0	3

Pre-requisite Courses	Nil	Co-requisite Courses	Nil	Progressive Courses	Nil
Course Offering Department	Nanotechnology	Data Book / Codes/Standards	Nil		

Course Learning Rationale (CLR):	The purpose of learning this course is to:
CLR-1 :	*Realize the basics of solid state physics with particular emphasis on semiconductors.*
CLR-2 :	*Provide in-depth understanding of diodes, acquire knowledge of various types and operation of diodes.*
CLR-3 :	*Develop key understanding related to basics of transistors along with processes involved in working of transistors*
CLR-4 :	*Understand the important ingredient towards technological application of transistors, specifically, field effect transistors*
CLR-5 :	*Get acquainted with various solid state devices and application.*
CLR-6 :	*Develop idea about few exemplary real commonly used electronic devices.*

Course Learning Outcomes (CLO):	At the end of this course, learners will be able to:	Learning 1: Level of Thinking (Bloom)	Learning 2: Expected Proficiency (%)	Learning 3: Expected Attainment (%)	PLO 1: Engineering Knowledge	PLO 2: Problem Analysis	PLO 3: Design & Development	PLO 4: Analysis, Design, Research	PLO 5: Modern Tool Usage	PLO 6: Society & Culture	PLO 7: Environment & Sustainability	PLO 8: Ethics	PLO 9: Individual & Team Work	PLO 10: Communication	PLO 11: Project Mgt. & Finance	PLO 12: Life Long Learning	PLO 13: PSO - 1	PLO 14: PSO - 2	PLO 15: PSO – 3
CLO-1 :	*Appreciate the importance of “solid state devices” for the advancement of technology*	2	80	75	H	M	H	H	H	M	M	H	H	H	M	H	H	H	H
CLO-2 :	*Analyze diodes and understand its significance in technological application*	2	80	70	H	M	M	H	M	M	M	H	M	H	M	H	M	M	M
CLO-3 :	*Obtain the knowledge on the transistors and its working principles*	2	75	70	H	M	H	H	H	H	H	M	H	H	H	H	H	H	H
CLO-4 :	*Achieve knowledge about variety of transistors and difference between various transistors*	2	80	75	M	H	H	M	H	H	H	H	H	H	M	H	H	H	H
CLO-5 :	*Evaluate the working principles of existing devices based on solid state electronics*	2	80	70	H	M	H	H	H	M	M	H	M	H	M	H	H	H	H
CLO-6 :	*Get an idea of future device application in advancing the existing technology for power efficient devices*	2	80	75	H	M	M	H	H	M	M	H	H	H	M	H	H	M	H

Duration (hour)		9	9	9	9	9
S-1	SLO-1	*Brief introduction to crystal structure in solids*	*Basic structure of p-n junction*	*Basics of Bipolar transistors*	*Introduction to Field Effect Transistors (FET)*	*Introduction to light emitting diode (LED)*
	SLO-2	*Electronic band structure*	*Current transport in p-n junction diode*	*Usefulness of transistors*	*Working principle of FET*	*Working principle of LED*
S-2	SLO-1	*Detailed discussion on energy bands in solids*	*I-V Characteristics, Zero applied bias: Electric field*	*Theory of operation and action of PNP*	*Junction FET*	*Different useful materials for LED*
	SLO-2	*Discussion on band structure calculation*	*Built-in potential, junction capacitance, Diffusion capacitance*	*NPN transistors*	*Theory of operation and current equation*	*Multilayers heterojunctions for LED*
S-3	SLO-1	*Elemental and compound semiconductors*	*Generation-recombination currents*	*Description of majority and minority carrier distribution*	*Introduction of Metal semiconductor FET (MOSFET)*	*Photodiodes-current and voltage in an illuminated junction*
	SLO-2	*Doping in semiconductors, Shallow and deep levels*	*Junction breakdown mechanisms*	*Terminal currents in transistors*	*Application of MOSFET*	*Exemplary description of photodiodes*
S-4	SLO-1	*Carrier statistics, Carrier transport, Carrier mobility*	*Introduction of Zener diode*	*How transistors can be used for amplification?*	*Metal oxide semiconductor FET (MOSFET): working principle*	*Photodetectors-noise*
	SLO-2	*Scattering mechanisms*	*Unique features associated with Zener diode*	*Transistor as amplifier*	*Application of MOSFET*	*Bandwidth of photodetectors*
S-5	SLO-1	*Non-equilibrium conditions, Quasi Fermi levels*	*Heterojunctions: Band alignments*	*What makes transistors to work as switch?*	*Details of VI Characteristics of MOSFET*	*Semiconductor lasers*
	SLO-2	*Recombination processes*	*Energy band diagrams of heterojunctions*	*Application of transistor as switch*	*Qualitative description of VI characteristics of MOSFET*	*Population inversion at a junction*
S-6	SLO-1	*Understanding current density*	*Formation of two dimensional electron gas*	*How transistors can be used for switching?*	*Depletion and enhancement types - threshold voltage*	*Detailed description of emission spectra for p-n junction lasers*
	SLO-2	*Mathematical description of continuity equations*	*Qualitative description of two dimensional electron gas*	*Summary of transistor application*	*Gate capacitance inversion and accumulation layers*	*Quantitative interpretation of emission spectra for p-n junction lasers*
S-7	SLO-1	*Surface recombination*	*Metal-semiconductor contacts*	*Open-circuited transistors-biasing in active region,*	*Complementary MOSFET*	*Heterojunction lasers-materials for semiconductor lasers*

	SLO-2	*Surface states*	*Schottky barrier diode*	*Ways to bias a transistors*	*Significance of CMOSFET*	*Semiconductor laser applications*
S-8	SLO-1	*Excitons in semiconductors*	*Fermi level pinning*	*Detailed description of Schottky transistors*	*Introduction to high electron mobility transistor (HEMT)*	*Introduction to Solar cells*
	SLO-2	*How to estimate carrier concentration?*	*C-V characteristics of a Schottky diode*	*Working principles of Schottky transistors*	*Ways to achieve HEMT*	*Relevance of semiconducting materials in solar cell application*
S-9	SLO-1	*Discussion on Hall effect measurements*	*Current transport processes*	*Detailed description of Optical transistors*	*Working principle of charge coupled devices (CCD)*	*Transistors as building block of memory devices*
	SLO-2	*Discussion on fractional quantum Hall effect*	*I-V characteristics*	*Application of Optical transistors*	*Interpretation of information obtained from CCD*	*Advanced solid state memory devices*

Learning Resources	1. *Solid State Electronic Devices, by Streetman and Ben Garland, Prentice Hall, 2000* 2. *Physics of Semiconductor Devices, by S. M. Sze and Kwok. K. Ng, John Wiley & Sons, Inc., 2007*	3. *Art of Electronics, by Horowitz and Hill, Cambridge University Press, 2nd ed., 1989*

Learning Assessment

	Bloom's Level of Thinking	Continuous Learning Assessment (50% weightage)								Final Examination (50% weightage)	
		CLA – 1 (10%)		CLA – 2 (15%)		CLA – 3 (15%)		CLA – 4 (10%)#			
		Theory	Practice	Theory	Practice	Theory	Practice	Theory	Practice	Theory	Practice
Level 1	Remember Understand	*30 %*	-	*30 %*	-	*30 %*	-	*30 %*	-	*30%*	-
Level 2	Apply Analyze	*40 %*	-	*40 %*	-	*40 %*	-	*40 %*	-	*40%*	-
Level 3	Evaluate Create	*30 %*	-	*30 %*	-	*30 %*	-	*30 %*	-	*30%*	-
	Total	100 %		100 %		100 %		100 %		100 %	

CLA – 4 can be from any combination of these: Assignments, Seminars, Tech Talks, Mini-Projects, Case-Studies, Self-Study, MOOCs, Certifications, Conf. Paper etc.,

Course Designers

Experts from Industry	Experts from Higher Technical Institutions	Internal Experts
1. Dr. Hemant Dixit, Global Foundaries,USA, aplahemant@gmail.com	*1. Dr. Debanjan Bhowmik, IIT Delhi, debanjan@ee.iitd.ac.in*	*1. Dr. Jaivardhan Sinha, SRMIST*
2. Dr. Krishna Surendra Muvvala, Saint Gobain Research India, India, Krishna.muvvala@saintgobain.com	*2. Dr. M. S. Ramachandra Rao, IIT Madras, msrrao@iitm.ac.in*	*2. Dr. S. Chandramohan, SRMIST*

Course Code	18NTO303T	Course Name	MICRO AND NANOELECTRONICS	Course Category	O	Open Elective	L	T	P	C
							3	0	0	3

Pre-requisite Courses	Nil	Co-requisite Courses	Nil	Progressive Courses	Nil
Course Offering Department	Nanotechnology	Data Book / Codes/Standards	Nil		

Course Learning Rationale (CLR):	*The purpose of learning this course is to:*
CLR-1 :	*Understand the physical effects of semiconductor-semiconductor junction, its electrostatics, and device operation*
CLR-2 :	*Learn methodology of lithography and etching to pattern materials at micro and nanoscale*
CLR-3 :	*Acquire knowledge of VLSI design and fabrication*
CLR-4 :	*Get acquainted with CMOS fabrication rules*
CLR-5 :	*Learn integrated circuit passive and component fabrication processes*
CLR-6 :	*Introduce next generation printed electronics technology*

Course Learning Outcomes (CLO):	*At the end of this course, learners will be able to:*	Learning 1: Level of Thinking (Bloom)	Learning 2: Expected Proficiency (%)	Learning 3: Expected Attainment (%)	PLO 1: Engineering Knowledge	PLO 2: Problem Analysis	PLO 3: Design & Development	PLO 4: Analysis, Design, Research	PLO 5: Modern Tool Usage	PLO 6: Society & Culture	PLO 7: Environment & Sustainability	PLO 8: Ethics	PLO 9: Individual & Team Work	PLO 10: Communication	PLO 11: Project Mgt. & Finance	PLO 12: Life Long Learning	PLO 13: PSO - 1	PLO 14: PSO - 2	PLO 15: PSO - 3
CLO-1 :	*Apply working of semiconductor devices in its large scale operation*	2	80	75	H	M	H	H	H	M	M	H	H	H	M	H	H	H	H
CLO-2 :	*Pattern diverse materials using lithography techniques to enhance the device density on chip*	2	80	70	H	M	M	H	M	M	M	H	M	H	M	H	M	M	M
CLO-3 :	*Design the VLSI components*	2	75	70	H	M	H	H	H	H	H	M	H	H	H	H	H	H	H
CLO-4 :	*Fabricate small-scale devices and chip level device space management*	2	80	75	M	H	H	M	H	H	H	H	H	H	M	H	H	H	H
CLO-5 :	*Imagining importance of nanoscale devices*	2	80	70	H	M	H	H	H	M	M	H	M	H	M	H	H	H	H
CLO-6 :	*Envision low cost production of electronic devices using printed technology*	2	80	75	H	M	M	H	H	M	M	H	H	H	M	H	H	M	H

Duration (hour)		9	9	9	9	9
S-1	SLO-1	*Fundamentals of Electronic Devices*	*Need and basics of lithography*	*History of complementary metal-oxide-semiconductor (CMOS)*	*Integrated circuit fabrication technology*	*Overview of flexible electronics*
	SLO-2	*Overview of semiconductor Physics*	*Optical lithography*	*CMOS processing: LOCOS and STI isolation*	*Moor's law and scaling*	*Advantages of printing*
S-2	SLO-1	*Intrinsic semiconductors*	*Optical lithography controls*	*Layout design rules*	*Passive component fabrication*	*Requirements of printing*
	SLO-2	*Extrinsic semiconductors*	*Photo-mask making*	*Rules for: well, transistor, contact, via, etc.*	*Fabrication of integrated resistor*	*Printing tools*
S-3	SLO-1	*p-n junction formation*	*Working concept and controls of e-beam lithography*	*MOSIS Scalable CMOS Design Rules*	*Fabrication of integrated capacitor*	*Types of fluids for ink*
	SLO-2	*Charge distribution and Fermi level in p-n junction*	*Resolution of electron beam lithography*	*Micron design rules*	*Fabrication of integrated inductor*	*Properties of fluids in printing processes*
S-6	SLO-1	*Depletion region capacitance*	*Wet etching mechanism and disadvantages*	*CMOS integrated inverter working principle*	*Self-aligned gate*	*Working principle of flexographic printing (FP)*
	SLO-2	*Depletion region width and its bias dependence*	*Wet etching of silicon, silicon dioxide and metal*	*IV characteristics of inverter*	*fabrication of NMOS with polysilicon self-aligned gate*	*Advantages and disadvantages of FP*
S-7	SLO-1	*Metal-Oxide-Semiconductor (MOS) capacitor*	*Types of dry etching*	*CMOS fabrication process*	*3D transistors requirements*	*Working principle of gravure printing (GP)*
	SLO-2	*Operation of MOS capacitor*	*Ways of plasma generation for etching processes, Sputter etching*	*CMOS integrated inverter design rules*	*FinFET technology*	*Advantages and disadvantages of GP*
S-8	SLO-1	*Operation of MOSFETs in linear region*	*Capacitively coupled plasma*	*CMOS process enhancement*	*Integrated memory devices*	*Working principle of screen printing (SP)*
	SLO-2	*Operation of MOSFETs in saturation region*	*Reactive ion etching*	*Enhancement for transistor and interconnect*	*Dynamic RAM (DRAM) fabrication*	*Advantages and disadvantages of SP*
S-9	SLO-1	*Sub threshold region*	*Inductively coupled plasma*	*Manufacturing issues*	*Challenges for nanoelectronics*	*Working principle of inkjet printing (IP), Advantages and disadvantages*

	SLO-2	*MOSFET scaling*	*Deep reactive ion etching and bosh process*	*Yield management*	*Requirements of nanoelectronics*	*Future of printed low-cost electronics*

Learning Resources	1. *S. M. Sze, and S. Lee, "Semiconductor Devices Physics and Technology", Wiley, 2012* 2. *Neil H. E. Weste and David Money Harris, "CMOS VLSI design", Addison-Wesley, 2011*	3. *Giovanni Nisato, Donald Lupo, Simone Ganz, "Organic and Printed Electronics", CRC Press, 2016.* 4. *Hans H. Gatzen, Volker Saile, Jürg Leuthold, "Micro and Nano Fabrication", Springer 2015*

Learning Assessment

	Bloom's Level of Thinking	Continuous Learning Assessment (50% weightage)								Final Examination (50% weightage)	
		CLA – 1 (10%)		CLA – 2 (15%)		CLA – 3 (15%)		CLA – 4 (10%)#			
		Theory	Practice	Theory	Practice	Theory	Practice	Theory	Practice	Theory	Practice
Level 1	Remember Understand	*30 %*	-	*30 %*	-	*30 %*	-	*30 %*	-	*30%*	-
Level 2	Apply Analyze	*40 %*	-	*40 %*	-	*40 %*	-	*40 %*	-	*40%*	-
Level 3	Evaluate Create	*30 %*	-	*30 %*	-	*30 %*	-	*30 %*	-	*30%*	-
	Total	100 %		100 %		100 %		100 %		100 %	

CLA – 4 can be from any combination of these: Assignments, Seminars, Tech Talks, Mini-Projects, Case-Studies, Self-Study, MOOCs, Certifications, Conf. Paper etc.,

Course Designers

Experts from Industry	Experts from Higher Technical Institutions	Internal Experts
1. Dr. Hemant Dixit, Global Foundaries, USA, aplahemant@gmail.com	*1. Dr. A. Subrahmanyam, IIT Madras, manu@iitm.ac.in*	*1. Dr. Abhay Sagade, SRMIST*
2. Dr. Krishna Surendra Muvvala, Saint Gobain Research India, India, Krishna.muvvala@saintgobain.com	*2. Dr. N. N. Murthy, IIT Tirupati, nnmurty@iittp.ac.in*	*2. Dr. A. Karthigeyan, SRMIST*

Course Code	18NTO304T	Course Name	ENVIRONMENTAL NANOTECHNOLOGY	Course Category	O	Open Elective Course	L	T	P	C
							3	0	0	3

Pre-requisite Courses	Nil	Co-requisite Courses	Nil	Progressive Courses	Nil
Course Offering Department	Nanotechnology	Data Book / Codes/Standards	Nil		

Course Learning Rationale (CLR):	*The purpose of learning this course is to:*
CLR-1 :	*Acquire knowledge on nanotechnology in environmental and health effects*
CLR-2 :	*Understand the effect of nanomaterials for environmental protection*
CLR-3 :	*Describes the effect of nanomaterials in environment*
CLR-4 :	*Explains the safety measurements*
CLR-5 :	*Gain knowledge on different sustainable nanotechnologies*
CLR-6 :	*Educate and understanding of sustainable nanotechnology*

Course Learning Outcomes (CLO):	*At the end of this course, learners will be able to:*	Learning			Program Learning Outcomes (PLO)														
		1	2	3	1	2	3	4	5	6	7	8	9	10	11	12	13	14	15
		Level of Thinking (Bloom)	Expected Proficiency (%)	Expected Attainment (%)	Engineering Knowledge	Problem Analysis	Design & Development	Analysis, Design, Research	Modern Tool Usage	Society & Culture	Environment & Sustainability	Ethics	Individual & Team Work	Communication	Project Mgt. & Finance	Life Long Learning	PSO - 1	PSO - 2	PSO – 3
CLO-1 :	*Elucidate the effects to human health and the environment*	*2*	*80*	*75*	*H*	*M*	*H*	*H*	*H*	*M*	*M*	*H*	*H*	*H*	*M*	*H*	*H*	*H*	*H*
CLO-2 :	*Analyze the relationships between key properties of nanomaterials and their environmental fate*	*2*	*80*	*70*	*H*	*M*	*M*	*H*	*M*	*M*	*M*	*H*	*M*	*H*	*M*	*H*	*M*	*M*	*M*
CLO-3 :	*Apply the physical and chemical properties of nanomaterials*	*2*	*75*	*70*	*H*	*M*	*H*	*H*	*H*	*H*	*H*	*M*	*H*	*H*	*H*	*H*	*H*	*H*	*H*
CLO-4 :	*Approach the influence of the behavior of nanomaterials in the environment and in biological systems*	*2*	*80*	*75*	*M*	*H*	*H*	*M*	*H*	*H*	*H*	*H*	*H*	*H*	*M*	*H*	*H*	*H*	*H*
CLO-5 :	*Demonstrate the knowledge of mapping of the environmental fate of nanomaterials*	*2*	*80*	*70*	*H*	*M*	*H*	*H*	*H*	*M*	*M*	*H*	*M*	*H*	*M*	*H*	*H*	*H*	*H*
CLO-6 :	*Elucidate the use of nanoparticles for environmental remediation and water treatment*	*2*	*80*	*75*	*H*	*M*	*M*	*H*	*H*	*M*	*M*	*H*	*H*	*H*	*M*	*H*	*H*	*M*	*H*

Duration (hour)		9	9	9	9	9
S-1	SLO-1	*Nanotechnology in environmental and health effects*	*Nanomaterials for Environmental Protection*	*Identification and characterization of Hazardous waste*	*Environmental Nano Remediation Technology*	*Sustainable Nanotechnology*
	SLO-2	*Environmental pollutants in air*	*Nanotechnology processes*	*Nano Pollution*	*Thermal methods*	*Application of industrial ecology to nanotechnology*
S-2	SLO-1	*Environmental pollutants in water*	*Nano Engineering materials for Pollution Prevention*	*Air/Gas Contaminants*	*Physical methods*	*Fate of nanomaterials in environment*
	SLO-2	*Environmental pollutants in soil*	*Green Chemistry*	*Water Contaminants*	*Chemical methods*	*environmental life cycle of nano materials*
S-3	SLO-1	*Hazardous and toxic wastes*	*Energy efficient resources and materials*	*Soil Contaminants*	*Biological Methods*	*environmental impacts of nano materials*
	SLO-2	*Challenges to occupational health*	*Nanotechnology products- Nanomaterials*	*Identification and Characterization of Organic and inorganics*	*Nano Filtration methods for treatment of waste water*	*health impacts of nano materials*
S-4	SLO-1	*Challenges to occupational hygiene*	*Nanodevices and nanosystems*	*Identification and Characterization of Organic and inorganics*	*removal of organics & inorganics and pathogens*	*toxicological threats*
	SLO-2	*Toxicity of nanoparticles*	*Synthesis of nanomaterials by Physico-chemical approaches*	*Nanomaterials-Remediation*	*removal of inorganics*	*eco-toxicology*
S-5	SLO-1	*Effects of inhaled nanosized particles*	*Bio-nancomposites*	*Nano Membranes*	*removal of pathogens*	*exposure to nano particles – biological damage*
	SLO-2	*Skin exposure to nanoparticles*	*Nanoparticles and Microorganisms*	*Nano Meshes*	*Nanotechnology for water 5 remediation and purification*	*threat posed by nano materials to humans*
S-6	SLO-1	*Impact of CNTs on respiratory systems*	*Microbial Synthesis of Nanomaterials*	*Nano Fibres*	*Treatment of hi-tech industrial waste waters using nano particles/ modified structures/devices*	*environmental reconnaissance and surveillance*
	SLO-2	*Hazards of exposure to nanoparticles*	*Biological Methods for Synthesis of nano-emulsions using bacteria*	*Nano Clays and Adsorbents, Zeolites, Nano Catalysts, Carbon Nano Tubes,*	*Treatment of hi-tech industrial waste waters using modified structures*	*Corporate social responsibility for nanotechnology*
S-7	SLO-1	*Risks of exposure to nanoparticles*	*Fungi and Actinomycetes*	*Bio Polymers*	*Treatment of hi-tech industrial waste waters using dyes*	*Combining Life Cycle and Risk Assessment*

	SLO-2	*Screening of nanomaterials for understanding potential effects to human health and the environment*	*Different plants based nanoparticle synthesis*	*Single Enzyme Nanoparticles*	*Groundwater remediation*	*Proposed Solutions to prevent toxicology*
S-8	SLO-1	*Mapping of the environmental fate of nanomaterials*	*Plants based nanoparticle synthesis*	*Bio Metallic Iron Nanoparticles*	*Surface water treatment*	*Safety measurements*
	SLO-2	*Relationships between key properties of nanomaterials and their environmental fate*	*Nano composite biomaterials – Fibres*	*Nano SemiConductors*	*Titanium dioxide*	*Education and understanding of sustainable nanotechnology*
S-9	SLO-1	*Transport and transportation of nanomaterials*	*Devices and Structures*	*Photo catalysis*	*Challenges*	*Applications of nanotechnology for sustainability*
	SLO-2	*Bio-distribution and toxicity of nanomaterials*	*Nano Bio systems.*	*Nano-sensors*	*Environmental Benefits of nanomaterials*	*Nanomaterials in future - implications.*

Learning Resources	1. *Nanotechnlogy: Health and Environmental risk by Jo Anne Shatkin. CRC press, 2008.* 2. *Nanotechnologies, Hazards and Resource efficiency by M. Steinfeldt, Avon Gleich, U. Petschow, R. Haum. Springer, 2007.*	3. *Environanotechnology by Mao Hong fan, Chin-pao Huang, Alan E Bland, Z Honglin Wang, RachidSliman, Ian Wright. Elsevier, 2010.* 4. *Nanostructured conductive polymers. Edited by Ali Eftekhari. Wiley, 2010.*

Learning Assessment

	Bloom's Level of Thinking	Continuous Learning Assessment (50% weightage)								Final Examination (50% weightage)	
		CLA – 1 (10%)		CLA – 2 (15%)		CLA – 3 (15%)		CLA – 4 (10%)#			
		Theory	Practice	Theory	Practice	Theory	Practice	Theory	Practice	Theory	Practice
Level 1	Remember Understand	*30 %*	-	*30 %*	-	*30 %*	-	*30 %*	-	*30%*	-
Level 2	Apply Analyze	*40 %*	-	*40 %*	-	*40 %*	-	*40 %*	-	*40%*	-
Level 3	Evaluate Create	*30 %*	-	*30 %*	-	*30 %*	-	*30 %*	-	*30%*	-
	Total	100 %		100 %		100 %		100 %		100 %	

CLA – 4 can be from any combination of these: Assignments, Seminars, Tech Talks, Mini-Projects, Case-Studies, Self-Study, MOOCs, Certifications, Conf. Paper etc.,

Course Designers

Experts from Industry	Experts from Higher Technical Institutions	Internal Experts
1. Dr. N. Vijayan, CSIR-NPL, nvijayan@nplindia.org	*1. Prof. S. Balakumar, University of Madras, balakumar@unom.ac.in*	*1. Dr. M.Navaneethan, SRMIST*
2. Dr. Krishna SurendraMuvvala, Saint Gobain Research India, India, Krishna.muvvala@saintgobain.com	*2. Prof. V. Subramaniyam, IIT Madras, manianvs@iitm.ac.in*	*2. Dr. E. Senthil Kumar, SRMIST*

Course Code	18NTO305T	Course Name	MEDICAL NANOTECHNOLOGY	Course Category	O	Open Elective course	L	T	P	C
							3	0	0	3

Pre-requisite Courses	Nil	Co-requisite Courses	Nil	Progressive Courses	Nil
Course Offering Department		Nanotechnology	Data Book / Codes/Standards	Nil	

Course Learning Rationale (CLR):	The purpose of learning this course is to:
CLR-1 :	*Understanding the basics of medicine*
CLR-2 :	*Know the various classification of nanomedicine*
CLR-3 :	*Getting knowledge about interaction of nanomaterials with biological environment*
CLR-4 :	*Gain a broad understanding about nanosystems for the diagnosis and therapy*
CLR-5 :	*Get acquainted with future aspects of nanosurgery*
CLR-6:	*Comprehend the principles behind medical nanotechnology*

Course Learning Outcomes (CLO):	At the end of this course, learners will be able to:	Learning 1 Level of Thinking (Bloom)	2 Expected Proficiency (%)	3 Expected Attainment (%)	PLO 1 Engineering Knowledge	2 Problem Analysis	3 Design & Development	4 Analysis, Design, Research	5 Modern Tool Usage	6 Society & Culture	7 Environment & Sustainability	8 Ethics	9 Individual & Team Work	10 Communication	11 Project Mgt. & Finance	12 Life Long Learning	13 PSO - 1	14 PSO - 2	15 PSO – 3
CLO-1 :	*To distinguish the advantages between conventional and nanomedicine*	2	80	75	H	M	H	H	H	M	M	H	H	H	M	H	H	H	H
CLO-2 :	*Analyze the concepts of medical nanotechnology*	2	80	70	H	M	M	H	M	M	M	H	M	H	M	H	M	M	M
CLO-3 :	*Apply concepts of nanomedicine to a focused clinical area of their choice*	2	75	70	H	M	H	H	H	H	H	M	H	H	H	H	H	H	H
CLO-4 :	*Apply the nanosystems for diagnosis and therapy*	2	80	75	M	H	H	M	H	H	H	H	H	H	M	H	H	H	H
CLO-5 :	*Apply the concepts of nanosurgery*	2	80	70	H	M	H	H	H	M	M	H	M	H	M	H	H	H	H
CLO-6 :	*Apply the principle of nanomolecular tracking*	2	80	75	H	M	M	H	H	M	M	H	H	H	M	H	H	M	H

Duration (hour)		9	9	9	9	9
S-1	SLO-1	*Conventional medicine*	*Nanosensors & nanoscale scanning*	*Nanoparticles for imaging & drug delivery*	*Nanodiagnostics*	*Nanodevices for Clinical Nanodiagnostics*
	SLO-2	*Prospect of nanomedicine*	*Nanosensor Technology*	*Types of Nanoparticles for drug delivery*	*Nanosensors for Diagnosis*	*Types of Nanodevices for diagnosis*
S-2	SLO-1	*Current Medical Practice*	*Chemical Nanosensor*	*Nanoparticles for medical imaging*	*Nanoarrays for Molecular Diagnostics*	*Nanoendoscopy*
	SLO-2	*Challenges in Current Medical Practice*	*Molecular Nanosensor*	*Enhancement for X-ray*	*Types of Nanoarrays*	*Uses and advantage of nanoendoscopy*
S-3	SLO-1	*Evolution of Scientific Medicine*	*Displacement Sensor*	*MRI imaging*	*Nanoparticles for Molecular Diagnostics*	*Nanobiotechnology and Drug Delivery Devices*
	SLO-2	*Drawinian medicine*	*Motion Sensors*	*IR imaging*	*Gold Nanoparticles*	*Types of Nanodevices for drug delivery*
S-4	SLO-1	*Volitional Normative Model of Disease*	*Force Nanosensor*	*Visible imaging*	*Magnetic Nanoparticles*	*Tools for Nanosurgery*
	SLO-2	*Disease Nominalism,Disease Relativism*	*Thermal Nanosensor*	*UV imaging*	*Quantum Dots for Molecular Diagnostics*	*Nanoscale Laser Surgery*
S-5	SLO-1	*Treatment Methodology*	*Electric and Magnetic Sensing*	*Nanoparticles for targeted imaging*	*DNA Nanomachines*	*Nanorobotics for Surgery*
	SLO-2	*Conventional methods*	*Cellular Bio scanning*	*Targetting moieties*	*DNA Nanomachines for Molecular Diagnostics*	*Nanotechnology for Detection of Cancer*
S-6	SLO-1	*Evolution of Bedside Practice*	*Macrosensing*	*Nanoparticles for delivery of energy*	*Nanobarcodes Technology*	*QDs for Sensing Cancer Cell Apoptosis*
	SLO-2	*Benefits of Bedside Practice*	*Intergated nanosensor technologies*	*Types of nanoparticles for delivery of energy*	*Commercially available Nanobarcodes*	*Dendrimers for Sensing Cancer Cell Apoptosis*
S-7	SLO-1	*Molecular Nanotechnology*	*Genomics*	*Nanoparticles for delivery of drugs*	*Cantilevers as Biosensors for Molecular Diagnostics*	*Gold Nanoparticles for Cancer Diagnosis*
	SLO-2	*Introduction and Basic principles*	*Methods in Genomics*	*Types of nanoparticles for delivery of drugs*	*Types of Cantilevers as Biosensors for Molecular Diagnostics*	*Nanotubes for Detection of Cancer Proteins*
S-8	SLO-1	*Pathways to Molecular Manufacturing*	*Proteomics*	*Materials for drug delivery*	*Nanodiagnostics for the Battle Field*	*Nanoparticles for the Optical Imaging of Tumors*
	SLO-2	*Molecular Transport*	*Methods in Proteomics*	*Fabrication for drug delivery*	*Uses of Nanodiagnostics for the Battle Field*	*Nanolaser Spectroscopy for Detection of Cancer in Single Cells*

S-9	SLO-1	*Molecular Sortation*	*Real-time monitoring*	*Nanocapsulation for drug delivery*	*Nanodiagnostics for Integrating Diagnostics with Therapeutics.*	*Nanoparticles-MRI for Tracking Dendritic Cells in Cancer Therapy*
	SLO-2	*Types of Molecular Sortation*	*In vivo medical monitoring*	*Application of Nanocapsulation for drug delivery*	*Advantages of Integrating Diagnostics with Therapeutics.*	*Advantages of Nanoparticle tracking*

Learning Resources	*1. Robert .A. Freital.Jr, "Nanomedicine"- Landes Bioscience Press 2010.* *2. Harry F.Tibbals, "Medical Nanotechnology & Nanomedicine' - CRC press,2011.*	*3. Jain.K.K, "Handbook of Nanomedicine"- Springer, 2012.*

Learning Assessment

	Bloom's Level of Thinking	Continuous Learning Assessment (50% weightage)								Final Examination (50% weightage)	
		CLA – 1 (10%)		CLA – 2 (15%)		CLA – 3 (15%)		CLA – 4 (10%)#			
		Theory	Practice	Theory	Practice	Theory	Practice	Theory	Practice	Theory	Practice
Level 1	Remember Understand	*30 %*	-	*30 %*	-	*30 %*	-	*30 %*	-	*30%*	-
Level 2	Apply Analyze	*40 %*	-	*40 %*	-	*40 %*	-	*40 %*	-	*40%*	-
Level 3	Evaluate Create	*30 %*	-	*30 %*	-	*30 %*	-	*30 %*	-	*30%*	-
	Total	100 %		100 %		100 %		100 %		100 %	

CLA – 4 can be from any combination of these: Assignments, Seminars, Tech Talks, Mini-Projects, Case-Studies, Self-Study, MOOCs, Certifications, Conf. Paper etc.,

Course Designers

Experts from Industry	Experts from Higher Technical Institutions	Internal Experts
1. Mr. K. Chandru Trivitron Healthcare Pvt. Ltd. Chennai, chandru.k@trivitron.com	*1. Dr. Amit Kumar Mishra , IIT Jodhpur, amit@iitj.ac.in*	*1. Dr. Devanandh Venkata Subhu, SRMIST*
2. Dr.Nagesh Kini,Thermax,Pune,Maharastra,nagesh.kini@gmail.com	*2. Dr. Sampath Kumar T.S,IIT Madras, tssk@iitm.ac.in*	*2. Dr. Selvamurugan, SRMIST*

Course Code	18NTO306T	Course Name	NANOSCALE SURFACE ENGINEERING	Course Category	O	Open Elective	L	T	P	C
							3	0	0	3

Pre-requisite Courses	Nil	Co-requisite Courses	Nil	Progressive Courses	Nil
Course Offering Department	Nanotechnology	Data Book / Codes/Standards	Nil		

Course Learning Rationale (CLR):	*The purpose of learning this course is to:*
CLR-1 :	*Obtain vast knowledge on Surface and Interfaces and its structure*
CLR-2 :	*Understand the process involved in surface and Interfaces*
CLR-3 :	*Understand the Diffusion process involved in surface and related laws*
CLR-4 :	*Describe the laws related to surface phenomena*
CLR-5 :	*Gain knowledge on Surface Analysis Techniques*
CLR-6 :	*Understand the principles of XPS, UPS and ISS*

Course Learning Outcomes (CLO):	*At the end of this course, learners will be able to:*	Learning 1	2	3	Program Learning Outcomes (PLO) 1	2	3	4	5	6	7	8	9	10	11	12	13	14	15
		Level of Thinking (Bloom)	Expected Proficiency (%)	Expected Attainment (%)	Engineering Knowledge	Problem Analysis	Design & Development	Analysis, Design, Research	Modern Tool Usage	Society & Culture	Environment & Sustainability	Ethics	Individual & Team Work	Communication	Project Mgt. & Finance	Life Long Learning	PSO - 1	PSO - 2	PSO – 3
CLO-1 :	*Apply the concept of Surface crystallography to understand the surface structure*	2	80	75	H	M	H	H	H	M	M	H	H	H	M	H	H	H	H
CLO-2 :	*Able to analyze surface related process and its measurements*	2	80	70	H	M	M	H	M	M	M	H	M	H	M	H	M	M	M
CLO-3 :	*Apply the concept of Fick's law to have clear a understanding on surface diffusion process*	2	75	70	H	M	H	H	H	H	H	M	H	H	H	H	H	H	H
CLO-4 :	*Analyze the different mechanisms involved in surface diffusion and kinetics*	2	80	75	M	H	H	M	H	H	H	H	H	H	M	H	H	H	H
CLO-5 :	*Utilize the Photoelectron spectroscopic and Secondary electron techniques to understand the properties of surface*	2	80	70	H	M	H	H	H	M	M	H	M	H	M	H	H	H	H
CLO-6 :	*Analyze different types of metal and semiconducting surfaces and its properties*	2	80	75	H	M	M	H	H	M	M	H	H	H	M	H	H	M	H

Duration (hour)		9	9	9	9	9
S-1	SLO-1	*Introduction to surfaces and interfaces and its related terms and definitions*	*Adsorption and desorption: Definition & Concept*	*Concept of Random-walk motion*	*Surface specificity*	*Nanoscale Characterization for Surfaces*
	SLO-2	*surface energy, surface tension and surface states*	*Various types of adsorption and desorption*	*Basic equations -random-walk motion*	*Spectrum of secondary electrons*	*Scanning tunneling microscopy (STM) – historical perspective and theory*
S-2	SLO-1	*Some basic concepts of bulk crystallography : Direct lattices and directions*	*Basics of adsorption kinetics*	*Fick's laws: Definition and its explanation*	*Photoelectron spectroscopy - Physical process: photoemission, spectral feature*	*STM: electron tunneling*
	SLO-2	*Symmetry groups and planes*	*Concept of coverage dependence*	*Fick's laws: Definition and its explanation*	*Photoelectron spectroscopy -depth specificity*	*STM imaging*
S-3	SLO-1	*Structure of the unit cell, Primitive cell in bulk crystals.*	*Coverage dependence derivation*	*Tracer diffusion*	*Photoelectron spectroscopy (XPS and UPS) - compositional information*	*Scanning tunneling spectroscopy*
	SLO-2	*Concept of ideal crystal and of ideal crystal*	*Langmuir Isotherm*	*Chemical, diffusion*	*Photoelectron spectroscopy (XPS and UPS) - elemental sensitivity*	*STM: Instrumentation*
S-4	SLO-1	*Surface structure and surface order*	*Temperature dependence Kinetics*	*Intrinsic diffusion*	*Photoelectron spectroscopy (XPS and UPS) - chemical-state information*	*Semiconductor surfaces*
	SLO-2	*Surface crystallography*	*Temperature dependence derivation*	*Mass transfer diffusion*	*Photoelectron spectroscopy (XPS and UPS) -spectral resolution and depth profiling*	*Semiconductor surfaces: Si (111)*
S-5	SLO-1	*Surface Crystallography of a plane,*	*Angular dependence Kinetics*	*Anisotropy of surface diffusion*	*Photoelectron spectroscopy (XPS and UPS) -Modular instrumentation: excitation sources*	*Semiconductor surfaces: Si (100)*
	SLO-2	*And its point and space group symmetry*	*Kinetic energy dependence Kinetics*	*Anisotropy of surface diffusion*	*Energy analyzers and detectors*	*Semiconductor surfaces: GaAs (110)*
S-6	SLO-1	*Unit mesh transformation approach*	*Thermal deposition*	*Atomistic mechanisms of surface diffusion and its types*	*Auger Electron spectroscopy (AES): physical process: photoemission*	*Photo induced process*

	SLO-2	*Wood notation description*	*Theory of Desorption kinetics*	*Atomistic mechanisms of surface diffusion: hopping mechanism*	*Ion Scattering Spectroscopy (ISS): physical process: photoemission*	*Different types involved in Photo induced process*
S-7	SLO-1	*Unit mesh transformation approach*	*Thermal desorption spectroscopy: Basic working Principle*	*Atomistic mechanisms of surface diffusion: Vacancy mechanism*	*Spectral feature and depth Specificity*	*Metal – semiconductor surfaces*
	SLO-2	*Matrix notation and classification of overlayer meshes*	*Thermal desorption spectroscopy: Instrumentation*	*Atomistic mechanisms of surface diffusion: Atomic exchange mechanism*	*AES and ISS: compositional information*	*Analysis of Metal – semiconductor surfaces properties*
S-8	SLO-1	*Electronic structure (for three dimension)*	*Adsorption Isotherms: A detailed study*	*Atomistic mechanisms of surface diffusion:Tunneling mechanism*	*AES and ISS:elemental sensitivity*	*Alkali – metal – semiconductor interfaces*
	SLO-2	*Density of States (Surface states)*	*Various types of Adsorption Isotherms*	*Atomistic mechanisms of surface diffusion:Tunneling mechanism*	*AES and ISS: chemical-state information & spectral resolution and depth profiling*	*Analysis of Alkali – metal – semiconductor interfaces properties*
S-9	SLO-1	*Surface states structure (for two dimension)*	*Non-Thermal desorption*	*Nucleation and Equilibration via Surface Diffusion*	*AES and ISS: excitation sources*	*Growth of trivalent metals on Si (001)*
	SLO-2	*Surface electronic structure (for two dimension)*	*Types of Non-Thermal desorption*	*Experimental study of surface diffusion*	*AES and ISS: energy analyzers and detectors*	*Analysis of Growth of trivalent metals on Si (001) properties*

Learning Resources	*1. John DiNardo N., "Nanoscale Characterization Of Surface And Interfaces", Wiley-VCH, 2008* *2. Oura K., V. G. Lifshits, A. A. Saranin, A. V. Zotov and M. Katayama, "Surface Science – An Introduction" Springer, 2013*	*3. Unertl W.N., "Physical structure" Elsevier Science B. V, 2006* *4. Riviere J.C and Myhra S., "Handbook of Surface and Interface analysis", CRC Press, 2009*

Learning Assessment

	Bloom's Level of Thinking	Continuous Learning Assessment (50% weightage)								Final Examination (50% weightage)	
		CLA – 1 (10%)		CLA – 2 (15%)		CLA – 3 (15%)		CLA – 4 (10%)#			
		Theory	Practice	Theory	Practice	Theory	Practice	Theory	Practice	Theory	Practice
Level 1	Remember Understand	*30 %*	-	*30 %*	-	*30 %*	-	*30 %*	-	*30%*	-
Level 2	Apply Analyze	*40 %*	-	*40 %*	-	*40 %*	-	*40 %*	-	*40%*	-
Level 3	Evaluate Create	*30 %*	-	*30 %*	-	*30 %*	-	*30 %*	-	*30%*	-
	Total	100 %		100 %		100 %		100 %		100 %	

CLA – 4 can be from any combination of these: Assignments, Seminars, Tech Talks, Mini-Projects, Case-Studies, Self-Study, MOOCs, Certifications, Conf. Paper etc.,

Course Designers

Experts from Industry	Experts from Higher Technical Institutions	Internal Experts
1.Mr.Solomon Jonnes,Bengaluru,solomon@terracarb.com	*1. Dr.Amit Kumar Mishra , IIT Jodhpur, amit@iitj.ac.in*	*1. Dr. V. Kathirvel, SRMIST*
2. Dr.Nagesh Kini,Thermax,Pune,Maharastra,nagesh.kini@gmail.com	*2. Dr.Sampath Kumar T.S, IIT Madras, tssk@iitm.ac.in*	*2. Dr. A. Alagirisamy SRMIST*

Course Code	18NTO307T	Course Name	NANOCOMPUTING	Course Category	O	Open Elective	L	T	P	C
							3	0	0	3

Pre-requisite Courses	Nil	Co-requisite Courses	Nil	Progressive Courses	Nil
Course Offering Department	Nanotechnology	Data Book / Codes/Standards	Nil		

Course Learning Rationale (CLR):	*The purpose of learning this course is to:*
CLR-1 :	*Acquire knowledge on nanoelectronics and its importance*
CLR-2 :	*Introduce the concept of molecular and optical computing*
CLR-3 :	*Understand about biocomputers and related nanomachines*
CLR-4 :	*Learn basics and advancements of quantum computing*
CLR-5 :	*Understand the architecture of processing in nanosystems*
CLR-6 :	*Gain knowledge on soft computing and neural networks*

Course Learning Outcomes (CLO):	*At the end of this course, learners will be able to:*	Learning 1: Level of Thinking (Bloom)	Learning 2: Expected Proficiency (%)	Learning 3: Expected Attainment (%)	PLO 1: Engineering Knowledge	PLO 2: Problem Analysis	PLO 3: Design & Development	PLO 4: Analysis, Design, Research	PLO 5: Modern Tool Usage	PLO 6: Society & Culture	PLO 7: Environment & Sustainability	PLO 8: Ethics	PLO 9: Individual & Team Work	PLO 10: Communication	PLO 11: Project Mgt. & Finance	PLO 12: Life Long Learning	PLO 13: PSO - 1	PLO 14: PSO - 2	PLO 15: PSO – 3
CLO-1 :	*Apply the basic concepts in nanocomputing*	2	80	75	H	M	H	H	H	M	M	H	H	H	M	H	H	H	H
CLO-2 :	*Explain major advances in molecular and optical computing*	2	80	70	H	M	M	H	M	M	M	H	M	H	M	H	M	M	M
CLO-3 :	*Recognize the evolution and advancements of biocomputers*	2	75	70	H	M	H	H	H	H	H	M	H	H	H	H	H	H	H
CLO-4 :	*Utilize the knowledge in quantum computing*	2	80	75	M	H	H	M	H	H	H	H	H	H	M	H	H	H	H
CLO-5 :	*Get familiarized with designing of parallel information processing machines*	2	80	70	H	M	H	H	H	M	M	H	M	H	M	H	H	H	H
CLO-6 :	*Apprehend the importance of soft computing*	2	80	75	H	M	M	H	H	M	M	H	H	H	M	H	H	M	H

Duration (hour)		9	9	9	9	9
S-1	SLO-1	*History of computing*	*Molecular computing*	*Biological networks and neurons*	*Quantum computers-Bit and Qubit*	*Parallel Architectures for Nanosystems-Architectural principles*
	SLO-2	*Nanocomputing*	*Brief background of molecular electronics*	*Function of neuronal cell*	*Coherence and entanglement*	*Mono and multiprocessor systems*
S-2	SLO-1	*Transistors inside the Machine*	*Origin of molecular computing*	*Biology-inspired concepts*	*Quantum parallelisms*	*Some considerations to parallel processing*
	SLO-2	*Quantum computers*	*Molecular computing architecture*	*Biological Neuronal cells on silicon*	*Classical gates*	*Influence of delay time*
S-3	SLO-1	*Nanocomputing technologies*	*Some techniques of molecular computing-Adleman's landmark experiment*	*Modeling of neuron cells by VLSI circuits*	*Reversible operations*	*Power dissipation and Parallelism*
	SLO-2	*From Microelectronics to Nanoelectronics*	*DNA computation in ciliates-Bacteriorhodopsin*	*Neuronal networks with local adaptation*	*Beyond Classical Gates-Superposition*	*Architecture for processing in Nanosystems-Classic systolic arrays*
S-4	SLO-1	*From Nanoelectronics to Nanoelectronics computers*	*Challenges of molecular computing-Reliability, Efficiency and Scalability*	*Distributed data processing*	*Sqrt(NOT) operation*	*Processor with large memories*
	SLO-2	*Alternative to Transistor technology – quantum computing*	*Encoding problem-Error-preventing codes*	*Biocomputers – biochemical computers*	*Quantum algorithms-Necessity of quantum software in Conjunction with the hardware*	*Processor array with SIMD and PIP architectures*
S-5	SLO-1	*Nanoinformation processing - Prospects and challenges*	*Building and programming molecular computers*	*Biomechanical computers*	*Searching by using Sqrt (NOT)*	*Reconfigurable computers*
	SLO-2	*Digital signals and gates*	*Optical computing- Introduction*	*Bioelectronic computers*	*Hardware challenges to large Quantum Computers*	*Teramac concept as a prototype*
S-6	SLO-1	*Silicon nanoelectronics-short channel effects*	*Current use of optics for computing*	*Engineering biocomputers*	*Ion traps-Solids*	*Soft computing*

	SLO-2	*Leakage current in scaled devices-process variation*	*Advantages of optical methods over electronic ones*	*DNA computer*	*NMR in organic liquids-Optics*	*Methods of soft computing -Fuzzy systems*
S-7	SLO-1	*Carbon nanotube electronics*	*Some roles of optics – 2D array mapping*	*Information processing with chemical reactions*	*Fabrication Challenges*	*Evolutionary algorithms*
	SLO-2	*Band structure of carbon nanotubes-Carbon Nanotube properties*	*Garbage free operations*	*Peptide computing*	*Testing and architectural challenges*	*Connectionistic systems*
S-8	SLO-1	*Carbon nanotube field effect transistors*	*Optical computing paradigms*	*Development of a peptide computer*	*Quantum dot cellular automata*	*Computational Intelligence systems*
	SLO-2	*Simulation of Schottky barrier carbon nanotube FETs*	*Ultrafast pulse shaping -Tb/sec data speeds*	*Nanomachines*	*Computing with QCA*	*Characteristics of neural networks in nanoelectronics*
S-9	SLO-1	*MOSFET like carbon nanotube FETs*	*Role of non-linear materials in Nanocomputing: Need for new materials*	*Wetware computer*	*QCA clocking*	*Local processing*
	SLO-2	*Simulation of MOSFET characteristics*	*Advance in Photonic switches*	*Parallel processing*	*QCA design rules*	*Self organization*

Learning Resources	1. *Vishal Sahni and Debabrata Goswami, "Nanocomputing: The Future of Computing", Tata McGraw-Hill Education, 2008*	2. *Karl Goser, Peter Glösekötter and Jan Dienstuhl, "Nanoelectronics and Nanosystems: From Transistors to Molecular and Quantum devices", Springer, 2005*

Learning Assessment											
	Bloom's Level of Thinking	Continuous Learning Assessment (50% weightage)								Final Examination (50% weightage)	
		CLA – 1 (10%)		CLA – 2 (15%)		CLA – 3 (15%)		CLA – 4 (10%)#			
		Theory	Practice	Theory	Practice	Theory	Practice	Theory	Practice	Theory	Practice
Level 1	Remember Understand	*30 %*	-	*30 %*	-	*30 %*	-	*30 %*	-	*30%*	-
Level 2	Apply Analyze	*40 %*	-	*40 %*	-	*40 %*	-	*40 %*	-	*40%*	-
Level 3	Evaluate Create	*30 %*	-	*30 %*	-	*30 %*	-	*30 %*	-	*30%*	-
	Total	100 %		100 %		100 %		100 %		100 %	

CLA – 4 can be from any combination of these: Assignments, Seminars, Tech Talks, Mini-Projects, Case-Studies, Self-Study, MOOCs, Certifications, Conf. Paper etc.,

Course Designers		
Experts from Industry	Experts from Higher Technical Institutions	Internal Experts
1. Dr. Hemant Dixit, Global Foundaries,USA, aplahemant@gmail.com	*1. Dr. Ranjit Kumar Nanda, IIT Madras, nandab@iitm.ac.in*	*1. Dr. V. J. Surya, SRMIST*
2. Dr. Krishna Surendra Muvvala, Saint Gobain Research India, India, Krishna.muvvala@saintgobain.com	*2. Dr. G. P. Das,IIT Kharagpur gpdas@metal.iitkgp.ac.in*	*2. Dr. Saurabh Ghosh, SRMIST*

Course Code	18NTO308T	Course Name	SMART SENSOR SYSTEMS	Course Category	O	Open Elective	L	T	P	C
							3	0	0	3

Pre-requisite Courses	Nil	Co-requisite Courses	Nil	Progressive Courses	Nil
Course Offering Department	Nanotechnology	Data Book / Codes/Standards	Nil		

Course Learning Rationale (CLR):	The purpose of learning this course is to:
CLR-1 :	*Acquire knowledge on various sensor systems*
CLR-2 :	*Understand different conversion phenomena involved in sensors*
CLR-3 :	*Describe construction and function of different sensors*
CLR-4 :	*Gain knowledge on the material requirement for different sensing mechanisms*
CLR-5 :	*Gain knowledge on individual sensing devices and integration of technologies*
CLR-6 :	*Understand the basic requirements of basic microsystem technologies and MEMS fabrication processes*

		Learning			Program Learning Outcomes (PLO)														
		1	2	3	1	2	3	4	5	6	7	8	9	10	11	12	13	14	15
Course Learning Outcomes (CLO):	At the end of this course, learners will be able to:	Level of Thinking (Bloom)	Expected Proficiency (%)	Expected Attainment (%)	Engineering Knowledge	Problem Analysis	Design & Development	Analysis, Design, Research	Modern Tool Usage	Society & Culture	Environment & Sustainability	Ethics	Individual & Team Work	Communication	Project Mgt. & Finance	Life Long Learning	PSO - 1	PSO - 2	PSO – 3
CLO-1 :	*Apply the principles involved in conversion from one energy domain to electrical signal*	2	80	75	H	M	H	H	H	M	M	H	H	H	M	H	H	H	H
CLO-2 :	*Analyze the sensor characteristics and its suitability for a particular application*	2	80	70	H	M	M	H	M	M	M	H	M	H	M	H	M	M	M
CLO-3 :	*Utilize the suitable material properties to design a sensor*	2	75	70	H	M	H	H	H	H	H	M	H	H	H	H	H	H	H
CLO-4 :	*Implement a suitable sensor technology for a particular application*	2	80	75	M	H	H	M	H	H	H	H	H	H	M	H	H	H	H
CLO-5 :	*Explain the concepts of system organization and integration to make a smart sensor*	2	80	70	H	M	H	H	H	M	M	H	M	H	M	H	H	H	H
CLO-6 :	*Utilize the different sensor concepts to design a lab-on-chip*	2	80	75	H	M	M	H	H	M	M	H	H	H	M	H	H	M	H

Duration (hour)		9	9	9	9	9
S-1	SLO-1	*Definitions of Sensors and Smart Sensors*	*Acoustic waves: Fundamentals*	*Light Detectors*	*Biosensors definition*	*Fundamentals of MEMS/ fabrication:*
	SLO-2	*Integrated Smart Sensors and Applications*	*Piezoelectric materials for acoustic sensors*	*Photodiodes, Photoresistors*	*Bioreceptors*	*Frequently Used Microfabrication Processes*
S-2	SLO-1	*Sensors classifications*	*Solid state SAW sensors*	*HgCdTe infrared sensors*	*Construction of different biosensors*	*Lithography, thin film deposition*
	SLO-2	*Detection means used in sensors and conversion phenomena*	*Applications of SAW sensors*	*Visible-light color sensors, high-energy photodiodes*	*Immobilization of biological elements*	*Oxidation, Etching (wet and dry)*
S-3	SLO-1	*Measurements*	*Acoustic Sensors: Resistive Microphones, Condenser Microphones*	*Radiation Detectors: Scintillating Detectors*	*Transduction principles used in biosensing*	*MEMS fabrication technologies: Bulk micromachining and structures*
	SLO-2	*Units of Measurements*	*Piezoelectric Microphones*	*Semiconductor Radiation Detectors*	*Lab-on-chip/Microsystems/MicroTAS*	*Surface micromachining and structures*
S-4	SLO-1	*Sensor Characteristics: Transfer Function, Calibration, Static Characteristics*	*Magnetic sensors*	*Thermal Sensors: Functional Principle*	*Microfluidics*	*High-aspect-ratio technology microfluidics microsystem components*
	SLO-2	*Accuracy, Calibration Error, Hysteresis, Nonlinearity, Resolution, Dynamic Characteristics*	*Magnetic Effects and materials*	*Heat Transfer Mechanisms*	*Microfluidic unit operations*	*LIGA(Lithographie, Galvanoformung, Abformung)*
S-5	SLO-1	*Physical principles of sensing: electric charges*	*Integrated Hall sensors*	*Temperature Sensors*	*Microsystem Integration*	*Microsystem components*
	SLO-2	*Electric fields, and potentials*	*Magnetotransistors*	*Thermoresistive Sensors*	*System organization and functions*	*Application of different Microsystem components*
S-6	SLO-1	*Capacitance, dielectric constant*	*Force, Strain, and Tactile Sensors*	*Thermoelectric Contact Sensors, Thermocouple Assemblies*	*Interface electronics*	*Nanotechnology:*
	SLO-2	*Magnetic Principle*	*Strain Gauges, Piezoelectric Force Sensors*	*Semiconductor pn-Junction thermal Sensors, Optical Temperature Sensors*	*Fundamentals of interfacing*	*product prospects - application trends*

S-7	SLO-1	*Induction Principle*	*Tactile Sensors*	*Chemical sensors: Classes of Chemical Sensors*	*Universal transducer interface*	*Ultra-thin films*
	SLO-2	*Electrical Resistance*	*Piezoresistive sensors(Tactile)*	*Interaction of gaseous species at semiconductor Surfaces*	*Three-Signal Technique*	*Making of ultrathin films*
S-8	SLO-1	*Piezoelectric effect*	*Piezoelectric Sensors(Tactile)*	*Catalysis, the acceleration of chemical reactions,*	*Introduction to microsystems engineering*	*Creation of lateral nanostructures,*
	SLO-2	*Pyroelectric effect*	*Capacitive Touch Sensors (Tactile)*	*Thin-film sensors (Chemoresistive sensors)*	*Microtechnologies*	*Creation of clusters and nanocrystalline materials*
S-9	SLO-1	*Hall effect Principle*	*PiezoresistivePressure Sensors*	*Filed Effect Transistor for Gas sensing*	*Systems development: methods and tools*	*Principles of self-organization*
	SLO-2	*Seebeck and Peltier effects*	*Capacitive Pressure Sensor*	*FET devices ion sensing*	*Constructive and connective techniques*	*Future trends*

Learning Resources	1. *Jacob Fraden, "Handbook of Modern Sensors: Physics, Designs, and Applications", Springer; 4th ed. 2010* 2. *S. M. Sze, "Semiconductor Sensors", Wiley-Interscience,1994*	3. *Gerard Meijer, "Smart sensor systems", Wiley, 2008* 4. *W Gopel, J. Hesse, J. N. Zemel, "Sensors A Comprehensive Survey" Vol. 8, Wiley-VCH, 1995*

Learning Assessment												
	Bloom's Level of Thinking	Continuous Learning Assessment (50% weightage)								Final Examination (50% weightage)	
		CLA – 1 (10%)		CLA – 2 (15%)		CLA – 3 (15%)		CLA – 4 (10%)#			
		Theory	Practice	Theory	Practice	Theory	Practice	Theory	Practice	Theory	Practice
Level 1	Remember / Understand	*30 %*	-	*30 %*	-	*30 %*	-	*30 %*	-	*30%*	-
Level 2	Apply / Analyze	*40 %*	-	*40 %*	-	*40 %*	-	*40 %*	-	*40%*	-
Level 3	Evaluate / Create	*30 %*	-	*30 %*	-	*30 %*	-	*30 %*	-	*30%*	-
	Total	100 %		100 %		100 %		100 %		100 %	

CLA – 4 can be from any combination of these: Assignments, Seminars, Tech Talks, Mini-Projects, Case-Studies, Self-Study, MOOCs, Certifications, Conf. Paper etc.,

Course Designers		
Experts from Industry	Experts from Higher Technical Institutions	Internal Experts
1. Dr. N. Vijayan, CSIR-NPL, nvijayan@nplindia.org	*1. Prof. S. Balakumar, University of Madras, balakumar@unom.ac.in*	*1. Dr. A. Karthigeyan, SRMIST*
2. Dr. Krishna SurendraMuvvala, Saint Gobain Research India, India, Krishna.muvvala@saintgobain.com	*2. Prof. V. Subramaniyam, IIT Madras, manianvs@iitm.ac.in*	*2. Dr. M.Kiran, SRMIST*

Course Code	18NTO401T	Course Name	2D MATERIALS AND APPLICATIONS	Course Category	O	Open Elective	L	T	P	C
							3	0	0	3

Pre-requisite Courses	Nil	Co-requisite Courses	Nil	Progressive Courses	Nil
Course Offering Department	Nanotechnology	Data Book / Codes/Standards		Nil	

Course Learning Rationale (CLR):	*The purpose of learning this course is to:*
CLR-1 :	*Acquire knowledge on graphene and its superior physical properties*
CLR-2 :	*Gain the knowledge on other emerging semiconducting and insulating layered materials*
CLR-3 :	*Describe the methods on synthesis of 2D materials*
CLR-4 :	*Understand the 2D materials physical properties using micro and nanocharacterization techniques*
CLR-5 :	*Gain knowledge on applications 2D materials in technological applications*
CLR-6 :	*Understand the importance of 2D materials applications real life applications*

Course Learning Outcomes (CLO):	*At the end of this course, learners will be able to:*	Learning			Program Learning Outcomes (PLO)														
		1	2	3	1	2	3	4	5	6	7	8	9	10	11	12	13	14	15
		Level of Thinking (Bloom)	Expected Proficiency (%)	Expected Attainment (%)	Engineering Knowledge	Problem Analysis	Design & Development	Analysis, Design, Research	Modern Tool Usage	Society & Culture	Environment & Sustainability	Ethics	Individual &Team Work	Communication	Project Mgt. & Finance	Life Long Learning	PSO - 1	PSO - 2	PSO - 3
CLO-1 :	*Understand the scientific knowledge on producing graphene*	2	80	75	H	M	H	H	H	M	M	H	H	H	M	H	H	H	H
CLO-2 :	*Analyze different 2D materials with tunable properties*	2	80	70	H	M	M	H	M	M	M	H	M	H	M	H	M	M	M
CLO-3 :	*Different methods of synthesis method for 2D materials*	2	75	70	H	M	H	H	H	H	H	M	H	H	H	H	H	H	H
CLO-4 :	*Utilize the spectroscopic concepts to analyze the properties of materials*	2	80	75	M	H	H	M	H	H	H	H	H	H	M	H	H	H	H
CLO-5 :	*Use the 2D materials for Biomedical applications*	2	80	70	H	M	H	H	H	M	M	H	M	H	M	H	H	H	H
CLO-6 :	*Use the 2D materials for optoelectronics and nanoelectronics*	2	80	75	H	M	M	H	H	M	M	H	H	H	M	H	H	M	H

Duration (hour)		9	9	9	9	9
S-1	SLO-1	*Carbon Atom and Its Allotropes*	*Graphene derivatives: Graphene Oxide*	*Synthesis of 2D materials*	*Applications of 2D materials*	*Graphene-based transistors*
	SLO-2	*Diamond, Graphite, Fullerenes*	*Graphene composites*	*Bottom up methods*	*Biomedical applications of rGO*	*Graphene based RF transistors for Flexible electronics*
S-2	SLO-1	*Graphene*	*Beyond graphene*	*Chemical Vapor Deposition*	*Drug/gene delivery,bioimaging, biosensing*	*2D TMD based Photodetectors*
	SLO-2	*Electronic Structure of graphene*	*Transition metal dichalcogenide (TMD) and white graphene(White graphene)*	*Pulsed Laser Deposition*	*Photothermal therapy*	*Phototransistors*
S-3	SLO-1	*Electronic properties*	*Crystal structure*	*Epitaxial growth*	*Tissue engineering and anti-bacterial applications*	*Hybrid Phototransistors*
	SLO-2	*Optical properties*	*Electronic and optical properties*	*Physical vapor deposition*	*Biocompatibility and biodistribution*	*Heterostructure Photodetectors*
S-4	SLO-1	*Helicity and Chirality*	*Traps and defects*	*Top down methods*	*Scaffolds for tissue engineering*	*2D TMD based Light Emitters*
	SLO-2	*Klein Tunneling*	*Mechanical properties*	*Mechanical Exfoliation*	*Cancer therapy*	*Hot Carrier EL*
S-5	SLO-1	*High Mobility of graphene*	*Strain effect on electrical and vibrational properties*	*Liquid phase exfoliation*	*Graphene devices for Biomolecule detection*	*Light-Emitting Diodes*
	SLO-2	*Minimum Conductivity and Universal Optical Conductivity of graphene*	*Theoretical methods*	*Electrochemical Lithium Intercalation*	*Graphene devices for Biomolecule sequencing*	*Circularly Polarized Light Emission*
S-6	SLO-1	*Bilayer and multilayer Graphene*	*Silicene and Germanene*	*Ball Milling*	*Photocatalysts*	*Heterostructure Light Emitters*
	SLO-2	*Presence of a Magnetic Field*	*Properties of Silicene and Germanene*	*Hydrodynamics Exfoliation*	*Graphene oxide (GO) forDye degradation and pollutant adsorption*	*2D TMD-Based Photovoltaics applications :*
S-7	SLO-1	*Homogeneous Magnetic Field*	*2D Topological Insulator*	*Basic Characterization of 2D materials*	*Hydrogen production form water splitting*	*Solar cells*
	SLO-2	*LLs in Bilayer Graphene*	*Phosphorene: A Novel 2D Material*	*UV-Vis absorption Spectroscopy*	*TMDs 2D materials for Electrocatalysis and electrochemical sensing*	*Graphene membranes*
S-8	SLO-1	*Anomalous Quantum Hall Effect*	*2D Crystal-Based Heterostructures*	*Raman spectroscopy*	*Oxygen evolution reaction (OER)*	*Membranes for separation*
	SLO-2	*Carrier density*	*A 'Legoland' of Two-Dimensional Materials*	*Scanning electron microscopy*	*Oxygen reduction reaction (ORR)*	*Membranes as barriers*

S-9	SLO-1	*Gauge Fields Induced by Lattice Deformation*	*Handling of 2D Heterostructures: Practical Issues*	*Transmission electron microscopy*	*Hydrogen evolution reaction (HER)*	*Supercapacitor electrodes*
	SLO-2	*Deformation and Elastic strain*	*Tunnel Diodes and Transistors Based on 2D Heterostructures*	*Atomic force microscopy*	*Hydrogen oxidation reaction (HOR)*	*2D Black phosphorus based FET for Sensor and detector applications*

Learning Resources	*1. Banks, Craig E., and Dale AC Brownson, eds. "2D Materials: Characterization, Production and Applications"- CRC Press, 2018.* *2. Houssa, Michel, Athanasios Dimoulas, and Alessandro Molle,"2D Materials for Nanoelectronics"- CRC Press, 2016.*	*3. Tiwari, Ashutosh, and Mikael Syväjärvi, eds. "Advanced 2D Materials" - John Wiley & Sons, 2016.* *4. Dragoman, Mircea, and Daniela Dragoman,"2D Nanoelectronics: Physics and Devices of Atomically Thin Materials"- Springer, 2016.*

Learning Assessment

	Bloom's Level of Thinking	Continuous Learning Assessment (50% weightage)								Final Examination (50% weightage)	
		CLA – 1 (10%)		CLA – 2 (15%)		CLA – 3 (15%)		CLA – 4 (10%)#			
		Theory	Practice	Theory	Practice	Theory	Practice	Theory	Practice	Theory	Practice
Level 1	Remember Understand	*30 %*	-	*30 %*	-	*30 %*	-	*30 %*	-	*30%*	-
Level 2	Apply Analyze	*40 %*	-	*40 %*	-	*40 %*	-	*40 %*	-	*40%*	-
Level 3	Evaluate Create	*30 %*	-	*30 %*	-	*30 %*	-	*30 %*	-	*30%*	-
	Total	100 %		100 %		100 %		100 %		100 %	

CLA – 4 can be from any combination of these: Assignments, Seminars, Tech Talks, Mini-Projects, Case-Studies, Self-Study, MOOCs, Certifications, Conf. Paper etc.,

Course Designers

Experts from Industry	Experts from Higher Technical Institutions	Internal Experts
1. Dr. Hemant Dixit, GlobalFoundaries,USA, aplahemant@gmail.com	*1. Dr. Ramaprabhu, IIT Madras, ramp@iitm.ac.in*	*1. Dr.V.Eswaraiah, SRMIST*
2. Dr. Krishna Surendra Muvvala, Saint Gobain Research India, India, Krishna.muvvala@saintgobain.com	*2. Dr. M. S. Ramachandra Rao, IIT Madras, msrrao@iitm.ac.in*	*2. Dr. Abhay, SRM IST*

Course Code	18NTO402T	Course Name	NANO AND MICRO ELECTROMECHANICAL SYSTEMS	Course Category	O	Open Elective	L	T	P	C
							3	0	0	3

Pre-requisite Courses	Nil	Co-requisite Courses	Nil	Progressive Courses	Nil
Course Offering Department		Nanotechnology	Data Book / Codes/Standards	Nil	

Course Learning Rationale (CLR):	*The purpose of learning this course is to:*
CLR-1 :	*Acquire knowledge on MEMS and NEMS fundamentals*
CLR-2 :	*Understand different principles involved in MEMS devices*
CLR-3 :	*Describe construction and function of MEMS actuators*
CLR-4 :	*Gain knowledge on the material requirement for different actuation mechanisms*
CLR-5 :	*Gain knowledge on individual sensing and Micromechanical components and their integration*
CLR-6 :	*Understand the basic microsystem and MEMS fabrication process technologies*

Course Learning Outcomes (CLO):	*At the end of this course, learners will be able to:*	Learning 1 Level of Thinking (Bloom)	2 Expected Proficiency (%)	3 Expected Attainment (%)	PLO 1 Engineering Knowledge	2 Problem Analysis	3 Design & Development	4 Analysis, Design, Research	5 Modern Tool Usage	6 Society & Culture	7 Environment & Sustainability	8 Ethics	9 Individual & Team Work	10 Communication	11 Project Mgt. & Finance	12 Life Long Learning	13 PSO - 1	14 PSO - 2	15 PSO – 3
CLO-1 :	*Apply the principles of sensing and actuation to design NEMS and MEMS devices*	*2*	*80*	*75*	*H*	*M*	*H*	*H*	*H*	*M*	*M*	*H*	*H*	*H*	*M*	*H*	*H*	*H*	*H*
CLO-2 :	*Analyze the suitability of a actuation mechanism for a particular application*	*2*	*80*	*70*	*H*	*M*	*M*	*H*	*M*	*M*	*M*	*H*	*M*	*H*	*M*	*H*	*M*	*M*	*M*
CLO-3 :	*Utilize the suitable material properties to design a MEMS structure*	*2*	*75*	*70*	*H*	*M*	*H*	*H*	*H*	*H*	*H*	*M*	*H*	*H*	*H*	*H*	*H*	*H*	*H*
CLO-4 :	*Apply a suitable microsystem technology to create different nano and micro mechanical structure*	*2*	*80*	*75*	*M*	*H*	*H*	*M*	*H*	*H*	*H*	*H*	*H*	*H*	*H*	*H*	*H*	*H*	*H*
CLO-5 :	*Design high aspect ratio structure and integration with microsystem technologies*	*2*	*80*	*70*	*H*	*M*	*H*	*H*	*H*	*M*	*M*	*H*	*M*	*H*	*M*	*H*	*H*	*H*	*H*
CLO-6 :	*Utilize the different sensing and actuation concepts to design a lab-on-chip*	*2*	*80*	*75*	*H*	*M*	*M*	*H*	*H*	*M*	*M*	*H*	*H*	*H*	*H*	*H*	*H*	*M*	*H*

Duration (hour)		9	9	9	9	9
S-1	SLO-1	*Micro- and nanoelectromechanical systems*	*Photolithography*	*SensingPrinciples*	*Magnetic materials used in MEMS*	*Principles of MOEMS technology*
	SLO-2	*MEMS and NEMS: An overview*	*Structural and sacrificial materials*	*Actuation Principles*	*MagneticProperties used in MEMS*	*Applications of MOEMS*
S-2	SLO-1	*Nanoelectromechanical Systems*	*Thin film deposition*	*Components: Beam*	*Magnetic sensing and detection*	*Properties of Light*
	SLO-2	*Scaling Laws*	*Physical Vapor Deposition , Chemical Vapor Deposition techniques*	*Cantilever, microplates*	*Magneto resistive sensor*	*Light modulators*
S-3	SLO-1	*Modeling*	*Impurity doping*	*Capacitive effects*	*Hall Effect based sensors*	*Beam splitters*
	SLO-2	*The input-output concept*	*Etching (Wet and Dry)*	*Piezo elements*	*Magnetodiodes, Magntotransistor*	*Micro lens*
S-4	SLO-1	*Sensors and Actuators*	*Bulk micromachining*	*Strain Measurements*	*Magnetic actuation Principles*	*Micro mirror,Digital micromirror device*
	SLO-2	*Energy Domains and Transducers*	*Surface micromachining*	*Pressure and flow measurements*	*Essential magnetic actuation concepts*	*Optical switch, Wave guide and tuning*
S-5	SLO-1	*Sensors considerations*	*Wafer bonding*	*MEMS Gyroscopes*	*Magnetic MEMS actuators*	*Properties of fluid*
	SLO-2	*Actuator considerations*	*Lithographie, Galvanoformung, Abformung (LIGA) Process*	*Shear modepiezo actuators*	*Bidirectional Microactuators*	*Fluid actuation methods*
S-6	SLO-1	*Mechanical MEMS*	*MEMS Integration*	*Gripping piezo actuators*	*RF based communication systems*	*Dilectrophoresis, Electrothermal flow*
	SLO-2	*Thermal MEMS*	*Packaging considerations*	*Strain Measurement*	*RF MEMS*	*thermo capillary effect*
S-7	SLO-1	*Micro-Opto-Electro-Mechanical Systems (MOEMS)*	*Basic Modeling elements: Mechanical*	*Thermal sensors and actuators*	*MEMS inductor*	*Micropumps: design consideration*
	SLO-2	*Magnetic MEMS, Radio-Frequency MEMS*	*Basic Modeling elements: Electrical systems*	*Thermal basics*	*MEMS Varactors*	*Lab-on-chip*
S-8	SLO-1	*Microfluidic systems*	*Basic Modeling elements: Fluid systems*	*Thermocouples*	*MEMS Tuner/filter*	*IC technology*
	SLO-2	*Bio-Chemo devices*	*Basic Modeling elements: Thermal systems*	*Thermoresistors*	*MEMS Resonators*	*MEMS Fabrication versus IC fabrication*
S-9	SLO-1	*MEMS Architectures*	*Translational pure mechanical systems*	*Actuators based on thermal expansion*	*MEMS Switches*	*IntegratingIC and MEMS*
	SLO-2	*NEMS Architectures*	*Rotational pure mechanical systems*	*Applications of thermal actuators*	*MEMS Phase shifter*	*Future prospects*

Learning Resources	1. *Mahalik N P, "MEMS", Tata McGraw-Hill Education, 2008* 2. *Sergey Edward Lyshevski, "Micro-Electro Mechanical and Nano-Electro Mechanical Systems, Fundamental of Nano-and Micro-Engineering", CRC Press, 2005*	3. *Chang Liu "Foundation of MEMS", Prentice Hall, 2012*

Learning Assessment											
	Bloom's Level of Thinking	Continuous Learning Assessment (50% weightage)								Final Examination (50% weightage)	
		CLA – 1 (10%)		CLA – 2 (15%)		CLA – 3 (15%)		CLA – 4 (10%)#			
		Theory	Practice	Theory	Practice	Theory	Practice	Theory	Practice	Theory	Practice
Level 1	Remember Understand	*30 %*	-	*30 %*	-	*30 %*	-	*30 %*	-	*30%*	-
Level 2	Apply Analyze	*40 %*	-	*40 %*	-	*40 %*	-	*40 %*	-	*40%*	-
Level 3	Evaluate Create	*30 %*	-	*30 %*	-	*30 %*	-	*30 %*	-	*30%*	-
	Total	100 %		100 %		100 %		100 %		100 %	

CLA – 4 can be from any combination of these: Assignments, Seminars, Tech Talks, Mini-Projects, Case-Studies, Self-Study, MOOCs, Certifications, Conf. Paper etc.,

Course Designers		
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2. Dr. Krishna Surendra Muvvala, Saint Gobain Research India, India, Krishna.muvvala@saintgobain.com	*2. Dr. M. S. Ramachandra Rao, IIT Madras, msrrao@iitm.ac.in*	*2. Dr. M. Kiran, SRMIST*

Course Code	18NTO403T	Course Name	SCIENTIFIC RESEARCH PRINCIPLES	Course Category	O	Open Elective	L	T	P	C
							3	0	0	3

Pre-requisite Courses		Co-requisite Courses	Nil	Progressive Courses	Nil
Course Offering Department	Nanotechnology	Data Book / Codes/Standards	Nil		

Course Learning Rationale (CLR):	The purpose of learning this course is to:
CLR-1 :	*Familiarize with the concept of research ethics*
CLR-2 :	*Understand the concept of academic plagiarism*
CLR-3 :	*Understand the concept of Good, Bad science and pseudoscience*
CLR-4 :	*Gain knowledge on research methodology*
CLR-5 :	*Learn the process of scientific writing*
CLR-6 :	*Understand the principles of research Design*

Course Learning Outcomes (CLO):	At the end of this course, learners will be able to:	Learning 1 Level of Thinking (Bloom)	2 Expected Proficiency (%)	3 Expected Attainment (%)	PLO 1 Engineering Knowledge	2 Problem Analysis	3 Design & Development	4 Analysis, Design, Research	5 Modern Tool Usage	6 Society & Culture	7 Environment & Sustainability	8 Ethics	9 Individual & Team Work	10 Communication	11 Project Mgt. & Finance	12 Life Long Learning	13 PSO - 1	14 PSO - 2	15 PSO – 3
CLO-1 :	*Apply the scientific concepts of ethics and plagiarism*	2	80	80	H	M	H	H	H	M	M	H	H	H	M	H	H	H	H
CLO-2 :	*Acquire the knowledge of global and national research ethics*	2	80	75	H	M	M	H	M	M	M	H	M	H	M	H	M	M	M
CLO-3 :	*Ability to appreciate the importance of honesty and integrity in academic life*	2	80	80	H	M	H	H	H	H	H	M	H	H	H	H	H	H	H
CLO-4 :	*Apply scientific research methodology for real life problems*	2	75	70	M	H	H	M	H	H	H	H	H	H	M	H	H	H	H
CLO-5 :	*Utilize the method of scientific writing*	2	75	70	H	M	H	H	H	M	M	H	M	H	M	H	H	H	H
CLO-6 :	*Utilize the methods of data analysis in various applications*	2	80	75	H	M	M	H	H	M	M	H	H	H	M	H	H	M	H

Duration (hour)		9	9	9	9	9
S-1	SLO-1	*Introduction – ethics*	*Research and ethics*	*Good science vs. Bad science*	*Research design*	*Scientific Writing*
	SLO-2	*Scientific ethics*	*Scientific misconduct*	*Pseudoscience*	*Design of the apparatus*	*Authenticity, accuracy*
S-2	SLO-1	*Code of ethics*	*Forms of misconduct*	*Ways of identification*	*Design issues and remedies*	*Originality of the work*
	SLO-2	*Ethics for Engineering*	*Cheating*	*Curiosity and research*	*Design methodology*	*Title preparation*
S-3	SLO-1	*Standards of ethical conduct*	*Plagiarism*	*Empiricism*	*Experimentation – sampling*	*List of authors and addresses*
	SLO-2	*Ethical conduct-expectations and outcome*	*Recognizing plagiarism*	*Rationalism*	*Experimentation –measurements*	*Abstract writing*
S-4	SLO-1	*National research ethics*	*Self-plagiarism*	*Intuition, authority*	*Replication of the data*	*introduction writing*
	SLO-2	*Global research ethics*	*Ghostwriting and detection*	*Literature review*	*Data analysis*	*Description of methods*
S-5	SLO-1	*Intellectual property rights*	*Honor code system*	*Elementary scientific methods*	*Error identification*	*Description of methodology*
	SLO-2	*Fundamental IP laws*	*academic dishonesty*	*Observations and observational bias*	*Error in measurement*	*Measurements*
S-6	SLO-1	*Patent and copy rights*	*Prejudice*	*Problem identification*	*Classification of errors*	*Description and types of measurements*
	SLO-2	*Authorship and credit*	*Intuition*	*Basic assumptions*	*Errors analysis*	*Analysis of results*
S-7	SLO-1	*Conflict of interest*	*Observation bias*	*Hypothesis*	*Interpretation of the data*	*Explanation of results*
	SLO-2	*Error and negligence*	*Self-misunderstanding*	*Formulation of an hypothesis*	*Test of the hypothesis*	*Result and analysis*
S-8	SLO-1	*Case studies – cloning scandal, miracle drug thalidomide*	*Egoism*	*Hypothesis driven research design*	*Mathematical modeling*	*Discussion and acknowledgement*
	SLO-2	*Case studies –, miracle drug thalidomide*	*Some plagiarism cases in India*	*Verification of Hypothesis*	*Types of mathematical modeling*	*Conflict of interest declaration*
S-9	SLO-1	*Jan HendrikSchön case*	*Recent Plagiarism cases (abroad)*	*Identification of experimental techniques*	*Numerical computation*	*References, paper/poster presentation*
	SLO-2	*The Baltimore affair*	*Consequence of Plagiarism*	*Implementation of the experimental techniques*	*Result presentation*	*Electronic publication*

Learning Resources		
	1. National academy of Science, National academy of Engineering, and Institute of Medicine, "On being a scientist: A guide to responsible conduct in research", Third edition, The National Academics Press, 2009 *2. Adam Briggle and Carl Mitcham, "Ethics and science: An Introduction", Cambridge University Press, 2012*	*3. David B. Resnik, "The ethics of science: An introduction", Routledge Publication, 1998* *4. Gary Comstock, "Research Ethics: A philosophical guide to the responsible conduct of Research" Cambridge University Press, 2013*

Learning Assessment											
	Bloom's Level of Thinking	Continuous Learning Assessment (50% weightage)								Final Examination (50% weightage)	
		CLA – 1 (10%)		CLA – 2 (15%)		CLA – 3 (15%)		CLA – 4 (10%)#			
		Theory	Practice	Theory	Practice	Theory	Practice	Theory	Practice	Theory	Practice
Level 1	Remember Understand	*30 %*	-	*30 %*	-	*30 %*	-	*30 %*	-	*30%*	-
Level 2	Apply Analyze	*40 %*	-	*40 %*	-	*40 %*	-	*40 %*	-	*40%*	-
Level 3	Evaluate Create	*30 %*	-	*30 %*	-	*30 %*	-	*30 %*	-	*30%*	-
	Total	100 %		100 %		100 %		100 %		100 %	

CLA – 4 can be from any combination of these: Assignments, Seminars, Tech Talks, Mini-Projects, Case-Studies, Self-Study, MOOCs, Certifications, Conf. Paper etc.,

Course Designers		
Experts from Industry	Experts from Higher Technical Institutions	Internal Experts
1. Dr. Narayanasvamy Vijayan, National Physical Laboratory, nvijayan@nplindia.org	*1. Prof. V. Subramaniam, IITM, Chennai, manianvs@iitm.ac.in*	*1. Dr. A. Karthigeyan, SRMIST*
2. Dr.A. Pandikumar, Scientist, CSIR-CERL, pandikumar@cecri.res.in	*2. Prof. D. Arivuoli, Anna University, arivuoli@annauniv.edu*	*2. Dr. A. A. Alagirisamy, SRMIST*

Course Code	18NTO404T	Course Name	MICRO AND NANOFLUIDIC TECHNOLOGY	Course Category	O	Open Elective	L	T	P	C
							3	0	0	3

Pre-requisite Courses	Nil	Co-requisite Courses	Nil	Progressive Courses	Nil
Course Offering Department	Nanotechnology	Data Book / Codes/Standards	Nil		

Course Learning Rationale (CLR):	The purpose of learning this course is to:
CLR-1 :	*Understand the theory of fluidics in a micro scale*
CLR-2 :	*Gain knowledge in micro fluidics equations*
CLR-3 :	*Understand the concept behind viscous flow in micro scale*
CLR-4 :	*Acquire the knowledge in Micro fluidic devices and manufacturing*
CLR-5 :	*Gain knowledge scaling materials for manufacturing*
CLR-6 :	*Understand the sensors for micro fluidic application*

Course Learning Outcomes (CLO):	At the end of this course, learners will be able to:	Learning 1: Level of Thinking (Bloom)	2: Expected Proficiency (%)	3: Expected Attainment (%)	PLO 1: Engineering Knowledge	2: Problem Analysis	3: Design & Development	4: Analysis, Design, Research	5: Modern Tool Usage	6: Society & Culture	7: Environment & Sustainability	8: Ethics	9: Individual & Team Work	10: Communication	11: Project Mgt. & Finance	12: Life Long Learning	13: PSO - 1	14: PSO - 2	15: PSO – 3
CLO-1 :	*Apply the concept of fluidics in micro and nanoscale*	2	80	75	H	M	H	H	H	M	M	H	H	H	M	H	H	H	H
CLO-2 :	*Analyze the flow and viscosity of the fluidics*	2	80	70	H	M	M	H	M	M	M	H	M	H	M	H	M	M	M
CLO-3 :	*Analyze the viscous flow of micro/nano fluidic devices*	2	75	70	H	M	H	H	H	H	H	M	H	H	H	H	H	H	H
CLO-4 :	*Utilize the knowledge gained for designing micro/nano fluidic devices*	2	80	75	M	H	H	M	H	H	H	H	H	H	M	H	H	H	H
CLO-5 :	*Apply the various fluidic equations to design micro/nano fluidic devices*	2	80	70	H	M	H	H	H	M	M	H	M	H	M	H	H	H	H
CLO-6 :	*Design micro/nano fluidic devices based on theory*	2	80	75	H	M	M	H	H	M	M	H	H	H	M	H	H	M	H

Duration (hour)		9	9	9	9	9
S-1	SLO-1	*Introduction: Fundamentals of kinetic theory*	*Micro and nanofluids – An Introduction*	*Introduction to Microscale Viscous Flow*	*Introduction - concepts microfluidic devices*	*Introduction to Electro chemistry*
	SLO-2	*Fundamentals of molecular models*	*Basic concepts in microfluidics & Nanoscale fluidics*	*Structure of flow in a pipe or channel*	*Microfluidic Technology*	*Electrical double layer*
S-2	SLO-1	*Kinetic theory of micro and macroscopic properties*	*Governing equations*	*Posiseuille's equation*	*Fabrication Of A Simple Microfluidic Chip*	*Electro-chemical potential*
	SLO-2	*Molecular models of micro and macroscopic properties*	*Applications- Preparatory concepts*	*Posiseuille flow in a pipe*	*Advantages of microfluidic devices*	*Chemical potential-acid and base*
S-3	SLO-1	*Binary collisions*	*Laws of fluid flows determination of transport properties*	*Velocity in slip flow of gases*	*Fluidic transport mechanisms In Microfluidic Devices*	*Electrolyte & electrical conductivity*
	SLO-2	*Distribution functions*	*Classification of fluid flow*	*Velocity in slip flow of liquids*	*Pressure-driven and electro-kinetically driven flows in Devices*	*Semi-permeable membrane*
S-4	SLO-1	*Boltzmann equation*	*Continuum approximation*	*Theory of flow in a thin film under gravity*	*Scaling of materials*	*Micro and nanofluidics devices*
	SLO-2	*Maxwellian distribution functions*	*Limitations and drawbacks*	*Two and three dimensional approach*	*Silicon materials for the manufacture*	*Applications in different fields*
S-5	SLO-1	*Wall slip effects*	*Kinematics of Microscale Liquid Flow*	*Derivation - thin film under gravity*	*Glass materials for the manufacture*	*Fabrication and design of microfluid device*
	SLO-2	*Accommodation coefficients*	*Derivation of Kinematics of Microscale Liquid Flow*	*Properties of thin film equation*	*Polymers materials for the manufacture*	*Testing of microfluid device*
S-6	SLO-1	*Flow and heat transfer analysis of microscale*	*Liquid flow along surface*	*Developing suction and laminar flows*	*Fluidic structures*	*DNA transport*
	SLO-2	*Couette flows*	*Effect of body forces in liquid flow*	*Flow control*	*Manufacturing a fluidic structure*	*Development of artificial kidney*
S-7	SLO-1	*Pressure driven gas micro- flows*	*Navier- Stokes equation*	*Surface tension driven flow*	*Stacking sequence*	*Electrochemical sensing*
	SLO-2	*Micro flows with wall slip effects*	*Equation's properties*	*And its limitations*	*Stacking - fabrication methods*	*Electrochemical Micro/Nao fluidic devices*
S-8	SLO-1	*Concept of Heat transfer in micro-Poiseuille flows*	*Theory of Two-dimensional Navier- Stokes equation*	*Sedimentation of a solid particle*	*Surface modifications*	*Receptor and Transducer based classification of biosensors*

	SLO-2	*Expression for Poiseuille flows*	*Two-dimensional Navier- Stokes equation in terms of Reynolds Equation*	*Transportation of a solid particle*	*Different techniques involved in Surface modifications*	*Types of Biotransducers*
S-9	SLO-1	*Mechanism of micro flows under compression*	*Navier- Stokes equation for Steady and compressible flow*	*Simple model for blood flow*	*Spotting mechanisms*	*Nanopores and nanopore membrane for biochemical sensing*
	SLO-2	*Compressibility and its effects*	*Steady and incompressible flow Navier-Stokes equation*	*Non-Newtonian properties of blood*	*Detection mechanisms*	*Single Molecule sensing devices*

Learning Resources	*1. Terrence Conlisk, "Essential of Micro and nanofluidics: with applications to biological and chemical sciences", Cambridge University Press, 2012* *2. Joshua Edel, "Nanofluidics", RCS publishing, 2009*	*3. HenrikBruus, "Theoretical Microfluidics", Oxford Master Series in Physics,2007* *4. PatricTabeling, "Introduction to Microfluids", Oxford U. Press, 2005*

Learning Assessment

	Bloom's Level of Thinking	Continuous Learning Assessment (50% weightage)								Final Examination (50% weightage)	
		CLA – 1 (10%)		CLA – 2 (15%)		CLA – 3 (15%)		CLA – 4 (10%)#			
		Theory	Practice	Theory	Practice	Theory	Practice	Theory	Practice	Theory	Practice
Level 1	Remember Understand	*30 %*	-	*30 %*	-	*30 %*	-	*30 %*	-	*30%*	-
Level 2	Apply Analyze	*40 %*	-	*40 %*	-	*40 %*	-	*40 %*	-	*40%*	-
Level 3	Evaluate Create	*30 %*	-	*30 %*	-	*30 %*	-	*30 %*	-	*30%*	-
	Total	100 %		100 %		100 %		100 %		100 %	

CLA – 4 can be from any combination of these: Assignments, Seminars, Tech Talks, Mini-Projects, Case-Studies, Self-Study, MOOCs, Certifications, Conf. Paper etc.,

Course Designers		
Experts from Industry	Experts from Higher Technical Institutions	Internal Experts
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2. Mr. K. Chandru Trivitron Healthcare Pvt. Ltd. Chennai, chandru.k@trivitron.com	*2. Dr.Amit Kumar Mishra , IIT Jodhpur, amit@iitj.ac.in*	*2. Dr. Junaid MasudLaskar, SRMIST*

Course Code	18NTO405T	Course Name	THINFILM PHOTOVOLTAICS	Course Category	O	Open Elective	L	T	P	C
							3	0	0	3

Pre-requisite Courses	Nil	Co-requisite Courses	Nil	Progressive Courses	Nil
Course Offering Department	Nanotechnology	Data Book / Codes/Standards	Nil		

Course Learning Rationale (CLR):	*The purpose of learning this course is to:*
CLR-1 :	*Review the basic principles and design of photovoltaic cell technology*
CLR-2 :	*Understand the key properties of semiconductors films used in photovoltaic technology*
CLR-3 :	*Review the basic photovoltaic device structure and design*
CLR-4 :	*Develop an understanding of different thin film photovoltaic device technologies and their design*
CLR-5 :	*Gain exposure to the various tools and techniques used in thin film photovoltaics*
CLR-6 :	*Acquire knowledge on advanced concepts explored in thin film photovoltaics*

Course Learning Outcomes (CLO):	*At the end of this course, learners will be able to:*	Learning 1	2	3	Program Learning Outcomes (PLO) 1	2	3	4	5	6	7	8	9	10	11	12	13	14	15
		Level of Thinking (Bloom)	Expected Proficiency (%)	Expected Attainment (%)	Engineering Knowledge	Problem Analysis	Design & Development	Analysis, Design, Research	Modern Tool Usage	Society & Culture	Environment & Sustainability	Ethics	Individual & Team Work	Communication	Project Mgt. & Finance	Life Long Learning	PSO - 1	PSO - 2	PSO – 3
CLO-1 :	*Differentiate between different types of photovoltaic technologies*	2	80	75	H	M	H	H	H	M	M	H	H	H	M	H	H	H	H
CLO-2 :	*Interpret important properties of semiconductors relevant to thin film photovoltaics*	2	80	70	H	M	M	H	M	M	M	H	M	H	M	H	M	M	M
CLO-3 :	*Apply different photovoltaic device design concepts for different applications*	2	75	70	H	M	H	H	H	H	H	M	H	H	H	H	H	H	H
CLO-4 :	*Appreciate advancement of different types of thin film solar cells*	2	80	75	M	H	H	M	H	H	H	H	H	H	M	H	H	H	H
CLO-5 :	*Appreciate the advanced concepts and explorations in thin film photovoltaics*	2	80	70	H	M	H	H	H	M	M	H	M	H	M	H	H	H	H
CLO-6 :	*Perform thin film photovoltaic device fabrication, testing and calculations*	2	80	75	H	M	M	H	H	M	M	H	H	H	M	H	H	M	H

Duration (hour)		9	9	9	9	9
S-1	SLO-1	*Basics and basic components of PV systems*	*Semiconductor thin films-Optical absorption*	*Different generations of PV*	*Thin film deposition*	*Device architectures*
	SLO-2	*Mechanism of PV*	*Carrier photo generation*	*Thin film solar cells*	*Various techniques*	*Flexible substrates, transparent devices.*
S-2	SLO-1	*Sun as a source of energy*	*Band gap*	*Silicon solar cells*	*Evaporation techniques*	*Multi-junctions*
	SLO-2	*Solar spectrum , air mass*	*Direct Vs Indirect bandgaps*	*Thin film Silicon solar cells*	*Sputtering techniques*	*Tandem solar cells*
S-3	SLO-1	*Solar Cell parameters*	*Carriers*	*Amorphous Silicon based solar cells*	*MBE*	*Bandgap profile optimization*
	SLO-2	*Device testing*	*Carriers transport*	*a-Si and a-Si: H solar cells*	*Laser based techniques*	*Solar spectrum matching*
S-4	SLO-1	*Efficiency measurements*	*Minority carrier transport properties*	*II–VI thin film PV*	*CVD, PECVD*	*Light trapping*
	SLO-2	*FF, V_{OC}, J_{SC} etc for ideal cells*	*Carrier recombination–lifetime and defects*	*Chalcopyrite photovoltaics*	*Spray and Non vacuum routes*	*Antireflection coatings*
S-5	SLO-1	*Non-idealities, Loss mechanisms*	*Band to band and Shockley–Read–hall recombination*	*CdTe/CdS thin film solar cells*	*Techniques to measure thickness*	*Self-cleaning coatings*
	SLO-2	*Optical & electrical loss mechanisms*	*High injection effects*	*Superstrate structure*	*Optical and electronic properties of thin films*	*Plasmonic enhancements*
S-6	SLO-1	*Basics of solar cell device design*	*Surface and interface recombination*	*CuInGaSe2/CdS thin film cell technologies*	*Fabrication process of thin film solar cells*	*Luminescence concentrators*
	SLO-2	*Minimization of losses*	*Implications on device performance*	*Earth abundant alternatives*	*Specific techniques used*	*Up conversion*
S-7	SLO-1	*Lateral design*	*PN homojunctions*	*Thin film solar cells based on Cu2ZnSnS4*	*Established parameters in thin film cell technologies*	*New concepts*
	SLO-2	*Vertical design*	*Carrier transport under broad spectrum illumination*	*other materials*	*Basic characterization tools*	*quantum dots, & wires,*
S-8	SLO-1	*Optical versus electrical tradeoffs*	*Photocurrent and Spectral response*	*3rd generation thin film solar cells: DSSCs*	*Advanced characterization methods for device quality & defects*	*Intermediate band solar cells*

	SLO-2	*Optimization*	*Ideal diodes*	*QDSSCs, heterojunctions*	*Study of interfaces, recombination etc*	*Multiple exciton generation, hot carrier solar cells*
S-9	SLO-1	*Examples of semiconductors in PV*	*Real p-n diodes*	*3rd generation thin film solar cells: organic PV*	*Basics of device modelling*	*Commercial status*
	SLO-2	*Device types in PV*	*Temperature effects*	*Hybrid, perovskite solar cells etc.*	*Simulation softwares*	*Hopes and challenges for thin film PV*

Learning Resources	*1. Solanki C.S., "Solar photovoltaics - fundamentals, technologies and applications", 3rd edition, PHI LearningPvt Ltd, New Delhi, India* *2. Fonash S.J., "Solar Cell Device Physics", Academic, 2010* *3. Moller H.J., "Semiconductors for Solar Cells",Artech House, 1993*	*4. Green M.A., "Third Generation Photovoltaics: Advanced Solar Energy Conversion", Springer, 2006Fundamentals of Solid State Engineering, Manijeh Razeghi, KLUWER ACADEMIC PUBLISHERS, 2002* *5. Rointan. F, Bunshah," Hand Book of Deposition technologies for Thin Films and coatings by Science, Technology and Applications" ,Second Edition , Noyes Publications, 1993*

Learning Assessment											
	Bloom's Level of Thinking	Continuous Learning Assessment (50% weightage)								Final Examination (50% weightage)	
		CLA – 1 (10%)		CLA – 2 (15%)		CLA – 3 (15%)		CLA – 4 (10%)#			
		Theory	Practice	Theory	Practice	Theory	Practice	Theory	Practice	Theory	Practice
Level 1	Remember Understand	*30 %*	-	*30 %*	-	*30 %*	-	*30 %*	-	*30%*	-
Level 2	Apply Analyze	*40 %*	-	*40 %*	-	*40 %*	-	*40 %*	-	*40%*	-
Level 3	Evaluate Create	*30 %*	-	*30 %*	-	*30 %*	-	*30 %*	-	*30%*	-
	Total	100 %		100 %		100 %		100 %		100 %	

CLA – 4 can be from any combination of these: Assignments, Seminars, Tech Talks, Mini-Projects, Case-Studies, Self-Study, MOOCs, Certifications, Conf. Paper etc.,

Course Designers		
Experts from Industry	Experts from Higher Technical Institutions	Internal Experts
1. Dr. D.K. Aswal, National Physical Laboratory, dkaswal@nplindia.org	*1. Dr. Sudhakar Chandran, IIT Madras, csudhakar@iitm.ac.in*	*1. Dr. S Venkataprasad Bhat,, SRMIST*
2. Dr. S. Sudhakar, CSIR-CECRI, sudhakar@cecri.res.in	*2. Dr. M. S. Ramachandra Rao, IIT Madras, msrrao@iitm.ac.in*	*2. Dr. P. Malar, SRMIST*

Course Code	18NTO406T	Course Name	NANOTECHNOLOGY IN SOCIETAL DEVELOPMENT	Course Category	O	Open Elective	L	T	P	C
							3	0	0	3

Pre-requisite Courses	Nil	Co-requisite Courses	Nil	Progressive Courses	Nil
Course Offering Department		Department of Physics and Nanotechnology	Data Book / Codes/Standards		Nil

Course Learning Rationale (CLR):	The purpose of learning this course is to:	Learning			Program Learning Outcomes (PLO)														
CLR-1 :	*Provide an insight into the fundamentals of social-economic implications of nanotechnology*	1	2	3	1	2	3	4	5	6	7	8	9	10	11	12	13	14	15
CLR-2 :	*Provide an insight into the fundamentals of ethical implications of nanotechnology*																		
CLR-3 :	*Understand the legal risks related with the nanotechnology*																		
CLR-4 :	*Understand the implications of nanotechnology in quality of life*																		
CLR-5 :	*Understand the problems of governance of nanotechnology*																		
CLR-6 :	*Explore the matters related to patents associated with nanotechnology*																		
Course Learning Outcomes (CLO):	*At the end of this course, learners will be able to:*	Level of Thinking (Bloom)	Expected Proficiency (%)	Expected Attainment (%)	Engineering Knowledge	Problem Analysis	Design & Development	Analysis, Design, Research	Modern Tool Usage	Society & Culture	Environment & Sustainability	Ethics	Individual & Team Work	Communication	Project Mgt. & Finance	Life Long Learning	PSO - 1	PSO - 2	PSO – 3
CLO-1 :	*Address the socioeconomic implications of nanotechnology*	*2*	*80*	*75*	*M*	*H*	*M*	*H*	*M*	*H*	*H*	*H*	*H*	*H*	*M*	*H*	*H*	*H*	*H*
CLO-2 :	*Apply the knowledge of ethical implications pertaining to nanotechnology*	*2*	*80*	*70*	*M*	*H*	*M*	*H*	*M*	*H*	*H*	*H*	*H*	*H*	*M*	*H*	*M*	*M*	*M*
CLO-3 :	*Address the legal risks related with the nanotechnology*	*2*	*75*	*70*	*M*	*M*	*M*	*H*	*M*	*H*	*H*	*M*	*H*	*H*	*M*	*H*	*H*	*H*	*H*
CLO-4 :	*Improve the quality of life*	*2*	*80*	*75*	*H*	*H*	*M*	*H*	*M*	*H*	*H*	*H*	*H*	*H*	*M*	*H*	*H*	*H*	*H*
CLO-5 :	*Handle the issues related to patents associated with nanotechnology*	*2*	*80*	*70*	*M*	*M*	*H*	*H*	*M*	*M*	*M*	*H*	*M*	*H*	*H*	*H*	*H*	*H*	*H*
CLO-6 :	*Address the problems of governance of nanotechnology*	*2*	*80*	*75*	*M*	*M*	*M*	*H*	*M*	*H*	*H*	*H*	*H*	*H*	*M*	*H*	*H*	*M*	*H*

Duration (hour)		9	9	9	9	9
S-1	SLO-1	*Knowledge and Scientific Understanding of Nature*	*National Nanotechnology Initiative*	*Nanotechnology, Education, and the Fear of Nanobots*	*Societal Implications of Nanotechnology (*	*Public Perceptions of Nanotechnology*
	SLO-2	*Industrial Manufacturing, Materials and Products*	*The Age of Transitions*	*Mathematical Challenges in Nanoscience and Nanotechnology*	*Socio-economic Research on Nanoscale Science and Technology: A European Overview and Illustration*	*Public Awareness of Nanotechnology*
S-2	SLO-1	*Medicine and the Human Body*	*Technological Implications of Nanotechnology: Why the Future Needs Us*	*Implications of Nanotechnology for the Workforce*	*Nanotechnology and Unintended Consequences*	*Public interaction research*
	SLO-2	*Sustainability: Agriculture, Water, Energy, Materials, and Clean Environment*	*Don't Count Society Out - A Response to Bill Joy*	*Societal Impacts of Nanotechnology in Education and Medicine*	*A Cultural Ecology of Nanotechnology*	*Nanotechnological risks*
S-3	SLO-1	*Space Exploration*	*National Needs Drivers for Nanotechnology*	*Technological and Educational Implications of Nanotechnology: Infrastructural and Educational Needs*	*Envisioning and Communicating Nanotechnology to the Public*	*Assessment of Nanotechnological risks*
	SLO-2	*National Security*	*Nanotechnology and Societal Transformation*	*Dynamics of the Emerging Field of Nanoscience*	*Vision, innovation, and policy*	*Importance of Risk communication*
S-4	SLO-1	*Moving into the Market*	*Focus on Economic and Political Implications of Potential Technology*	*Focus on Medical, Environmental, Space Exploration and National Security Implications*	*Challenges for government and universities*	*Problems in Risk communication*
	SLO-2	*The Interactive Process of Innovation and Diffusion*	*Impact of Nanotechnology on the Chemical and Automotive Industries*	*Challenges and Vision for Nanoscience and Nanotechnology in Medicine: Cancer as a Model*	*Environmental Impacts of Nanomaterials*	*Nanotechnology's social impacts*
S-5	SLO-1	*Unintended and Second-order Consequences*	*Information Technology Based on a Mature Nanotechnology: Some Societal Implications*	*Nanotechnology in Medicine*	*Nanoparticle Toxicity and risk*	*A preliminary analysis of nanotechnology in the media*
	SLO-2	*Ethical Issues and Public Involvement in Decision Making*	*Societal Implications of Scaling to Nanoelectronics*	*Lifecycle/Sustainability Implications of Nanotechnology*	*Social impacts of nano biotechnology issues*	*Nanoscience and engineering - Public engagement*

S-6	SLO-1	*Education of Nanoscientists, Nanotechnologists, and Nanofabrication Technicians*	*Future Implications of Nanoscale Science and Technology: Wired Humans, Quantum Legos, and an Ocean of Information*	*Implications of Nanotechnology for Space Exploration*	*Problems of governance of nanotechnology*	*Nanophobia – Fear of Nanotechnology*
	SLO-2	*Education of Social Scientists*	*Implications of Nanotechnology in the Pharmaceutics and Medical Fields*	*Security Aspects of Nanotechnology*	*Negotiations over quality of life in the nanotechnology initiative. Governance*	*Public Engagement with nanotechnology*
S-7	SLO-1	*Social Science Research Approaches and Methodologies*	*We've Only Just Begun*	*Focus on Social, Ethical, Legal, and Cultural Implications*	*Technological revolutions and the limits of ethics in an age of commercialization*	*Nanotechnology: moving beyond risk*
	SLO-2	*Institutional Infrastructure for Societal Implications Research*	*An Economist Õs Approach to Analyzing the Societal Impacts of Nanoscience and Nanotechnology*	*Social Science Research Methods for Assessing Societal Implications of Nanotechnology*	*Regulatory structures and society*	*Communication streams and nanotechnology: interpretation of a nanotechnology*
S-8	SLO-1	*Other Measures*	*The Strategic Impact of Nanotechnology on the Future of Business and Economics*	*Ethical Issues in Nanotechnology*	*Nanotechnology and social trends*	*Individual perspectives of nanotechnology*
	SLO-2	*Specific Areas for Research and Education Investment*	*Nano-Science and Society: Finding a Social Basis for Science Policy*	*Social Acceptance of Nanotechnology*	*Integrative Technology*	*The case of Cold Fusion*
S-9	SLO-1	*Recommendations to Organizations*	*Focus on Science and Education Implications*	*Social, Ethical and Legal Implications of Nanotechnology*	*Institutionalizing Multi-Disciplinary Engagement*	*The case of Recombinant DNA*
	SLO-2	*With an Eye to the Future*	*Implications of Nanoscience for Knowledge and Understanding*	*Envisioning Life on the Nano-Frontier*	*Nano revolution implications for the artist*	*Historical comparisons - for anticipating public reactions to nanotechnology*

Learning Resources	1. *Mihail C.R., and William S.B., "Nanotechnology: societal implications", Springer publication, 2011 (978-1-4020-5432-7 (e-book))* 2. *Ronald Sandler, "Nanotechnology the Social & Ethical Issues", Woodrow Wilson, 2009*	3. *Mihail C. Roco and William Sims Bainbridge," Societal Implications of Nanoscience and Nanotechnology", National Science Foundation, 2001 (978-0-7923-7178-6)*

Learning Assessment

	Bloom's Level of Thinking	Continuous Learning Assessment (50% weightage)								Final Examination (50% weightage)	
		CLA – 1 (10%)		CLA – 2 (15%)		CLA – 3 (15%)		CLA – 4 (10%)#			
		Theory	Practice	Theory	Practice	Theory	Practice	Theory	Practice	Theory	Practice
Level 1	Remember Understand	*30 %*	-	*30 %*	-	*30 %*	-	*30 %*	-	*30%*	-
Level 2	Apply Analyze	*40 %*	-	*40 %*	-	*40 %*	-	*40 %*	-	*40%*	-
Level 3	Evaluate Create	*30 %*	-	*30 %*	-	*30 %*	-	*30 %*	-	*30%*	-
	Total	100 %		100 %		100 %		100 %		100 %	

CLA – 5 can be from any combination of these: Assignments, Seminars, Tech Talks, Mini-Projects, Case-Studies, Self-Study, MOOCs, Certifications, Conf. Paper etc.,

Course Designers

Experts from Industry	Experts from Higher Technical Institutions	Internal Experts
1. Mr.Ajay Kumar, Avansa Technology and services, India ajaykumar@avansa.co.in	*1. Dr. Hirendra N Ghosh, Institute of Nanoscience and Technology, Punjab, hnghosh@inst.ac.in*	*1. Dr. C.Gopalakrishnan, , SRMIST*
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Course Code	18NTO407T	Course Name	POLYMER ENGINEERING	Course Category	O	Open Elective	L	T	P	C
							3	0	0	3

Pre-requisite Courses	Nil	Co-requisite Courses	Nil	Progressive Courses	Nil
Course Offering Department	Nanotechnology	Data Book / Codes/Standards	Nil		

Course Learning Rationale (CLR):	The purpose of learning this course is to:
CLR-1 :	*Acquire basic knowledge about the structure and property of polymers*
CLR-2 :	*Impart chemistry aspects on various polymer materials*
CLR-3 :	*Acquaint with various compounding ingredients and mixing equipments*
CLR-4 :	*Understand the principles behind the elasticity of the polymers*
CLR-5 :	*Gain knowledge about reinforcements and effect of nanofillers*
CLR-6 :	*Describe rheological behavior with different modifiers*

Course Learning Outcomes (CLO):	At the end of this course, learners will be able to:	Learning 1: Level of Thinking (Bloom)	2: Expected Proficiency (%)	3: Expected Attainment (%)	PLO 1: Engineering Knowledge	2: Problem Analysis	3: Design & Development	4: Analysis, Design, Research	5: Modern Tool Usage	6: Society & Culture	7: Environment & Sustainability	8: Ethics	9: Individual & Team Work	10: Communication	11: Project Mgt. & Finance	12: Life Long Learning	13: PSO - 1	14: PSO - 2	15: PSO – 3
CLO-1 :	*Apply the engineering principles underlying the processing of polymer raw materials*	2	80	75	H	M	H	H	H	M	M	H	H	H	M	H	H	H	H
CLO-2 :	*Extend and apply the knowledge of polymers to materials science and engineering*	2	80	70	H	M	M	H	M	M	M	H	M	H	M	H	M	M	M
CLO-3 :	*Identify different fillers as reinforcements*	2	75	70	H	M	H	H	H	H	H	M	H	H	H	H	H	H	H
CLO-4 :	*Illustrate the working of moulding and extrusion techniques*	2	80	75	M	H	H	M	H	H	H	H	H	H	M	H	H	H	H
CLO-5 :	*Evaluate the mechanical behavior of polymers*	2	80	70	H	M	H	H	H	M	M	H	M	H	M	H	H	H	H
CLO-6 :	*Enhance knowledge about the various composite materials*	2	80	75	H	M	M	H	H	M	M	H	H	H	M	H	H	M	H

Duration (hour)		9	9	9	9	9
S-1	SLO-1	*Basics and chemistry of polymeric Materials*	*Mechanical behavior of Polymers*	*Polymer Viscoelasticity and Rheology*	*Reinforced Polymers and Composites*	*Elements of Design*
	SLO-2	*Historical developments in polymeric materials*	*Deformation*	*Definition of elastomers*	*Reinforced plastics*	*Engineering thermoplastics*
S-2	SLO-1	*Monomer & functionality*	*Fracture in polymers*	*Requirements of polymer to be elastomer*	*Nanofillers and reinforcements*	*Thermosets and composites*
	SLO-2	*Oligomer*	*Crack growth*	*Nature of viscoelasticity*	*Effect of reinforcements like calcium carbonate, dolomite, silica glass*	*Compression moulds : positive, semi-positive*
S-3	SLO-1	*Polymer structure*	*Tensile strength,*	*Definition of elastomers*	*Fibrous reinforcements (inorganic and organic)*	*Flash mould with horizontal and vertical flash*
	SLO-2	*Methods of synthesis*	*Flexural strength*	*Classifications of elastomers*	*Glass fiber and boron fiber*	*Injection moulds : Two plate and three plates types*
S-4	SLO-1	*Addition polymerization*	*Impact resistance*	*Stress relaxation*	*Carbon fiber and aramide fibers*	*Joining and fastening*
	SLO-2	*Condensation polymerization*	*Percentage elongation*	*Relaxation and retardation times*	*Compression moulding*	*Post extrusion techniques*
S-5	SLO-1	*Co- polymers*	*Griffin theory*	*The time - temperature superposition principle*	*Classification and characteristics of composite materials*	*Metallization*
	SLO-2	*Cross linked polymers*	*Tear test*	*Dynamic properties*	*Fibrous composite materials*	*electroplating*
S-6	SLO-1	*Crosslinking plasticizers and fillers*	*Fatigue and wear*	*Zener model*	*Laminated composite materials*	*Stamping*
	SLO-2	*Crystallinity*	*Hardness*	*Polymer melt viscosity*	*Particulate composite materials*	*Welding and bonding*
S-7	SLO-1	*Glass transition temperature*	*Compressive strength*	*Plasticizers*	*Combinations of composite materials*	*printing and painting on plastics*
	SLO-2	*Degree of polymerization*	*Time dependent properties*	*Lubricants*	*Strength of composites*	*Cross-linking of thermoplastics materials*
S-8	SLO-1	*Classification of polymers*	*Creep*	*Polymer Rheology*	*Failure modes of long, fibre composites*	*Cellular plastics*
	SLO-2	*Molecular weight*	*Effect of weathering*	*Rheological concepts of polymer solutions and melts*	*Axial tensile failure*	*Compound development*
S-9	SLO-1	Molecular weight distribution.	Stress-strain behavior of polymers	Degradation plasticization	Transverse tensile failure, shear failure	Principles of mixing
	SLO-2	Determination of number and average molecular weight	Mechanical behavior of biomedical polymers	Various rheology modifiers	Applications of fiber reinforced polymer composites	Rubbers, designing for strength

Learning Resources	1. *Sperling L.H., Introduction to Physical Polymer Science, Wiley inter science, 4th Edition, 2006* 2. *Mc Crum, Principles of polymer Engineering, 2nd Edition, Oxford, 2001*	3. *HullD., and Clyne W., An Introduction to Composite Materials, Cambridge University Press, 2nd Edition, 1996* 4. *Jones R.M., "Mechanics of Composite Materials", Taylor & Francis, 2nd Edition, 1999*

Learning Assessment											
	Bloom's Level of Thinking	Continuous Learning Assessment (50% weightage)								Final Examination (50% weightage)	
		CLA – 1 (10%)		CLA – 2 (15%)		CLA – 3 (15%)		CLA – 4 (10%)#			
		Theory	Practice	Theory	Practice	Theory	Practice	Theory	Practice	Theory	Practice
Level 1	Remember Understand	*30 %*	-	*30 %*	-	*30 %*	-	*30 %*	-	*30%*	-
Level 2	Apply Analyze	*40 %*	-	*40 %*	-	*40 %*	-	*40 %*	-	*40%*	-
Level 3	Evaluate Create	*30 %*	-	*30 %*	-	*30 %*	-	*30 %*	-	*30%*	-
	Total	100 %		100 %		100 %		100 %		100 %	

CLA – 4 can be from any combination of these: Assignments, Seminars, Tech Talks, Mini-Projects, Case-Studies, Self-Study, MOOCs, Certifications, Conf. Paper etc.,

Course Designers		
Experts from Industry	Experts from Higher Technical Institutions	Internal Experts
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2. Dr. P. Sudhakara, CLRI – CSIR, Jalandhar, sudhakarp@clri.res.in	*2. Dr. A. Kannan, IIT Madras, kannan@iitm.ac.in*	*2. Dr. C. Siva, SRMIST*

Course Code	18NTO408T	Course Name	INDUSTRIAL NANOTECHNOLOGY	Course Category	O	Open Elective	L	T	P	C
							3	0	0	3

Pre-requisite Courses	Nil	Co-requisite Courses	Nil	Progressive Courses	Nil
Course Offering Department	Nanotechnology	Data Book / Codes/Standards		Nil	

Course Learning Rationale (CLR):	*The purpose of learning this course is to:*
CLR-1 :	*Understand various nanotechnology techniques and materials from the point of view of the industry*
CLR-2 :	*Understand the practical and business aspects of nanotechnology*
CLR-3 :	*Understand the concept of self-assembly of carbon nanostructures and various other materials and their applications*
CLR-4 :	*Gain knowledge on material in the nanoscale which can be use in Electronics, Medical, Textiles Industry*
CLR-5 :	*Acquire knowledge on physical properties of nanostructured materials and their size and dimensionality dependence*
CLR-6 :	*Acquire knowledge on the measurement techniques at the nanoscale*

Course Learning Outcomes (CLO):	*At the end of this course, learners will be able to:*	Learning 1: Level of Thinking (Bloom)	Learning 2: Expected Proficiency (%)	Learning 3: Expected Attainment (%)	PLO 1: Engineering Knowledge	PLO 2: Problem Analysis	PLO 3: Design & Development	PLO 4: Analysis, Design, Research	PLO 5: Modern Tool Usage	PLO 6: Society & Culture	PLO 7: Environment & Sustainability	PLO 8: Ethics	PLO 9: Individual & Team Work	PLO 10: Communication	PLO 11: Project Mgt. & Finance	PLO 12: Life Long Learning	PLO 13: PSO - 1	PLO 14: PSO - 2	PLO 15: PSO – 3
CLO-1 :	*Elucidate on advantages of nanotechnology based applications in each industry*	2	80	75	H	M	H	H	H	M	M	H	H	H	M	H	H	H	H
CLO-2 :	*Provide instances of contemporary industrial applications of nanotechnology*	2	80	70	H	M	M	H	M	M	M	H	M	H	M	H	M	M	M
CLO-3 :	*Provide an overview of future technological advancements and increasing role of nanotechnology in each industry*	2	75	70	H	M	H	H	H	H	H	M	H	H	H	H	H	H	H
CLO-4 :	*Apply the techniques for fabrication of small-scale devices such as micro/nano electromechanical systems etc.*	2	80	75	M	H	H	M	H	H	H	H	H	H	M	H	H	H	H
CLO-5 :	*Utilize the knowledge on nanomaterial to open a startup company*	2	80	70	H	M	H	H	H	M	M	H	M	H	M	H	H	H	H
CLO-6 :	*Apply the techniques for fabrication of nanofiber on advance textiles Industry*	2	80	75	H	M	M	H	H	M	M	H	H	H	M	H	H	M	H

Duration (hour)		9	9	9	9	9
S-1	SLO-1	*Nano electrical*	*Nanoparticles in bone substitutes*	*Background of TiO_2 as a semiconductor photocatalyst*	*Applications of nanotechnology in the agriculture*	*Nanotechnology and Nanofibers*
	SLO-2	*Nano electronic devices and its advantages*	*Nanoparticles in dentistry*	*Photocatalytic mechanism and general pathway*	*Agriculture chemicals*	*Nanofibre production –electrospinning*
S-2	SLO-1	*Data storage*	*Tissue engineering*	*Photocatalytic kinetics*	*Nanomaterials in plant protection*	*Basic to Electrospinning: Solution surface tension, Polymer solubility, viscosity*
	SLO-2	*Memory devices*	*Regenerative medicine*	*TiO_2nanoparticles for water purification*	*Diagnosis and control of plant diseases*	*Electrospinning parameters: Controlling morphologies of nanofibers*
S-3	SLO-1	*Micromechanical systems*	*Tissue engineering and nanotechnology*	*Photocatalytic degradation of specific waterborne pollutants*	*Potential of nano-fertilizers*	*Electrospun Polycrylonitrile Nanofibers*
	SLO-2	*Nanoelectromechanical systems*	*Incorporated scaffolds for tissue engineering*	*Nanomaterials in water treatment*	*Nano-fertilizers: Nutritional value and health*	*ElectospunTiC/C composite for energy related application*
S-4	SLO-1	*Lasers*	*Nanorobotics in surgery*	*Origin of arsenic in groundwater, Health impacts of arsenic*	*Applications of nanotechnology in food industry*	*Light-emitting polymer nanofiber*
	SLO-2	*Use of lasers in lighting and displays*	*Role of nanoparticles in drug delivery*	*Nanoparticles for treatment of arsenic*	*Protein nanostructures*	*Polymer nanofiber field-effect transistors*
S-5	SLO-1	*Rechargeable batteries*	*Nanoparticles in targeted drug delivery*	*Mechanism of treatment methods of arsenic-contaminated water*	*Engineered nanoparticles in food*	*Multifunctional polymer nanocomposites*
	SLO-2	*Nanostructured electrodes*	*Metal oxide nanocarriers for drug delivery*	*Treatment of arsenic using nanoparticles other than TiO_2*	*Silica (SiO_2) and silicates nanoparticles in food*	*Electrospun carbon nanofiber: electrode material*
S-6	SLO-1	*Basic concepts of fuel cells*	*Silica-based nano drug delivery*	*CNTs in water treatment technology*	*Nanomaterials in active packaging for food preservation*	*Nano finishing in textiles: UV resistant, antibacterial*
	SLO-2	*Different types of fuel cells*	*Polymer based nanomaterials for drug delivery*	*Functionalized graphene for removal of contaminations and water treatment*	*Barrier nanomaterials for food packaging*	*Nano finishing in textiles: hydrophilic, self-cleaning*
S-7	SLO-1	*Photovoltaic cells characterization*	*Cancer diagnostics: nanotechnology*	*Gas-sensor: Techniques used for gas-sensor*	*Nano-enabled indicators of food quality and safety*	*Protective textile against electromagnetic radiation*

	SLO-2	*Nanomaterials and different types of photovoltaic cells*	*Cancer therapy: nanotechnology*	*Conduction mechanism in semiconducting sensing films*	*Challenges of using nanotechnology in agriculture and food sectors*	*Nanotechnology: Self-Cleaning textile*
S-8	SLO-1	*Electric double layer capacitors*	*Nano-sensor in cancer*	*Metal-oxide based gas-sensor devices*	*Nanomaterials in active packaging for food preservation*	*Safety evaluation of nanomaterials in cosmetic products*
	SLO-2	*Capacitance versus pore size*	*Nanoparticle probes and molecular imaging in Cancer*	*Classification of semiconductor sensors*	*Principles of involved nano-enabled sensing*	*Nanomaterial in cosmetic: determination of physicochemical properties*
S-9	SLO-1	*Characterization of nanoparticle coatings*	*Nanomedicine-based use of siRNA in cancer*	*Challenges and opportunities in solid state sensors*	*Nanocomposite with antimicrobial properties*	*Cosmetic formulation: TiO_2 and ZnO Nanoparticles*
	SLO-2	*Nanoparticle coatings:Electrical and electronic applications and nanoparticle coatings for electrical products*	*Magnetic Nanoparticles and cancer*	*Small dimensional toxic gas sensor for air-quality monitoring*	*Nanotechnology for intelligent packaging as food freshness and safety monitoring solution*	*Nanotechnology in shampoos, hair-conditioners: Hair follicle targeting*

Learning Resources	1. *Kenneth E.G., Craig R.H., Cato T.L., Lakshmi S.N., Biomedical Nanostructures, John Wiley & Sons Inc., 2008* 2. *P. J. Brown, K. Stevens, Nanofibers and Nanotechnology in Textiles, Woodhead Publishing Limited, Cambridge, 2007* 3. *C. M. Hussain, A. K. Mishra, Nanotechnology in Environmental Science, Volume 2,John Wiley & Sons, 2018*	4. *M. A. Axelos, M. H. Van de Voorde, Nanotechnology in Agriculture and Food Science, John Wiley & Sons, 2017* 5. *M. H. Fulekar, Nanotechnology: Importance and Applications, IK International Publishing House Pvt. LTD, 2010*

Learning Assessment											
	Bloom's Level of Thinking	Continuous Learning Assessment (50% weightage)								Final Examination (50% weightage)	
		CLA – 1 (10%)		CLA – 2 (15%)		CLA – 3 (15%)		CLA – 4 (10%)#			
		Theory	Practice	Theory	Practice	Theory	Practice	Theory	Practice	Theory	Practice
Level 1	Remember Understand	*30 %*	-	*30 %*	-	*30 %*	-	*30 %*	-	*30%*	-
Level 2	Apply Analyze	*40 %*	-	*40 %*	-	*40 %*	-	*40 %*	-	*40%*	-
Level 3	Evaluate Create	*30 %*	-	*30 %*	-	*30 %*	-	*30 %*	-	*30%*	-
	Total	100 %		100 %		100 %		100 %		100 %	

CLA – 4 can be from any combination of these: Assignments, Seminars, Tech Talks, Mini-Projects, Case-Studies, Self-Study, MOOCs, Certifications, Conf. Paper etc.,

Course Designers		
Experts from Industry	Experts from Higher Technical Institutions	Internal Experts
1. Dr. Hemant Dixit, Global Foundaries,USA, aplahemant@gmail.com	*1. Dr. Pradeep T, IIT Madras, pradeep@iitm.ac.in*	*1. Dr.Debabrata Sarkar, SRMIST*
2. Dr. Krishna SurendraMuvvala, Saint Gobain Research India, India, Krishna.muvvala@saintgobain.com	*2. Dr. M. S. Ramachandra Rao, IIT Madras, msrrao@iitm.ac.in*	*2. Dr. Senthilkumar E, SRMIST*

ACADEMIC CURRICULA

Professional Core Courses

Regulations - 2018

SRM INSTITUTE OF SCIENCE AND TECHNOLOGY

(Deemed to be University u/s 3 of UGC Act, 1956)

Kattankulathur, Kancheepuram, Tamil Nadu, India

ACADEMIC CURRICULA

Professional Core Courses

AEROSPACE ENGINEERING

Regulations - 2018

SRM INSTITUTE OF SCIENCE AND TECHNOLOGY

(Deemed to be University u/s 3 of UGC Act, 1956)

Kattankulathur, Kancheepuram, Tamil Nadu, India

Course Code	18ASC301J	Course Name	COMPRESSIBLE AERODYNAMICS	Course Category	C	Professional Core	L	T	P	C
							3	0	2	4

Pre-requisite Courses	18ASC202J	Co-requisite Courses	Nil	Progressive Courses	Nil
Course Offering Department	Aerospace Engineering	Data Book / Codes/Standards	Gas tables		

Course Learning Rationale (CLR):	The purpose of learning this course is to:
CLR-1 :	*Identify the different wave types and wave propagation*
CLR-2 :	*Evaluate the change in properties across shock waves and optimize the supersonic vehicle design*
CLR-3 :	*Evaluate the change in properties across expansion waves*
CLR-4 :	*Evaluate and optimize the nozzle flow characteristics.*
CLR-5 :	*Design and Evaluate the duct flow with heat transfer and frictional effect.*
CLR-6 :	*Design and optimize the supersonic nozzle*

Course Learning Outcomes (CLO):	At the end of this course, learners will be able to:	Learning 1: Level of Thinking (Bloom)	Learning 2: Expected Proficiency (%)	Learning 3: Expected Attainment (%)	PLO 1: Engineering Knowledge	PLO 2: Problem Analysis	PLO 3: Design & Development	PLO 4: Analysis, Design, Research	PLO 5: Modern Tool Usage	PLO 6: Society & Culture	PLO 7: Environment & Sustainability	PLO 8: Ethics	PLO 9: Individual & Team Work	PLO 10: Communication	PLO 11: Project Mgt. & Finance	PLO 12: Life Long Learning	PLO 13: PSO - 1	PLO 14: PSO - 2	PLO 15: PSO – 3
CLO-1 :	*Understand the properties of different waves in supersonic flow*	*1*	*90*	*80*	*H*	*M*	*M*	*M*	*M*	-	-	-	-	-	-	*M*	-	*H*	-
CLO-2 :	*Analyze the properties of shock wave*	*2*	*80*	*75*	*H*	*H*	*H*	*H*	*H*	-	-	-	-	-	-	*H*	-	*H*	-
CLO-3 :	*Analyze the properties of expansion wave*	*3*	*80*	*75*	*H*	*H*	*H*	*H*	*H*	-	-	-	-	-	-	*H*	-	*H*	-
CLO-4 :	*Analyze the flow through nozzle*	*3*	*70*	*60*	*H*	*H*	*H*	*H*	*H*	-	-	-	-	-	-	*H*	-	*H*	-
CLO-5 :	*Analyze the heat transfer and frictional effect in flow*	*3*	*80*	*75*	*H*	*H*	*H*	*H*	*H*	-	-	-	-	-	-	*H*	-	*H*	-
CLO-6 :	*Analyze the compressibility effects and design the supersonic nozzle*	*2*	*70*	*60*	*H*	*H*	*H*	*H*	*H*	-	-	-	-	-	-	*H*	-	*H*	-

Duration (hour)		15	15	15	15	15
S-1	SLO-1	*Introduction to compressible flow*	*Normal shock wave properties – Mach number relation*	*Multiple shock system*	*Numerical problems on Nozzle flow relations*	*Fanno curve*
	SLO-2	*Basic thermodynamic concepts*	*Normal shock wave properties – density relation*	*Numerical problems on multiple shock systems*	*Numerical problems on Nozzle flow relations*	*Numerical problems on Fanno flow*
S-2	SLO-1	*Basic thermodynamic equations*	*Normal shock wave properties – pressure relation*	*The propagating shock wave*	*Numerical problems on Nozzle flow relations*	*Numerical problems on Fanno flow*
	SLO-2	*Momentum and Energy equations for compressible fluid flow*	*Normal shock wave properties – temperature relation*	*Numerical problems on propagating shock wave*	*Rayleigh flow equations – static properties*	*Numerical problems on Fanno flow*
S-3	SLO-1	*Wave propagation*	*Normal shock wave properties – entropy change*	*Governing equation of Prandtl-meyer expansion waves*	*Rayleigh flow equations – stagnation properties*	*Velocity potential equation for compressible flow*
	SLO-2	*Shock formation*	*Hugoniot equation*	*Expression of Prandtl –meyer function*	*variation of flow properties for subsonic flow*	*Small perturbation theory*
S 4-5	SLO-1 SLO-2	*Lab 1: Study of various types of Supersonic wind tunnel.*	*Lab 4: Calibration of supersonic wind tunnel*	*Lab 7: Visualization of shock wave pattern on ramp model using Schlieren flow visualization technique*	*Lab 10: Visualization of shock wave pattern on Diamond Airfoil using Schlieren flow visualization technique*	*Lab 13: Investigation of intersection of right and left running shock waves for various deflection angles using Schlieren flow visualization*
S-6	SLO-1	*types of waves*	*Numerical problems on normal shock*	*Numerical problems on expansion waves*	*variation of flow properties for supersonic flow*	*Small perturbation theory*
	SLO-2	*Speed of sound derivation*	*Numerical problems on normal shock*	*Numerical problems on expansion waves*	*Critical reference states*	*Linearized pressure coefficient*
S-7	SLO-1	*Change in entropy relation*	*Numerical problems on normal shock*	*Shock Expansion theory – flat plate*	*Rayleigh curve*	*Linearized pressure coefficient*
	SLO-2	*Numerical problems on thermodynamic concepts*	*Oblique shock properties*	*Numerical problems on shock expansion theory*	*Numerical problems on Rayleigh flow*	*Prandtl-Glauert compressibility correction*
S-8	SLO-1	*Isentropic relations*	*Θ-β-M relation and graph*	*Shock Expansion theory – Diamond airfoil*	*Numerical problems on Rayleigh flow*	*Supersonic linearized theory*
	SLO-2	*Numerical problems on isentropic relations*	*Supersonic flow over wedges and cones*	*Numerical problems on shock expansion theory*	*Numerical problems on Rayleigh flow*	*Application of Supersonic linearized theory*

S 9-10	SLO-1	Lab 2: Study of various Supersonic flow visualization techniques and its applications.	Lab 5: Mach number distribution of different area ratio C-D nozzles	Lab 8: Visualization of shock wave pattern on wedge model using Schlieren flow visualization technique	Lab 11: Investigation of supersonic flow over different aircraft/ missile models using Schlieren flow visualization technique	Lab 14: Experimental study of supersonic jet
	SLO-2					
S-11	SLO-1	Isentropic relations – stagnation state	Shock polar	Nozzle flow relations: Area – velocity	Fanno flow- equations	Numerical problems on linearized theory
	SLO-2	Numerical problems on isentropic relations	Shock reflections	Supersonic nozzle and diffuser	Fanno flow- equations	Numerical problems on linearized theory
S-12	SLO-1	Isentropic relations – critical state	Shock interactions	Nozzle flow relations: Area – Mach number	variation of flow properties with duct length	Introduction to Method of characteristics
	SLO-2	Numerical problems on isentropic relations	Numerical problems on oblique shock	Nozzle flow relations: Maximum mass flow rate	variation of flow properties for subsonic flow	Method of characteristics
S-13	SLO-1	Characteristic Mach number	Numerical problems on oblique shock	Variation of Pressure and Mach number along the C-D nozzle	variation of flow properties for supersonic flow	Application of Method of characteristics
	SLO-2	Numerical problems on isentropic relations	Numerical problems on oblique shock reflections	Under expansion and over expansion nozzle	Critical reference states	Application of Method of characteristics
S 14-15	SLO-1	Lab 3: Study of SRM supersonic wind tunnel and its instrumentations.	Lab 6: Investigation of starting normal shock wave movement inside Convergent Divergent Nozzle.	Lab 9: Verification of "Three dimensional relieving effect".	Lab 12: Investigation of detached shock wave pattern using Schlieren flow visualization technique	Lab 15: Noise measurement in supersonic jet
	SLO-2					

Learning Resources	1. Rathakrishnan, E., "Gas Dynamics", Prentice Hall India Learning Private Limited, 6th edition, Delhi, India, 2016. 2. Anderson J. D., Jr., "Modern Compressible Flow with Historical Perspective," McGraw Hill Publishing Co., 3rd edition, 2017	3. Shapiro, A.H., "The Dynamics and Thermodynamics of Compressible Fluid Flow (Vol I and Vol II)", Ronald Press, 1953. 4. Zucker, R. D., Biblarz, O., "Fundamentals of Gas Dynamics", Wiley-Blackwell; Third edition (2019) 5. Yahya, S. M., "Fundamentals of Compressible Flow with Aircraft and Rocket Propulsion", New Age International Publishers; Sixth edition (2018)

Learning Assessment

	Bloom's Level of Thinking	Continuous Learning Assessment (50% weightage)								Final Examination (50% weightage)	
		CLA – 1 (10%)		CLA – 2 (15%)		CLA – 3 (15%)		CLA – 4 (10%)#			
		Theory	Practice	Theory	Practice	Theory	Practice	Theory	Practice	Theory	Practice
Level 1	Remember Understand	20%	20%	15%	15%	15%	15%	15%	15%	15%	15%
Level 2	Apply Analyze	20%	20%	20%	20%	20%	20%	20%	20%	20%	20%
Level 3	Evaluate Create	10%	10%	15%	15%	15%	15%	15%	15%	15%	15%
	Total	100 %		100 %		100 %		100 %		100 %	

CLA – 4 can be from any combination of these: Assignments, Seminars, Tech Talks, Mini-Projects, Case-Studies, Self-Study, MOOCs, Certifications, Conf. Paper etc.,

Course Designers

Experts from Industry	Experts from Higher Technical Institutions	Internal Experts
Dr Manishankar C, Senior Scientist, CSIR - National Aerospace Laboratories Bangalore.	1. Dr .Arun Kumar Perumal, Mechanical Eng, IIT Jammu, arun.perumal@iitjammu.ac.in	Mr. R. Mohamed Arif, SRMIST. Dr. K. K. Bharadwaj, SRMIST.

Course Code	18ASC302T	Course Name	FLIGHT DYNAMICS - I	Course Category	C	Professional Core	L	T	P	C
							3	0	0	3

Pre-requisite Courses	18ASC202J	Co-requisite Courses	Nil	Progressive Courses	Nil
Course Offering Department	Aerospace Engineering	Data Book / Codes/Standards	Nil		

Course Learning Rationale (CLR):	The purpose of learning this course is to:
CLR-1 :	*Understand the art of application of aerodynamics knowledge into an aircraft*
CLR-2 :	*Know the performance of different powerplants at different flight conditions*
CLR-3 :	*Know the various performance parameters of an airplane*
CLR-4 :	*Learn optimizing different performance parameters for maximizing range, endurance and fuel efficiency*
CLR-5 :	*Learn role of performance parameters in various maneuvers of the airplane*
CLR-6 :	*Learn experimental determination of various performance parameters of a real airplane by flight testing*

Course Learning Outcomes (CLO):	At the end of this course, learners will be able to:	Learning 1: Level of Thinking (Bloom)	2: Expected Proficiency (%)	3: Expected Attainment (%)	PLO 1: Engineering Knowledge	2: Problem Analysis	3: Design & Development	4: Analysis, Design, Research	5: Modern Tool Usage	6: Society & Culture	7: Environment & Sustainability	8: Ethics	9: Individual & Team Work	10: Communication	11: Project Mgt. & Finance	12: Life Long Learning	13: PSO - 1	14: PSO - 2	15: PSO – 3
CLO-1 :	*Estimate and optimize drag polar of an aircraft*	3	85	90	H	M	M	H	L	-	H	-	-	-	-	H	H	H	-
CLO-2 :	*Select optimal powerplant for the required airplane with the desired performance*	3	80	85	M	M	M	M	L	-	H	-	M	-	-	H	H	H	-
CLO-3 :	*Indicate the different flight techniques for optimized steady and accelerated flight performance*	3	75	80	M	H	M	H	M	-	H	-	-	-	-	H	H	H	-
CLO-4 :	*Perform basic calibration of flight instrument data*	3	50	60	M	M	M	M	L	-	L	-	M	-	-	H	H	H	M
CLO-5 :	*Perform conceptual design of any type of airplane*	3	70	70	M	M	H	H	M	M	H	M	H	-	M	H	H	H	-
CLO-6 :	*Determine the drag polar of a real airplane with real flight testing*	3	00	80	M	H	M	M	M	-	-	-	M	M	-	H	-	H	M

Duration (hour)		9	9	9	9	9
S-1	SLO-1	*Forces and moments acting on a vehicle in flight*	*Thrust and propulsive efficiency of air breathing engine*	*Equation of motion for steady level flight*	*Range -Definition and conditions for maximum range for jet driven aircraft*	*Flight instruments- Air Data systems*
	SLO-2	*Coordinate systems*	*Thrust and propulsive efficiency of rocket engine*	*Conditions for maximum velocity in steady level flight*	*Range -Definition and conditions for maximum range for propeller driven aircraft*	*Altitude and speed definitions*
S-2	SLO-1	*Equations of motion of a rigid flight vehicle*	*Trade-off between thrust and propulsive efficiency*	*Conditions for minimum in steady level flight*	*Endurance – Definition and conditions for maximum endurance for jet driven airplane*	*Air speed indicator- construction and working*
	SLO-2	*Solving Problems*	*Solving Problems*	*Solving problems*	*Endurance – Definition and conditions for maximum endurance for propeller driven airplane*	*Air speed indicator- speed calibration*
S-3	SLO-1	*International Standard Atmosphere and various layers in ISA*	*TSFC and BSFC*	*Solving problems*	*Solving problems*	*Solving air speed calibration problems*
	SLO-2	*Derivation of hydrostatic equation*	*Variation of Thrust/Power and SFC with respect to velocity and altitude for reciprocating engine*	*Power required vs velocity – Graphical approach and analytical approach*	*Solving problems*	*Solving air speed calibration problems*
S-4	SLO-1	*Derivation of Pressure, Temperature and density in troposphere*	*The propeller – variation of propulsive efficiency with advance ratio*	*Power available and maximum velocity for propeller driven and jet driven aircraft*	*Accelerated flight- Level turn- Equations of motion*	*Altimeter- construction and working*
	SLO-2	*Solving Problems in Gradient layer*	*Constant speed propellers*	*Minimum velocity- Stall and high lift devices*	*Level turn- conditions for turn radius and turn rate*	*Altimeter- altitude corrections*
S-5	SLO-1	*Derivation of Pressure, Temperature and density in Stratosphere*	*Variation of Thrust/Power and SFC with respect to velocity and altitude for turbojet engine*	*Aerodynamic relations associated with maximum efficiency conditions*	*Level turn- constraints on load factor, Constraints on velocity,*	*Solving problems- altimeter*
	SLO-2	*Solving Problems in Iso thermal layer*	*Solving Problems*	*Solving problems*	*Level turn- calculation of minimum turn radius and minimum turn rate.*	*Rate of climb indicator – construction and working*

S-6	SLO-1	*Various types of drags acting on an airplane*	*Variation of Thrust/Power and SFC with respect to velocity and altitude for turbofan engine*	*Rate of climb- equation of motion*	*Solving problems*	*Mach meter- construction and working*
	SLO-2	*Methods to minimize various drags*	*Solving Problems*	*Rate of climb- Graphical approach and hodograph*	*Solving problems*	*Angle of attack indicator- construction and working*
S-7	SLO-1	*Interference Drag and methods to minimize it Drag polar of vehicles in subsonic speed*	*Variation of Thrust/Power and SFC with respect to velocity and altitude for turboprop engine*	*Analytical approach for maximum climb angle*	*Pull-up and pull-down maneuvers*	*Flight determination of drag polar-introduction*
	SLO-2	*Transonic Drag Divergence*	*Solving Problems*	*Analytical approach for maximum rate of climb*	*V-n diagram and its significance*	*Flight determination of drag polar- speed power method*
S-8	SLO-1	*Wave drag and methods to minimize it*	*Thrust available characteristics of different engines*	*Absolute ceiling and service ceiling*	*Takeoff performance – ground roll*	*Flight determination of drag polar- incremental drag method*
	SLO-2	*Solving Problems*	*Selection of Powerplant*	*Solving problems*	*Estimation of takeoff distance*	*Flight determination of drag polar- prop feathered sinks method*
S-9	SLO-1	*Drag polar of vehicles in supersonic speeds*	*Thrust required vs velocity- Graphical approach*	*Gliding flight- Equation of motion, glide hodograph*	*Landing performance – Estimation of landing distance*	*Flight determination of drag polar- incremental power method*
	SLO-2	*Drag polar of vehicles in hypersonic speeds*	*Thrust required vs velocity- Analytical approach*	*Minimum sink rate and minimum glide path angle conditions*	*Methods to minimise landing distance*	*Solving problems*

Learning Resources	1. *Perkins, C. D., and Hage, R, E., "Airplane Performance, Stability and Control," Wiley Toppan, 1974* 2. *John D. Anderson, "Aircraft Performance and Design", McGraw-Hill, 1999*	3. *Nelson, R.C., "Flight Stability and Automatic Control", McGraw Hill, 1989.* 4. *McCormik, B. W., "Aerodynamics, Aeronautics and Flight Mechanics", John Wiley, 1995.*

Learning Assessment

	Bloom's Level of Thinking	Continuous Learning Assessment (50% weightage)								Final Examination (50% weightage)	
		CLA – 1 (10%)		CLA – 2 (15%)		CLA – 3 (15%)		CLA – 4 (10%)#			
		Theory	Practice	Theory	Practice	Theory	Practice	Theory	Practice	Theory	Practice
Level 1	Remember Understand	*40 %*	-	*30 %*	-	*30 %*	-	*30 %*	-	*30%*	-
Level 2	Apply Analyze	*40 %*	-	*40 %*	-	*40 %*	-	*40 %*	-	*40%*	-
Level 3	Evaluate Create	*20 %*	-	*30 %*	-	*30 %*	-	*30 %*	-	*30%*	-
	Total	100 %		100 %		100 %		100 %		100 %	

CLA – 4 can be from any combination of these: Assignments, Seminars, Tech Talks, Mini-Projects, Case-Studies, Self-Study, MOOCs, Certifications, Conf. Paper etc.,

Course Designers

Experts from Industry	Experts from Higher Technical Institutions	Internal Experts
1. Dr. Raja S, CSIR-NAL, Bangalore, raja@nal.res.in	*1. Dr. K. M. Parammasivam, Madras Institute of Technology, Chennai, mparams@mitindia.edu*	*1. Mr. M. Vignesh Kumar, SRMIST*
2.Wg.Cdr K.Manoharan (Retd), Blue Dart Aviation Ltd., manoharank@bluedart.com	*2. Dr. P. K Dash, Nitte Meenakshi Institute of Technology, Bangalore, drpdash@gmail.com*	*2. Mr. K. Allwyn, SRMIST*

Course Code	18ASC303J	Course Name	ROCKET PROPULSION	Course Category	C	Professional Core	L	T	P	C
							3	0	2	4

Pre-requisite Courses	18ASC203T	Co-requisite Courses	Nil	Progressive Courses	Nil
Course Offering Department	Aerospace Engineering	Data Book / Codes/Standards	Gas Tables		

Course Learning Rationale (CLR):	The purpose of learning this course is to:
CLR-1 :	*Understand the basic principles of rocket propulsion system*
CLR-2 :	*Understand the basic performance parameters ofchemical propellants.*
CLR-3 :	*Design the Solid Propellant Rocket*
CLR-4 :	*Designthe Liquid Propellant Rocket*
CLR-5 :	*Understand the working of advanced rocket propulsion techniques*
CLR-6 :	*Understand Rocket propulsion system, design, advanced propulsion system and it's applications*

Course Learning Outcomes (CLO):	At the end of this course, learners will be able to:	Learning 1 Level of Thinking (Bloom)	2 Expected Proficiency (%)	3 Expected Attainment (%)	Program Learning Outcomes (PLO) 1 Engineering Knowledge	2 Problem Analysis	3 Design & Development	4 Analysis, Design, Research	5 Modern Tool Usage	6 Society & Culture	7 Environment & Sustainability	8 Ethics	9 Individual & Team Work	10 Communication	11 Project Mgt. & Finance	12 Life Long Learning	13 PSO - 1	14 PSO - 2	15 PSO – 3
CLO-1 :	*Design a multistage rocket and analyze its performance*	*2*	*85*	*75*	*H*	*-*	*H*	*-*	*-*	*-*	*-*	*-*	*-*	*-*	*-*	*-*	*M*	*-*	*M*
CLO-2 :	*Analyze the performance parameter and choose the chemical propellant*	*2*	*85*	*75*	*H*	*H*	*H*	*-*	*-*	*-*	*-*	*-*	*-*	*-*	*-*	*-*	*-*	*M*	*-*
CLO-3 :	*Analyze the Solid Propellant Rocket*	*2*	*85*	*75*	*H*	*-*	*H*	*H*	*-*	*-*	*-*	*-*	*-*	*-*	*-*	*-*	*M*	*M*	*M*
CLO-4 :	*Analyze the Liquid Propellant Rocket*	*2*	*85*	*75*	*H*	*H*	*-*	*-*	*-*	*-*	*-*	*-*	*-*	*-*	*-*	*-*	*M*	*M*	*M*
CLO-5 :	*Understand the working of advanced rocket propulsion techniques*	*2*	*85*	*75*	*H*	*-*	*-*	*-*	*-*	*-*	*-*	*-*	*-*	*-*	*-*	*-*	*-*	*H*	*-*
CLR-6 :	*Have a detailed knowledge of Rocket propulsion system, design, advanced propulsion system and it's applications*	*2*	*85*	*75*	*H*	*H*	*H*	*H*	*-*	*-*	*-*	*-*	*-*	*-*	*-*	*-*	*M*	*M*	*M*

Duration (hour)		15	15	15	15	15
S-1	SLO-1 SLO-2	*History and evolution of rockets*	*Introduction of chemical propellant*	*Introduction of Solid Propellant Rocket*	*Introduction of Liquid Propellant Rocket*	*Hybrid propellant rocket*
S-2	SLO-1	*Rocket working principle*	*Molecular mass*	*Classifications of Solid Propellant Rocket*	*Classifications of Liquid Propellant Rocket*	*Electrical rockets*
	SLO-2	*Classification of rockets*	*Specific Heat*	*Hardware components and its functions*	*Hardware components and its functions*	*Electro-thermal propulsion system*
S-3	SLO-1	*Rocket equation*	*specific heat ratio*	*Mechanism of burning*	*Propellant feed systems*	*Arc-jet thruster*
	SLO-2	*Numerical Problems on Rocket equation*	*Stoichiometric ratio*		*Pressure feed system*	*Resistojet thruster*
S 4-5	SLO-1 SLO-2	*Lab 1: Study of Piston Engines*	*Lab 4: Determination of convective heat transfer coefficient over a flat plate by forced convection*	*Lab 7: Performance test on a propeller*	*Lab 10: Burning rate measurement of solid propellant by using Window bomb setup*	*Lab 13: Hybrid Rocket motor fuel grain preparation*
S-6	SLO-1	*Mass ratio of rocket*	*mixture ratio and equivalence ratio*	*Ignition system*	*Turbo pump feed system*	*Electro-static propulsion system*
	SLO-2	*NumericalProblems on rocket parameters*	*Energy release during combustion*	*Igniter types*	*Numerical Problemson feed system*	*Electro-magnetic propulsion system*
S-7	SLO-1	*Rocket Nozzles and its Classifications*	*Heat of formation*	*Propellant grain*	*Injector*	*Ion thruster*
	SLO-2	*Nozzle Performance*	*Heat of combustion*	*configuration and applications of propellant grain*	*Types of injector*	*Hall Effect Thruster*
S-8	SLO-1	*Nozzle area ratio- Mass flow rate*	*Criterion for choice of propellant*	*Burn rate*	*NumericalProblems on injector*	*Magneto plasma dynamic thruster*
	SLO-2	*NumericalProblems on nozzle*	*Solid propellants*	*Factors influencing burn rates*		*Pulsed Plasma Thruster*
S 9-10	SLO-1 SLO-2	*Lab 2: Study of jet engines*	*Lab 5: Characteristic plots of a free jet through a non-circular orifice*	*Lab 8: Thrust measurement of a Ramjet engine*	*Lab 11: Thrust measurement on a prepared solid propellant*	*Lab 14: Regression rate measurement of hybrid rocket motor*
S-11	SLO-1	*Characteristic velocity and Thrust coefficient*	*Composition and processing*	*Burn rate index for stable operation*	*Thrust chamber*	*Nuclear rockets*
	SLO-2	*Numerical Problems on nozzle performance*	*Liquid propellants*	*Action time and burn time*	*Cooling of Thrust chamber*	
S-12	SLO-1	*Performance parameters and Efficiencies of rocket*	*Classifications of liquid propellant*	*Design of Solid Propellant rocket*	*Cryogenic propulsion system*	*Solar Propulsion system*

	SLO-2	*Numerical Problems on Performance parameters and Efficiencies of rocket*	*Storability of liquid propellant*		*Special features of cryogenic systems*	
S-13	SLO-1	*Staging and Clustering of rocket*	*Numerical Problems on chemical propellant*	*Numerical Problems on Solid Propulsion system*	*Numerical Problems on Liquid Propulsion system*	*Numerical problems*
	SLO-2	*Numerical Problems on Staging and Clustering of rocket*				
S 14-15	SLO-1	*Lab 3: Determination of convective heat transfer coefficient over a flat plate by natural convection*	*Lab 6: Characteristic plots of a wall jet through a non-circular orifice*	*Lab 9: Solid Rocket motor propellant preparation*	*Lab 12: Study of Liquid propulsion system*	*Lab 15: Thrust measurement of a hybrid rocket*
	SLO-2					

Learning Resources	1. *Ramamurthi.K, "Rocket propulsion", Laxmi Publications, India, Second edition 2016.* 2. *George P. Sutton, Oscar Biblarz, "Rocket propulsion elements", Wiley India Pvt Ltd. eighth Edition2010.* 3. *Philip Hill and Carl Peterson, "Mechanics and thermodynamics of propulsion", Pearson India, secondedition 2010.* 4. *Stephen R. Turns, "An Introduction to Combustion: Concepts and Applications", McGraw-HillEducation, third Edition , 2011.*

Learning Assessment

	Bloom's Level of Thinking	Continuous Learning Assessment (50% weightage)								Final Examination (50% weightage)	
		CLA – 1 (10%)		CLA – 2 (15%)		CLA – 3 (15%)		CLA – 4 (10%)#			
		Theory	Practice	Theory	Practice	Theory	Practice	Theory	Practice	Theory	Practice
Level 1	Remember Understand	*20 %*	*20 %*	*15 %*	*15 %*	*15 %*	*15 %*	*15 %*	*15 %*	*15 %*	*15 %*
Level 2	Apply Analyze	*20 %*	*20 %*	*20 %*	*20 %*	*20 %*	*20 %*	*20 %*	*20 %*	*20 %*	*20 %*
Level 3	Evaluate Create	*10 %*	*10 %*	*15 %*	*15 %*	*15 %*	*15 %*	*15 %*	*15 %*	*15 %*	*15 %*
	Total	100 %		100 %		100 %		100 %		100 %	

CLA – 4 can be from any combination of these: Assignments, Seminars, Tech Talks, Mini-Projects, Case-Studies, Self-Study, MOOCs, Certifications, Conf. Paper etc.,

Course Designers

Experts from Industry	Experts from Higher Technical Institutions	Internal Experts
1. Dr. S. Raja, Senior Principal Scientist and Professor, NAL – Bangalore. raja@nal.res.in	*1.Dr P K Dash Professor and HOD at Nitte Meenakshi Institute of Technology Bengaluru, Karnataka, India*	1. *Mr.G.Saravanan, SRMIST*
	2. Dr.K.M.Parammasivam, Professor, MIT-Chennai. mparams@mitindia.edu	2. *Mr. A.Vinoth Kumar, SRMIST*

Course Code	18ASC304J	Course Name	AIRCRAFT STRUCTURES	Course Category	C	Professional Core	L	T	P	C
							3	0	2	4

Pre-requisite Courses	18ASC201J	Co-requisite Courses	Nil	Progressive Courses	Nil
Course Offering Department	Aerospace	Data Book / Codes/Standards	Nil		

Course Learning Rationale (CLR):	*The purpose of learning this course is to:*
CLR-1 :	*Understand the physical meaning of symmetric bending and unsymmetrical bending*
CLR-2 :	*Know the procedure to fid the shear flow and shear center in open sections subjected to shear loads*
CLR-3 :	*Know the procedure to find the shear flow and shear center in closed sections subjected to shear loads*
CLR-4 :	*Know the procedure to find the shear flow in closed sections subjected to torque*
CLR-5 :	*Understand the buckling analysis of plates*
CLR-6 :	*Learn the experimental procedure of stress analysis in wing and fuselage*

Course Learning Outcomes (CLO):	*At the end of this course, learners will be able to:*	Learning 1 Level of Thinking (Bloom)	2 Expected Proficiency (%)	3 Expected Attainment (%)	PLO 1 Engineering Knowledge	2 Problem Analysis	3 Design & Development	4 Analysis, Design, Research	5 Modern Tool Usage	6 Society & Culture	7 Environment & Sustainability	8 Ethics	9 Individual & Team Work	10 Communication	11 Project Mgt. & Finance	12 Life Long Learning	13 PSO - 1	14 PSO - 2	15 PSO – 3
CLO-1 :	*Explain the differences between symmetrical bending and unsymmetrical bending*	2	85	75	H	H	H	H	-	H	H	H	-	-	-	M	M	M	M
CLO-2 :	*Improve the ability in solving geometrical applications of a structure*	2	85	75	H	H	H	H	-	H	H	H	-	-	-	M	M	M	M
CLO-3 :	*Gain the ability to solve the shear flow analysis and shear centre of open section beams*	2	85	75	H	H	H	H	-	H	H	H	-	-	-	M	M	M	M
CLO-4 :	*Solve the shear flow and shear center calculations in closed sections subjected to both shear loads and torsion loads.*	2	85	75	H	H	H	H	-	H	H	H	-	-	-	M	M	M	M
CLO-5 :	*Describe the buckling modes of thin plates for various end conditions*	2	85	75	H	H	H	H	H	H	H	H	-	-	-	M	M	M	M
CLO-6 :	*Describe the stress analysis in wing and fuselage*	2	85	75	H	H	H	H	H	H	H	H	-	-	-	M	M	M	M

		15	15	15	15	15
S-1	SLO-1	*Introduction to symmetrical bending*	*Introduction to thin walled beams*	*Concept of Bredt - Batho theory and assumptions for Engineers Theory of bending.*	*Introduction to thin plates and its application to aircraft structures.*	*Shear distribution for wings*
	SLO-2	*Concept of bending stresses in beams of symmetrical sections*	*Section properties of thin walled beams*	*Derivation of the relation between shear flow and the torque*	*Plate subjected to pure bending.*	*Numerical solving*
S-2	SLO-1	*Symmetrical bending, assumptions*	*Concept of shear flow and the shear centre.*	*Multi cell structure subjected to torque, shear flow determination*	*Flexural rigidity of a plate, anticlastic and synclastic surface*	*Bending moment distribution for wings*
	SLO-2	*Direct stress distribution*	*Introduction to thin walled open section beams, assumptions*	*Numerical solving*	*Plate subjected to bending and twisting*	*Numerical solving*
S-3	SLO-1	*Anticlastic bending, unsymmetrical bending, sign conventions and notation, Resolution of bending moments.*	*General stress, strain and displacement relationship for open thin-walled beams.*	*Shear flow and shear centre etermination, and shear flow distribution for a thin-walled symmetrical (three cell) closed sections subjected to torque.*	*Determination of shear strain for thin plates*	*Shear distribution for fuselage*
	SLO-2	*Derivation for bending stress expression due to bending.*	*Shear flow expression for open sections.*	*Numerical solving*	*Plates subjected to a distributed transverse load*	*Numerical solving*
S-4	SLO-1 SLO-2	*Lab 1: Determination of the position of principal axes of a Z section*	*Lab 4: Verification of principle of superposition (Cantilever beam)*	*Lab 7: Determination of shear center of closed section beam*	*Lab 10: Determination of the buckling stress of a given column*	*Lab 13: Study of free and forced vibration analysis*
S-5	SLO-1	*Position of neutral axis, calculation of section properties, Second moments of area of an inclined thin section and a semicircular section*	*Shear flow of C section*	*Shear flow and shear centre determination, and shear flow distribution for a thin-walled symmetrical (single cell) closed sections subjected to shear force*	*Plate element subjected to bending, twisting and transverse loads.*	*Bending moment distribution for fuselage*
	SLO-2	*Approximations for thin-walled sections*	*Shear flow of C section*	*Derivation of shear flow for closed section*	*Numerical solving*	*Numerical Solving*
S-6	SLO-1	*Bending of symmetric sections with symmetric loads - Numericals*	*Shear center of C section*	*Closed section single cell -shear flow determination*	*Boundary conditions for various types of edge supports*	*Shear resistant web beams.*
	SLO-2	*Numerical solving*	*Procedure of solving shear centre of c section*	*Numerical solving*	*Numerical solving*	*Numerical solving*

S-7	SLO-1	*Bending of symmetric sections with skew loads – Problems.*	*Shear flow distribution for thin walled open sections*	*Closed section two cell structure-shear flow determination*	*Combined bending and in-plane loading of a thin rectangular plate*	*Typical wing structural arrangement, wing strength requirements.*
	SLO-2	*Numerical solving*	*Shear center position for different type of thin walled open section*	*Numerical solving*	*Numerical solving*	*Numerical solving*
S-8	SLO-1 SLO-2	*Lab 2: Verification of Maxwell's reciprocal theorem(Cantilever beam)*	*Lab 5: Verification of principle of superposition (Simply supported beam)*	*Lab 8: Analysis of constant strength beam*	*Lab 11: Determination of the ratio of forces carried by two wires of different materials supported by hinged bar*	*Lab 14:Preparation of a composite laminate*
S-9	SLO-1	*Bending stress determination for symmetrical section with stringers.*	*Shear flow and shear centre determination, and shear flow distribution for thin-walled symmetrical open sections*	*Shear flow and shear centre determination, and shear flow distribution for a thin-walled symmetrical (single cell) closed sections subjected to shear force.*	*Buckling of thin plates*	*Tension (Wagner's) field beam – complete diagonal tension field beams.Derivation*
	SLO-2	*Numerical solving*	*Numerical solving*	*Numerical solving*	*Numerical solving*	*Incomplete diagonal tension field beams*
S-10	SLO-1	*Bending of unsymmetric sections with skew loads - Problems*	*Shear flow and shear centre determination, and shear flow distribution for thin-walled unsymmetrical open sections*	*Shear flow and shear centre determination, and shear flow distribution for a thin-walled symmetrical (two cell) closed sections subjected to shear force.*	*Inelastic buckling of plates*	*Typical wing structural arrangement, wing strength requirements.*
	SLO-2	*Numerical solving*	*Numerical solving*	*Numerical solving*	*Numerical solving*	*Beam theory assumptions, wing stress analysis methods.*
S-11	SLO-1	*Bending stress determination for unsymmetrical section with stringers.*	*Concept of structural idealization.*	*Shear flow and shear centre determination, and shear flow distribution for symmetrical and unsymmetrical (single cell) closed sections with stringers subjected to shear force*	*Local instability and Instability of stiffened panels*	*Shear lag concepts*
	SLO-2	*Numerical solving*	*Determination of boom areas*	*Numerical solving*	*Numerical solving*	*Basic fuselage structure, fuselage stress analysis methods.*
S-12	SLO-1 SLO-2	*Lab 3: Verification of Maxwell's reciprocal theorem(Simply supported beam)*	*Lab 6: Determination of shear center of open section beam*	*Lab 9: Determination of principal axes of a hollow shaft subjected to both bending and torsional loads*	*Lab 12:Determination of hoop stress and longitudinal stress in a thin walled pressure vessel*	*Lab 15:Design aspect of tension field beam*
S-13	SLO-1	*Bending of thin symmetric sections with symmetric loads - Problems*	*Shear flow and shear centre determination, and shear flow distribution for symmetrical open sections with stringers.*	*Shear flow and shear centre determination, and shear flow distribution for symmetrical and unsymmetrical (two cells) closed sections with stringers subjected to shear force.*	*Flexural–torsional buckling of thin-walled columns*	*shear flow distribution in the web of the tapered beam*
	SLO-2	*Numerical solving*	*Numerical solving*	*Numerical solving*	*Numerical solving*	*Calculation of direct stress due to bending in a fuselage*
S-14	SLO-1	*Bending of thin unsymmetric sections with skew loads - Problems.*	*Shear flow and shear centre determination, and shear flow distribution for a unsymmetrical open sections with stringers.*	*Shear flow and shear centre determination, and shear flow distribution for symmetrical and unsymmetrical (three cells) closed sections with stringers subjected to shear force.*	*Estimation of crippling stress using Needham's and Gerard's method.*	*shear flow distribution in the fuselage*
	SLO-2	*Numerical solving*	*Numerical solving*	*Numerical solving*	*Stiffened panel / Sheet effective width concepts*	*Principles of stiffener / web construction*
S-15	SLO-1	*Bending of thin symmetric sections with skew loads - Problems .*	*Walls effective in bending*	*Walls effective in bending*	*Inter rivet and sheet wrinkling failures.*	*Fuselage frames*
	SLO-2	*Numerical solving*	*Walls ineffective in bending*	*Walls ineffective in bending*	*Thin walled column strength, Torsional instability of thin walled columns.*	*Wing ribs*

Learning Resources	1. Megson T H G,'Aircraft Structures for Engineering Students', Elsevier, Fifth edition, 2013 2. Bruhn. E.F., 'Analysis and Design of Flight Vehicles Structures', Tri-state offset company, USA 1985 3. Aircraft Structures Laboratory manual	4. Rivello, R.M., Theory and Analysis of Flight Structures, McGraw Hill, 1993. 5. Peery, D.J., Aircraft Structures, 2md edition, McGraw-Hill, N.Y., 1999

Learning Assessment											
	Bloom's Level of Thinking	Continuous Learning Assessment (50% weightage)								Final Examination (50% weightage)	
		CLA – 1 (10%)		CLA – 2 (15%)		CLA – 3 (15%)		CLA – 4 (10%)			
		Theory	Practice	Theory	Practice	Theory	Practice	Theory	Practice	Theory	Practice
Level 1	Remember Understand	*20%*	*20%*	*15%*	*15%*	*15%*	*15%*	*15%*	*15%*	*15%*	*15%*
Level 2	Apply Analyze	*20%*	*20%*	*20%*	*20%*	*20%*	*20%*	*20%*	*20%*	*20%*	*20%*
Level 3	Evaluate Create	*10%*	*10%*	*15%*	*15%*	*15%*	*15%*	*15%*	*15%*	*15%*	*15%*
	Total	100%		100%		100%		100%		100%	

CLA – 4 can be from any combination of these: Assignments, Seminars, Tech Talks, Mini-Projects, Case-Studies, Self-Study, MOOCs, Certifications, Conf. Paper etc.,

Course Designers		
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Course Code	18ASC305T	Course Name	FLIGHT DYNAMICS - II	Course Category	C	Professional Core	L	T	P	C
							3	0	0	3

Pre-requisite Courses	18ASC302T	Co-requisite Courses	Nil	Progressive Courses	Nil
Course Offering Department	Aerospace Engineering	Data Book / Codes/Standards	Nil		

Course Learning Rationale (CLR):	*The purpose of learning this course is to:*
CLR-1 :	*Know the importance of stability and control of airplane*
CLR-2 :	*Learn the concepts of static stability and dynamic stability of airplane*
CLR-3 :	*Learn longitudinal, lateral and directional stabilities*
CLR-4 :	*Understand control fixed and control free effects*
CLR-5 :	*Learn the criteria for stability and instability*
CLR-6 :	*Learn experimental techniques to measure stability parameters of an airplane using real flight testing*

Course Learning Outcomes (CLO):	*At the end of this course, learners will be able to:*	Learning 1: Level of Thinking (Bloom)	Learning 2: Expected Proficiency (%)	Learning 3: Expected Attainment (%)	PLO 1: Engineering Knowledge	PLO 2: Problem Analysis	PLO 3: Design & Development	PLO 4: Analysis, Design, Research	PLO 5: Modern Tool Usage	PLO 6: Society & Culture	PLO 7: Environment & Sustainability	PLO 8: Ethics	PLO 9: Individual & Team Work	PLO 10: Communication	PLO 11: Project Mgt. & Finance	PLO 12: Life Long Learning	PLO 13: PSO - 1	PLO 14: PSO - 2	PLO 15: PSO – 3
CLO-1 :	*Determine the degree of stability of any airplane configuration*	5	85	90	H	M	M	H	L	-	H	-	-	-	-	H	H	H	-
CLO-2 :	*Design an airplane for the required degree of stability and maneuverability*	3	80	85	M	M	M	M	L	-	H	-	M	-	-	H	H	H	-
CLO-3 :	*Indicate the different flight techniques for safer flight*	4	75	80	M	H	M	H	M	-	H	-	-	-	-	H	H	H	-
CLO-4 :	*Perform basic calibration of control surfaces*	5	50	75	M	M	M	M	L	-	L	-	M	-	-	H	H	H	M
CLO-5 :	*Identify different instability modes in flight and suggest the correct recovery procedure*	5	80	80	M	M	H	H	M	M	H	M	H	-	M	H	H	H	-
CLO-6 :	*Determine the stability derivatives of a real airplane with real flight testing*	4	00	95	M	H	M	M	M	-	-	-	M	M	-	H	-	H	M

Duration (hour)		9	9	9	9	9
S-1	SLO-1	*Basic concepts of stability and control*	*Longitudinal control- basics*	*Dynamic stability- basics*	*Construction of stability matrix*	*Lateral- directional equations of motion*
	SLO-2	*Classification of stability- static and dynamic*	*Various factors affecting the design of control surface*	*Rigid body equation of motion for a disturbed flight- Forces*	*Decoupling of longitudinal and lateral modes*	*Spiral approximation- spiral divergence*
S-2	SLO-1	*Longitudinal static stability – basic criteria*	*Control effectiveness- elevator effectiveness*	*Rigid body equation of motion for a disturbed flight- moment*	*Significance of eigen values and eigen vectors of stability matrix*	*Directional divergence*
	SLO-2	*Wing contribution to longitudinal static stability*	*Solving problems*	*Defining equations of motion in inertial frame of reference*	*Solving problems*	*Dutch roll approximation*
S-3	SLO-1	*Tail contribution (Aft tail contribution) to longitudinal static stability*	*Elevator angle to trim*	*Euler angles*	*Solving Problems*	*Routh's criterion*
	SLO-2	*Solving problems*	*Solving problems*	*Orientation and position of the airplane*	*Longitudinal motion-stick fixed*	*Wing stall characteristics*
S-4	SLO-1	*Fuselage contribution*	*Elevator hinge moment*	*Gravitational and thrust forces*	*Second order differential equations*	*Autorotation and its recovery*
	SLO-2	*Power plant contribution*	*Stick free neutral point- definition*	*Small disturbance theory- assumptions*	*Variation of response with damping ratio*	*Spin (stalled) and its recovery*
S-5	SLO-1	*Canard configuration (Forward tail surface) contribution to longitudinal static stability*	*Relation between stick fixed and stick free neutral point*	*Small disturbance theory-linearized longitudinal rigid body equation of motion*	*Pure pitching motion*	*Aeroelastic effects- wing torsional divergence*
	SLO-2	*Stick fixed neutral point- definition*	*Aerodynamic balancing- basics*	*Small disturbance theory-linearized lateral rigid body equation of motion*	*State variable representation of the equations of motion*	*Aeroelastic effects- control reversal*
S-6	SLO-1	*Solving problems*	*Various methods of aerodynamic balancing- Set back hinge, horn balance*	*Aerodynamic force and moment representation by stability coefficient*	*Solving problems*	*Aeroelastic effects- control surface flutter*
	SLO-2	*Basic criteria for longitudinal, roll and directional stability*	*Various methods of aerodynamic balancing- Frise aileron, sealed nose balance and servo tab*	*Derivatives due to the change in forward speed*	*Longitudinal approximations*	*Stick fixed neutral point*
S-7	SLO-1	*Contribution of various components to roll stability*	*Trim tabs*	*Derivatives due to the change in pitching velocity*	*Phugoid and short period oscillations*	*Determination of stick fixed neutral point- parameters*
	SLO-2	*Dihedral effect and roll control*	*Critical conditions of stability and control*	*Derivatives due to the time rate of change of angle of attack*	*Influence of stability derivative on the longitudinal modes of motion*	*Determination of stick free neutral point- parameters*

S-8	SLO-1	*Solving problems*	*Static margin and neutral point- definition*	*Derivatives due to the rolling rate*	*Lateral motion – stick fixed*	*Determination of stick fixed maneuvering point- parameters*
	SLO-2	*Directional stability- basics*	*Stick forces and stick force gradients- definition*	*Derivatives due to the yawing rate*	*Pure rolling motion*	*Determination of stick free maneuvering point- parameters*
S-9	SLO-1	*Various requirements of rudder for directional control*	*Solving problems*	*Solving problems*	*Tutorial*	*Tutorial*
	SLO-2	*Solving problems*	*Solving problems*	*Solving problems*	*Tutorial*	*Tutorial*

Learning Resources	1. *Nelson, R,C.,"Flight Stability and Automatic Control", McGraw Hill, 1989* 2. *Bernard Etkin "Dynamics of atmospheric flight" Wiley, 1972*	3. *Perkins, C, D., and Hage, R,E., "Airplane Performance, Stability and Control," Wiley Toppan, 1974..* 4. *Babister, A, W.,"Aircraft Stability and Response", Pergamon Press,1980.* 5. *L J Clancy "Aerodynamics" John Wiley & Sons (1975)*

Learning Assessment

	Bloom's Level of Thinking	Continuous Learning Assessment (50% weightage)								Final Examination (50% weightage)	
		CLA – 1 (10%)		CLA – 2 (15%)		CLA – 3 (15%)		CLA – 4 (10%)#			
		Theory	Practice	Theory	Practice	Theory	Practice	Theory	Practice	Theory	Practice
Level 1	Remember Understand	*40 %*	-	*30 %*	-	*30 %*	-	*30 %*	-	*30%*	-
Level 2	Apply Analyze	*40 %*	-	*40 %*	-	*40 %*	-	*40 %*	-	*40%*	-
Level 3	Evaluate Create	*20 %*	-	*30 %*	-	*30 %*	-	*30 %*	-	*30%*	-
	Total	100 %		100 %		100 %		100 %		100 %	

CLA – 4 can be from any combination of these: Assignments, Seminars, Tech Talks, Mini-Projects, Case-Studies, Self-Study, MOOCs, Certifications, Conf. Paper etc.,

Course Designers

Experts from Industry	Experts from Higher Technical Institutions	Internal Experts
1. Dr. Raja S, CSIR-NAL, Bangalore, raja@nal.res.in	*1. Dr. K. M. Parammasivam, Madras Institute of Technology, Chennai, mparams@mitindia.edu*	*1. Mr. M. Vignesh Kumar, SRMIST*
2.Wg.Cdr K.Manoharan (Retd), Blue Dart Aviation Ltd., manoharank@bluedart.com	*2. Dr. P. K Dash, Nitte Meenakshi Institute of Technology, Bangalore, drpdash@gmail.com*	*2. Mr. K. Allwyn, SRMIST*

Course Code	18ASC306T	Course Name	INTRODUCTION TO SPACE TECHNOLOGY	Course Category	C	Professional Core	L	T	P	C
							3	0	0	3

Pre-requisite Courses	18ASC101T, 18MAB102T	Co-requisite Courses	Nil	Progressive Courses	Nil
Course Offering Department	Aerospace Engineering	Data Book / Codes/Standards	Nil		

Course Learning Rationale (CLR):	*The purpose of learning this course is to:*
CLR-1 :	*Learn about fundamental laws that govern the orbital dynamics.*
CLR-2 :	*Understand and apply the basic equations of orbital dynamics for different conic orbits.*
CLR-3 :	*Understand the importance of Keplerian orbital elements, Kepler's equation and orbital perturbations.*
CLR-4 :	*Learn the different types of orbit transfers, basics of interplanetary trajectories.*
CLR-5 :	*Study the governing equations of rocket motion, rocket motion under different conditions.*
CLR-6 :	*Understand the fundamentals of ballistic missile trajectory and its governing equations, errors associated during launching of ballistic missiles.*

Course Learning Outcomes (CLO):	*At the end of this course, learners will be able to:*	Learning 1 Level of Thinking (Bloom)	2 Expected Proficiency (%)	3 Expected Attainment (%)	PLO 1 Engineering Knowledge	2 Problem Analysis	3 Design & Development	4 Analysis, Design, Research	5 Modern Tool Usage	6 Society & Culture	7 Environment & Sustainability	8 Ethics	9 Individual & Team Work	10 Communication	11 Project Mgt. & Finance	12 Life Long Learning	13 PSO - 1	14 PSO - 2	15 PSO – 3
CLO-1 :	*Acquire knowledge of laws applied in orbital dynamics.*	2	85	75	H	M	L	L	-	-	-	-	-	-	-	L	M	M	M
CLO-2 :	*Analyze the properties of conic orbits using the governing equations of orbital mechanics.*	2	90	80	H	H	M	M	L	-	-	-	-	-	-	L	H	H	M
CLO-3 :	*Apply Kepler's equation, earth's oblateness for positioning the satellite at a desired position in orbit.*	2	80	75	H	M	M	M	-	-	-	-	-	-	-	L	M	M	H
CLO-4 :	*Accrue knowledge of different orbit transfers which can be used for many practical missions.*	2	85	75	H	H	M	M	L	-	-	-	-	-	-	L	H	M	M
CLO-5 :	*Apply the governing equations of rocket motion for different conditions.*	2	80	70	H	M	L	L	-	-	-	-	-	-	-	L	M	H	M
CLO-6 :	*Accrue understanding and importance of ballistic missile trajectory and effectively implement its equations by considering the launching errors.*	2	85	75	H	M	M	L	-	-	-	-	-	-	-	L	M	M	M

Duration (hour)		9	9	9	9	9
S-1	SLO-1	*Laws of Orbital Dynamics - Newton's Laws of Motion*	*Introduction to Coordinate Systems*	*Introduction to Orbital Maneuver, Impulsive Maneuvers*	*Rockets – Introduction, Tsiolkov sky rocket equation, Rocket Parameters*	*Introduction Ballistic missile and its trajectory*
	SLO-2	*Kepler's Laws, Conic Sections*	*Types of Coordinate Systems*			
S-2	SLO-1	*Structure of Upper Atmosphere*	*Time Systems - Definitions*	*Introduction to Single Impulse Maneuver – Adjustment of Heights, Simple Rotation.*	*Rocket Motion – Introduction, Two Dimensional Rocket Motion*	*Free-Flight Range Equation - Derivation*
	SLO-2	*Multi-Body / N-body problem*	*Orbital Elements - Introduction*			
S-3	SLO-1	*Two Body Problem – Introduction*	*Classical / Keplerian Orbital Elements*	*Introduction to Single Impulse Maneuver – Simple Plane Change, Combined Change of Plane and Height*	*Two Dimensional Equations of Motion of Rigid Rockets – Assumptions, Derivation*	*Flight-Path Angle Equation – Derivation*
	SLO-2	*Two Body Equation of Relative Motion – Assumptions, Significance*		*Introduction to Hohmann Transfer*		
S-4	SLO-1	*Orbit / Trajectory Equation*	*Kepler's Equation – Derivation*	*Hohmann Transfer*	*Rocket motion in Free Space*	*Numerical Problems on Free-Flight Range and Flight-Path Angle Equations*
	SLO-2					
S-5	SLO-1	*Constants of Motion – Introduction*	*Numerical Problems on Kepler's Equation*	*Bi-elliptic Transfer*	*Rocket Motion in Homogeneous Gravitational Field*	*Maximum Range Trajectory*
	SLO-2	*Conservation of Specific Angular Momentum*				*Time of Free-Flight*
S-6	SLO-1	*Conservation of Specific Mechanical Energy – Vis-Viva Equation*	*Types of Satellite Orbits*	*Numerical Problems on Hohmann and Bi-elliptic Transfers*	*Introduction to Vertical Flight Trajectory*	*Effect of Earth Rotation - Compensating for the Initial velocity*
	SLO-2					*Numerical Problems on Initial Velocity Compensation*
S-7	SLO-1	*Relating the Constants of Motion to the Geometry of the Orbit*		*One Tangent Burn Transfer - Introduction*	*Introduction to Constant Pitch Angle and Gravity Turn / Zero-Lift Trajectories*	*Effect of Earth Rotation – Compensating for the Movement of the Target*

	SLO-2	*Proof - Kepler's Second and Third Law*	*Earth's Oblateness and its Effects, Applications – Sun-Synchronous and Molniya Orbits*	*Phasing Maneuvers - Introduction*		*Numerical Problems on the Movement of the Target Compensation*
S-8	SLO-1	*Some Important Properties of Individual Conic Orbits – Circular Orbit, Elliptic Orbit*	*Introduction to Orbital Perturbations – Perturbing Forces, Perturbation Techniques – Definitions of Special and General Perturbations*	*Introduction to Inter-planetary Mission Trajectories*	*Introduction to Multi-Stage Rocket and its Types, Restricted Staging and Optimal Staging - Definitions*	*Effect of Launching Errors on Range – Introduction to Down-Range and Cross-Range Errors*
	SLO-2	*Some Important Properties of Individual Conic Orbits – Parabolic Orbit, Hyperbolic Orbit*				
S-9	SLO-1 SLO-2	*Tutorial*	*Tutorial*	*Tutorial*	*Tutorial*	*Tutorial*

Learning Resources	1. *Howard D. Curtis, Orbital Mechanics for Engineering Students, 4th Edition, Butterworth-Heinemann*, 2019. 2. *William E. Wiesel, Spaceflight Dynamics, 3rd Edition, CreateSpace, 2010.* 3. *Roger R. Bate, Donald D. Mueller & Jerry E. White, Fundamentals of Astrodynamics, Dover Publications, Inc., New York, 1971.* 4. *Ashish Tewari, Atmospheric and Space Flight Dynamics, Springer, 2007.* 5. *Cornelisse J.W., Schoyer H.F.R. & Wakker K.F., Rocket Propulsion and Spaceflight Dynamics, Pitman Publishing Ltd., 1979.* 6. *Martin J. L. Turner, Rocket and Spacecraft Propulsion, 3rd Edition, Springer, 2009.* 7. *Vladimir A. Chobotov, Orbital Mechanics, 3rd Edition, AIAA Education Series, AIAA, 2002.*

Learning Assessment

	Bloom's Level of Thinking	Continuous Learning Assessment (50% weightage)								Final Examination (50% weightage)	
		CLA – 1 (10%)		CLA – 2 (15%)		CLA – 3 (15%)		CLA – 4 (10%)#			
		Theory	Practice	Theory	Practice	Theory	Practice	Theory	Practice	Theory	Practice
Level 1	Remember Understand	*40 %*	-	*30 %*	-	*30 %*	-	*30 %*	-	*30%*	-
Level 2	Apply Analyze	*40 %*	-	*40 %*	-	*40 %*	-	*40 %*	-	*40%*	-
Level 3	Evaluate Create	*20 %*	-	*30 %*	-	*30 %*	-	*30 %*	-	*30%*	-
	Total	100 %		100 %		100 %		100 %		100 %	

CLA – 4 can be from any combination of these: Assignments, Seminars, Tech Talks, Mini-Projects, Case-Studies, Self-Study, MOOCs, Certifications, Conf. Paper etc.,

Course Designers		
Experts from Industry	Experts from Higher Technical Institutions	Internal Experts
Dr. Manishankar C., Senior Scientist, NAL, Bangalore	Prof. Arun Kumar P., Assistant Professor, IIT Jammu	Dr. S. M. Aravindh Kumar, SRMIST
		Mr. K. Allwyn, SRMIST

Course Code	18ASC307L	Course Name	AEROSPACE COMPUTATIONAL ANALYSIS LABORATORY	Course Category	C	Professional Core	L	T	P	C
							0	0	2	1

Pre-requisite Courses	18ASC201J ,18ASC301J	Co-requisite Courses	Nil	Progressive Courses	Nil
Course Offering Department	Aerospace Engineering	Data Book / Codes/Standards	Gas Table		

Course Learning Rationale (CLR):	*The purpose of learning this course is to:*
CLR-1 :	*To create 2D Design of aircraft components*
CLR-2 :	*To create 3-Dimensional Design and assembly of typical aircraft & its components.*
CLR-3 :	*To create drafting of aircraft components*
CLR-4 :	*To simulate and evaluate Structural characteristics of beams and aircraft structural components*
CLR-5 :	*To simulate and evaluate aerodynamic properties of Subsonic and supersonic flow over the objects*
CLR-6 :	*To simulate and evaluate Heat transfer and combustion process*

Course Learning Outcomes (CLO):	*At the end of this course, learners will be able to:*	Learning 1: Level of Thinking (Bloom)	2: Expected Proficiency (%)	3: Expected Attainment (%)	PLO 1: Engineering Knowledge	2: Problem Analysis	3: Design & Development	4: Analysis, Design, Research	5: Modern Tool Usage	6: Society & Culture	7: Environment & Sustainability	8: Ethics	9: Individual & Team Work	10: Communication	11: Project Mgt. & Finance	12: Life Long Learning	13: PSO - 1	14: PSO - 2	15: PSO – 3
CLO-1 :	*To familiarize with basic aircraft components*	1	80	75	H	L	M	M	H	-	-	-	-	-	-	H	-	H	-
CLO-2 :	*To familiarize 3-Dimensional Design of typical aircraft & its components.*	3	80	75	H	H	H	H	H	-	-	-	-	-	-	H	-	H	-
CLO-3 :	*To familiarize assembly and drafting of aircraft components*	3	70	60	H	H	H	H	H	-	-	-	-	-	-	H	-	H	-
CLO-4 :	*To familiarize Structural analysis of beams and aircraft structural components*	3	70	60	H	H	H	H	H	-	-	-	-	-	-	H	-	H	-
CLO-5 :	*To familiarize Subsonic and supersonic flow analysis over the objects*	3	70	60	H	H	H	H	H	-	-	-	-	-	-	H	-	H	-
CLO-6 :	*To familiarize Heat transfer and combustion analysis*	3	70	60	H	H	H	H	H	-	-	-	-	-	-	H	-	H	-

Duration (hour)		06	06	06	06	06
S 1-2	SLO-1 / SLO-2	*Lab 1: 2D layout of aircraft wing rib and bulkhead sections*	*Lab 4: Assembly of Typical Aircraft.*	*Lab 7: 2D analysis of subsonic flow over bluff /streamlined body.*	*Lab 10: Simulation of Premixed / Non-Premixed Combustion analysis*	*Lab 13: Heat transfer analysis over a flat plate with natural / forced convection*
S 3-4	SLO-1 / SLO-2	*Lab 2: 3D model of aircraft Wing Structure*	*Lab 5: Drafting of Typical Aircraft.*	*Lab 8: 2D analysis of supersonic flow over bluff /streamlined body.*	*Lab 11: structural analysis of beams*	*Lab 14: Heat transfer analysis over a composite plate with natural / forced convection*
S 5-6	SLO-1 / SLO-2	*Lab 3: 3D model of aircraft fuselage Structure*	*Lab 6: Introduction to CFD and Grid independency study*	*Lab 9: 2D analysis of supersonic flow through C-D Nozzle.*	*Lab 12: Structural analysis of aircraft wing*	*Lab 15: Heat Transfer analysis in a Thin Plate using MATLAB code*

Learning Resources	Laboratory manual User manual of respective software	Gas Table

Learning Assessment

	Bloom's Level of Thinking	Continuous Learning Assessment (50% weightage) CLA – 1 (10%) Theory	CLA – 1 (10%) Practice	CLA – 2 (15%) Theory	CLA – 2 (15%) Practice	CLA – 3 (15%) Theory	CLA – 3 (15%) Practice	CLA – 4 (10%)# Theory	CLA – 4 (10%)# Practice	Final Examination (50% weightage) Theory	Final Examination (50% weightage) Practice
Level 1	Remember / Understand	-	*40%*	-	*30%*	-	*30%*	-	*30%*	-	*30%*
Level 2	Apply / Analyze	-	*40%*	-	*40%*	-	*40%*	-	*40%*	-	*40%*
Level 3	Evaluate / Create	-	*20%*	-	*30%*	-	*30%*	-	*30%*	-	*30%*
	Total	100 %		100 %		100 %		100 %		100 %	

CLA – 4 can be from any combination of these: Assignments, Seminars, Tech Talks, Mini-Projects, Case-Studies, Self-Study, MOOCs, Certifications, Conf. Paper etc.,

Course Designers		
Experts from Industry	Experts from Higher Technical Institutions	Internal Experts
Dr. S. Raja, Senior Principal Scientist and Professor, NAL – Bangalore. raja@nal.res.in	*Dr.K.M.Parammasivam, MIT-Chennai. mparams@mitindia.edu*	*Mr. R. Mohamed Arif, SRMIST.*
		Mr. K. B. RavichandraKumar, SRMIST.

Course Code	18ASC350T	Course Name	COMPREHENSION	Course Category	C	Professional Core	L	T	P	C
							0	1	0	1

Pre-requisite Courses	Nil	Co-requisite Courses	Nil	Progressive Courses	Nil
Course Offering Department	Aerospace Engineering	Data Book / Codes/Standards	Machine Data		

Course Learning Rationale (CLR):	The purpose of learning this course is to:
CLR-1 :	*Acquire skills to solve real world problems in Engineering Graphics Design, Engineering Mechanics and Fluid Mechanics*
CLR-2 :	*Acquire skills to solve problems in Thermodynamics, Aircraft Systems and Instruments and Aircraft Materials, Production Techniques*
CLR-3 :	*Acquire skills to solve real world problems in Applied Solid Mechanics, Incompressible Aerodynamics and Air Breathing Propulsion*
CLR-4 :	*Acquire skills to solve real world problems in Compressible Aerodynamics, Rocket Propulsion and Aircraft Structures*
CLR-5 :	*Acquire skills to solve real world problems for competitive examinations in Aerospace Engineering*
CLR-6 :	*Acquire skills to solve real world problems in the broad domain of Aerospace Engineering*

Course Learning Outcomes (CLO):	At the end of this course, learners will be able to:	Learning 1: Level of Thinking (Bloom)	2: Expected Proficiency (%)	3: Expected Attainment (%)	PLO 1: Engineering Knowledge	2: Problem Analysis	3: Design & Development	4: Analysis, Design, Research	5: Modern Tool Usage	6: Society & Culture	7: Environment & Sustainability	8: Ethics	9: Individual & Team Work	10: Communication	11: Project Mgt. & Finance	12: Life Long Learning	13: PSO - 1	14: PSO - 2	15: PSO - 3
CLO-1 :	*Practice and gain confidence, competence to solveproblems in Engineering Graphics Design, Engineering Mechanics and Fluid Mechanics*	3	85	80	H	H	H	L	L	L	L	L	L	L	L	L	M	L	M
CLO-2 :	*Practice and gain confidence, competence in Thermodynamics, Aircraft Systems and Instruments, Aircraft Materials, Production Techniques*	3	85	80	H	H	M	L	L	L	L	L	L	L	L	L	M	M	M
CLO-3 :	*Solve problems in Applied Solid Mechanics, Incompressible Aerodynamics and Air Breathing Propulsion*	3	85	80	H	H	M	L	L	L	L	L	L	L	L	L	M	L	M
CLO-4 :	*Practice and gain confidence and competence to solve problems in Compressible Aerodynamics, Rocket Propulsion and Aircraft Structures*	3	85	80	H	H	M	L	L	L	L	L	L	L	L	L	M	M	M
CLO-5 :	*Practice and gain confidence and competence to solveproblems for competitive examinations in Aerospace Engineering*	3	85	80	H	H	H	L	L	L	L	L	L	L	L	L	M	L	M
CLO-6 :	*Practice and gain confidence and competence to solve problems in the broad domain of Aerospace Engineering*	3	85	80	H	H	M	L	L	L	L	L	L	L	L	L	M	M	M

Duration (hour)		3	3	3	3	3
S-1	SLO-1	*Tutorial on Engineering graphics and design*	*Tutorial on Thermodynamics*	*Tutorial on Applied Solid Mechanics*	*Tutorial on Compressible Aerodynamics*	*Problem Solving*
	SLO-2	*Problem Solving*	*Problem Solving*	*Problem Solving*	*Problem Solving*	*Problem Solving*
S-2	SLO-1	*Tutorial on Engineering Mechanics*	*Review of Aircraft Systems*	*Tutorial on Incompressible Aerodynamics*	*Tutorial on Rocket Propulsion*	*Problem Solving*
	SLO-2	*Problem Solving*	*Review of Aircraft Instruments*	*Problem Solving*	*Problem Solving*	*Problem Solving*
S-3	SLO-1	*Tutorial on Fluid mechanics*	*Review of Aircraft Materials*	*Tutorial on Air Breathing Propulsion*	*Tutorial on Aircraft Structures*	*Problem Solving*
	SLO-2	*Problem Solving*	*Review of Production Techniques*	*Problem Solving*	*Problem Solving*	*Problem Solving*

Learning Resources		
	1. Ferdinand P. Beer, E. Russell Johnston Jr., David Mazurek, Philip J Cornwell, "Vector Mechanicsfor Engineers: Statics and Dynamics" , McGraw - Hill, New Delhi, Tenth Edition, 2013. *2. Irving H. Shames, "Mechanics of Fluids", 4rd Edition, McGraw-Hill, 2003.* *3. Yunus A. Cengel and Michael A. Boles, "Thermodynamics an engineering approach", 7th ed., , McGraw Hill, 2011*	*4. Cohen. H. Rogers. G.F.C. and Saravanamuttoo. H.I.H.: Gas turbine theory. 4th ed., Pearson* *5. George P. Sutton, Oscar Biblarz, "Rocket propulsion elements", Wiley India Pvt Ltd.8th ed., 2010* *6. Anderson, J,D., "Fundamentals of Aerodynamics", McGraw Hill., New York, 6th ed.,,2016*

Learning Assessment

	Bloom's Level of Thinking	Continuous Learning Assessment (100% weightage)								Final Examination	
		CLA – 1 (20%)		CLA – 2 (30%)		CLA – 3 (30%)		CLA – 4 (20%)#			
		Theory	Practice	Theory	Practice	Theory	Practice	Theory	Practice	Theory	Practice
Level 1	Remember Understand	-	*40%*	-	*30%*	-	*30%*	-	*30%*	-	-
Level 2	Apply Analyze	-	*40%*	-	*40%*	-	*40%*	-	*40%*	-	-
Level 3	Evaluate Create	-	*20%*	-	*30%*	-	*30%*	-	*30%*	-	-
	Total	100 %		100 %		100 %		100 %		-	

CLA – 4 can be from any combination of these: Assignments, Seminars, Tech Talks, Mini-Projects, Case-Studies, Self-Study, MOOCs, Certifications, Conf. Paper etc.,

Course Designers

Experts from Industry	Experts from Higher Technical Institutions	Internal Experts
1. Dr. Raja S, CSIR-NAL, Bangalore, raja@nal.res.in	*1. Dr. K. M. Parammasivam, Madras Institute of Technology, Chennai, mparams@mitindia.edu*	*Mr.G.Mahendra Perumal , SRMIST*
2. Wg.Cdr K.Manoharan (Retd), Blue Dart Aviation Ltd., manoharank@bluedart.com	*2. Dr. P. K Dash, Nitte Meenakshi Institute of Technology, Bangalore, drpdash@gmail.com*	*Dr.S.Gurusideswar , SRMIST*

ACADEMIC CURRICULA

Professional Core Courses

AUTOMOBILE ENGINEERING

Regulations - 2018

SRM INSTITUTE OF SCIENCE AND TECHNOLOGY

(Deemed to be University u/s 3 of UGC Act, 1956)

Kattankulathur, Kancheepuram, Tamil Nadu, India

Course Code	18AUC301J	Course Name	AUTOMOTIVE ENGINES	Course Category	C	Professional Core	L	T	P	C
							3	0	2	4

Pre-requisite Courses	18AUC203T	Co-requisite Courses	Nil	Progressive Courses	Nil
Course Offering Department	Automobile Engineering	Data Book / Codes/Standards	Nil		

Course Learning Rationale (CLR):	*The purpose of learning this course is to:*
CLR-1 :	*Understand various components of the engine and its functions*
CLR-2 :	*Understand the combustion in SI Engine*
CLR-3 :	*Gain knowledge on combustion in CI Engine*
CLR-4 :	*Understand the lubrication, cooling system and able to test the lubricants and fuels used for IC engines*
CLR-5 :	*Understand the turbo, supercharging and scavenging system in IC Engines*
CLR-6 :	*Obtain the knowledge of test engines and can conduct the performance and heat balance test on IC engines using various dynamometers*

Course Learning Outcomes (CLO):	*At the end of this course, learners will be able to:*	Learning 1: Level of Thinking (Bloom)	Learning 2: Expected Proficiency (%)	Learning 3: Expected Attainment (%)	PLO 1: Engineering Knowledge	PLO 2: Problem Analysis	PLO 3: Design & Development	PLO 4: Analysis, Design, Research	PLO 5: Modern Tool Usage	PLO 6: Society & Culture	PLO 7: Environment & Sustainability	PLO 8: Ethics	PLO 9: Individual & Team Work	PLO 10: Communication	PLO 11: Project Mgt. & Finance	PLO 12: Life Long Learning	PLO 13: PSO - 1	PLO 14: PSO - 2	PLO 15: PSO – 3
CLO-1 :	*Understand the importance of valve timing diagram and firing order*	*1*	*90*	*85*	*H*	*M*	*H*	*M*	*M*	*L*	*M*	*L*	*L*	*L*	*L*	*M*	*M*	*L*	*M*
CLO-2 :	*Understand the combustion phenomena in SI Engines*	*1*	*90*	*85*	*H*	*L*	*L*	*M*	*L*	*L*	*H*	*L*	*L*	*L*	*L*	*H*	*H*	*L*	*M*
CLO-3 :	*Understand the combustion phenomena in CI Engines*	*1*	*90*	*85*	*H*	*L*	*L*	*M*	*L*	*L*	*H*	*L*	*L*	*L*	*L*	*H*	*H*	*L*	*M*
CLO-4 :	*Understand the lubrication and cooling system in IC Engines.*	*2*	*90*	*85*	*M*	*M*	*H*	*H*	*L*	*L*	*M*	*L*	*L*	*L*	*L*	*M*	*L*	*M*	*M*
CLO-5 :	*Understand the turbo, supercharging and scavenging system in IC Engines*	*2*	*90*	*85*	*H*	*M*	*M*	*L*	*M*	*L*	*M*	*L*	*L*	*L*	*L*	*M*	*M*	*M*	*M*
CLO-6 :	*Knowledge about the recent development in the area of engines*	*2*	*90*	*85*	*H*	*L*	*H*	*L*	*H*	*L*	*H*	*L*	*M*	*L*	*L*	*H*	*M*	*M*	*M*

Duration (hour)		15	15	15	15	15
S-1	SLO-1	*Introduction to engine components*	*Combustion in SI engines*	*Combustion in CI Engines*	*Introduction to Lubrication and Cooling system*	*Supercharging and Scavenging*
	SLO-2	*Constructional details of engine components, function,materials,*	*Stages of combustion, Flame propagation*	*Importance of air motion - Swirl, squish and turbulence*	*Need for cooling system - Types of cooling system*	*Objectives - Effects on engine performance*
S-2	SLO-1	*Valve timing diagram for SI and CI engine*	*Flame velocity and area of flame front*	*Swirl ratio. Fuel air mixing*	*Liquid cooled system*	*engine modification required*
	SLO-2	*Port timing diagram for SI and CI engine*	*Rate of pressure rise - Cycle to cycle variation*	*Stages of combustion*	*Thermosyphon system*	*Thermodynamics of supercharging*
S-3	SLO-1	*Firing order and its significance*	*Abnormal combustion - Theories of detonation*	*Delay period - Factors affecting delay period*	*Forced circulation system*	*Thermodynamics of Turbocharging*
	SLO-2	*Tutorial 1: Comparison of Valve Timing Diagrams for SI and CI engine*	*Tutorial 3: Comparison of SI and CI engine combustion process*	*Knocking in CI engines - methods of controlling diesel knock.*	*pressure cooling system*	*Turbo lag-Windage, losses*
S 4-5	SLO-1 SLO-2	*Lab 1: Valve Timing Diagram for Four Stroke Engine and port Timing Diagram for Two Stroke Engine*	*Lab 3: Performance test on Petrol engine at full throttle and part throttle conditions*	*Lab 5: Study of gasoline and diesel fuel supply system.*	*Lab 7: Test for optimum coolant flow rate in IC engines*	*Lab 9: Energy Balance test on an Automotive Diesel Engine*
S-6	SLO-1	*Intake system components - Discharge coefficient, Pressure drop*	*Introduction to Combustion chambers*	*CI engine combustion chamber.*	*Properties of coolant, additives for coolants*	*Turbo charging methods*
	SLO-2	*Air filter, intake manifold, Connecting Pipe*	*Effect of engine operating variables on combustion*	*Combustion chamber design objectives - open type*	*Need for lubrication system*	*Engine exhaust manifold arrangements.*
S-7	SLO-1	*Exhaust system components*	*Combustion chambers -types*	*Combustion chamber design objectives – divided type*	*Mist lubrication system*	*Classification of scavenging systems*
	SLO-2	*Exhaust manifold and exhaust pipe*	*factors controlling combustion chamber design*	*Induction swirl, turbulent combustion chambers*	*wet sump any dry sump lubrication*	*Mixture control through Reed valve*
S-8	SLO-1	*Spark arresters*	*Gasoline injection system*	*Air cell chamber - M Combustion chamber*	*Properties of lubricants, consumption of oil*	*Induction - Charging Processes in two-stroke cycle engine - Terminologies*

	SLO-2	*Exhaust mufflers, Types, operation*	*Tutorial 4: Combustion chamber designs*	*Diesel injection system*	*Tutorial 8: Lubrication methods*	*Shankey diagram - perfect displacement, perfect mixing.*
S 9-10	SLO-1	*Lab 2: Performance test on constant speed diesel engine*	*Lab 4: Morse test on petrol engines*	*Lab 6: Dismantling, measuring of components and Assembling of a multi cylinder engine.*	*Lab 8: Determination of viscosity of oil by different methods like, Redwood, Say bolt and Engler's Viscometer*	*Lab 10: Performance test on Diesel Engine at full load and part load conditions*
	SLO-2					

Learning Resources	*1. Ganesan V, "Internal combustion engines", 4th edition, Tata McGraw Hill Education, 2012.* *2. Rajput R. K, "A textbook of Internal Combustion Engines", 2nd edition, Laxmi Publications (P) Ltd, 2007.* *3. John. B, Heywood, "Internal Combustion Engine Fundamentals", McGraw Hill Publishing Co., New York, 1900.*	*4. Ramalingam K. K, "Internal Combustion Engines", Second Edition, Scitech Publications,2009* *5. Mathur and Sharma, "A course on Internal combustion Engines", Dhanpat Rai & Sons, 1985.* *6. Edward F, Obert, "Internal Combustion Engines and Air Pollution", Intext Education Publishers, 1980*

Learning Assessment

	Bloom's Level of Thinking	Continuous Learning Assessment (50% weightage)								Final Examination (50% weightage)	
		CLA – 1 (10%)		CLA – 2 (15%)		CLA – 3 (15%)		CLA – 4 (10%)#			
		Theory	Practice	Theory	Practice	Theory	Practice	Theory	Practice	Theory	Practice
Level 1	Remember Understand	*20%*	*20%*	*15%*	*15%*	*15%*	*15%*	*15%*	*15%*	*15%*	*15%*
Level 2	Apply Analyze	*20%*	*20%*	*20%*	*20%*	*20%*	*20%*	*20%*	*20%*	*20%*	*20%*
Level 3	Evaluate Create	*10%*	*10%*	*15%*	*15%*	*15%*	*15%*	*15%*	*15%*	*15%*	*15%*
	Total	100 %		100 %		100 %		100 %		-	

CLA – 4 can be from any combination of these: Assignments, Seminars, Tech Talks, Mini-Projects, Case-Studies, Self-Study, MOOCs, Certifications, Conf. Paper etc.,

Course Designers		
Experts from Industry	Experts from Higher Technical Institutions	Internal Experts
1. Mr.Jayaraman.R,BLG Logistics,jayaraman.r@blgparekh.com	*1. Dr.M.Parthasarathy, Vel Tech, nparthasarathy@veltech.edu.in*	*1. Dr. A. Prabu, SRMIST*
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Course Code	18AUC302J	Course Name	VEHICULAR STRUCTURES AND DRIVELINE SYSTEMS	Course Category	C	Professional Core	L	T	P	C
							3	0	2	4

Pre-requisite Courses	Nil	Co-requisite Courses	Nil	Progressive Courses	Nil
Course Offering Department	Automobile Engineering	Data Book / Codes/Standards	Nil		

Course Learning Rationale (CLR):	*The purpose of learning this course is to:*
CLR-1 :	*Familiarize the structure of Vehicle frames, Front and Rear axles*
CLR-2 :	*Acquire knowledge about various types of automotive driveline systems*
CLR-3 :	*Explore the various components and functions of steering and suspension systems*
CLR-4 :	*Understand the different types of automotive transmission systems*
CLR-5 :	*Impart the knowledge of braking system, Wheels and tyres*

Course Learning Outcomes (CLO):	*At the end of this course, learners will be able to:*	Learning 1: Level of Thinking (Bloom)	Learning 2: Expected Proficiency (%)	Learning 3: Expected Attainment (%)	PLO 1: Engineering Knowledge	PLO 2: Problem Analysis	PLO 3: Design & Development	PLO 4: Analysis, Design, Research	PLO 5: Modern Tool Usage	PLO 6: Society & Culture	PLO 7: Environment & Sustainability	PLO 8: Ethics	PLO 9: Individual & Team Work	PLO 10: Communication	PLO 11: Project Mgt. & Finance	PLO 12: Life Long Learning	PLO 13: PSO - 1	PLO 14: PSO - 2	PLO 15: PSO – 3
CLO-1 :	*Demonstrate the basic structure of an automobile and various types of axles.*	2	90	90	H	M	M	M	M	H	H	M	L	L	L	H	H	M	M
CLO-2 :	*Identify the various types of automotive driveline systems.*	2	90	90	H	M	M	M	M	H	H	M	L	L	L	H	H	M	M
CLO-3 :	*Classify the different types of steering and suspension systems.*	2	90	90	H	H	M	M	M	H	H	M	L	L	L	H	H	M	M
CLO-4 :	*Classify the different types of transmission systems.*	3	90	90	H	H	M	M	M	H	H	M	L	L	L	H	H	M	M
CLO-5 :	*Identify the various types of braking systems, wheels and tyres.*	2	90	90	H	M	M	M	M	H	H	M	L	L	L	H	H	M	M

		Frames, Front and Rear Axles	Drive Line and Final Drives	Steering and Suspension Systems	Transmission System	Brakes, Wheels and Tyres
Duration (hour)		15	15	15	15	15
S-1	SLO-1	*Different types of chassis layout- FF, FR,RR and 4WD.*	*Effect of driving thrust and torque reactions.*	*Front wheel geometry - Caster, Camber.*	*Types of clutches, construction and working of single plate.*	*Theory of braking.*
	SLO-2	*Different types of chassis layout- FF, FR,RR and 4WD.*	*Effect of driving thrust and torque reactions.*	*Front wheel geometry - Toe in and toe out, SAI.*	*Multi plate and centrifugal clutch.*	*Stopping distance - Braking efficiency , Numerical analysis.*
S-2	SLO-1	*Types of vehicle body and Classifications.*	*Hotchkiss and torque tube drive.*	*Steering systems - True rolling motion of wheels and Numerical Analysis.*	*Torque capacity of clutch – Numerical Analysis.*	*Drum brakes - Single cam, Double cam.*
	SLO-2	*Types of vehicle body and Classifications.*	*Front wheel drive.*	*Simple problems*	*Simple problems*	*Leading and Trailing shoe types.*
S-3	SLO-1	*Frames- construction, Materials, LoadsActing on frames.*	*Propeller shaft –Construction, Critical Speed.*	*Ackermann and Davis steering Mechanism.*	*Fluid coupling – Construction*	*Disc brakes - Fixed, floating and radial mounted calipers.*
	SLO-2	*Frames- construction, Materials, LoadsActing on frames.*	*Universal joint, Slip joint.*	*Constructional details of steering linkages for rigid front axle.*	*Fluid coupling –Principle of operation.*	*Ventilated discs, cross drilled discs, slotted discs.*
S 4-5	SLO-1 SLO-2	*Lab 1: Study and measurement of various types of vehicle frame, body and driver seat.*	*Lab 4: Dismantling, study and assembling of automobile driveline and differential.*	*Lab 7: Dismantling, study and assembling of automobile suspension system.*	*Lab 10: Calculating the maximum torque carrying capacity of the given clutch using clutch dynamometer.*	*Lab 13: Dismantling, assembling and bleeding of a braking system.*
S-6	SLO-1	*Types of vehicle frames-Ladder frame, Tubular frame.*	*Constant velocity joints.*	*Constructional details of steering linkages for independent front axles.*	*Torque converters - Construction*	*Mechanical and hydraulic brake actuation.*
	SLO-2	*Integral frame, X-frame, Roll-cage frames.*	*Rzeppa and Tripod joints.*	*Steering gear box - Re-circulating ball type,Rack and pinion type, Worm and Nut type.*	*Principle of operation.*	*Pneumatic braking system.*
S-7	SLO-1	*Common vehicle platform- Need.*	*Different types of final drive - Worm and worm wheel, Straight bevel gear.*	*Power assisted steering - Hydraulic and EPS.*	*Hydro kinetic drives - Multistage torque converters.*	*Vacuum assisted hydraulic brakes.*
	SLO-2	*Common vehicle platform- merits and demerits.*	*Spiral bevel gear and hypoid gear final drives.*	*Four wheel Steering.*	*Poly-phase torque converters.*	*Air assisted hydraulic brakes.*

S-8	SLO-1	Case study-Volkswagen PQ platform, Nissan B platform.	Double reduction final drive.	Need for suspension system. Types of suspension - Non independent suspension.	Types of gear boxes - Working of sliding And constant mesh gear boxes.	Need for ABS, ESP, EBD.
	SLO-2	Case study- Nissan B platform.	Twin speed final drive.	Independent suspension - McPherson and Wishbone suspension.	Construction and working of synchromesh gear box and principle of synchronizers	Need for Regenerative braking systems.
S 9-10	SLO-1 / SLO-2	Lab 2: Study of different types of front and rear axles and final drives. Calculation of final drive ratio.	Lab 5: Dismantling, study and assembling of different automobile steering systems.	Lab 8: Dismantling, study and assembling of automobile clutches.	Lab 11: Dismantling, gear ratio calculation and assembling of an automobile transmission.	Lab 14: Study and analysis of the construction of various wheels and tyres.
S-11	SLO-1	Front axle – Live axles, Dead axles.	Differential- Principle.	Types of suspension springs - Leaf spring, Coil spring, Torsion bar, and Rubber springs.	Planetary gear box - construction and working.	Types of Wheels
	SLO-2	Front axle – Drop axles, Push and tag axles.	Differential- Construction details.	Shock absorbers.	Planetary gear box - construction and working.	Dimensions and Constructional details
S-12	SLO-1	Rear axles – Semi, full and three quarter floating.	Differential lock.	Pneumatic suspension systems.	Numerical in Gear box.	Types - Construction - Cross ply, Radial ply,
	SLO-2	Housing types- Split Banjo and Salisbury type.	Differential lock.	Rear axle suspension system - Independent, Trailing Arm.	Automatic transmission - Chevrolet turbo glide - Construction and working..	Types - Construction - Tube and tubeless tyres.
S-13	SLO-1	Multi-link rear axles	Limited slip differential.	De-dion suspension and torsion beam.	Automatic transmission – Chevrolet Power glide - Construction and working..	Tyre designation.
	SLO-2	Multi-link rear axles	Limited slip differential.	Anti-roll bar, Pan hard rod and Radius rod	Hydraulic clutch actuation for Automatic transmission.	Tread patterns.
S 14-15	SLO-1 / SLO-2	Lab 3: CLA-1	Lab 6: CLA-2	Lab 9: CLA-3	Lab 12: CLA-4	Lab 15: University practical examination.

Learning Resources	1. Kirpal Singh, "Automobile Engineering - Vol I", Standard Publishers Distributors, 1999. 2. Crouse W.H, Anglin D.L, "Automotive Transmission and Power Train construction", McGraw Hill, 1976.	3. Heldt P.M, "Torque converters", Chilton Book Co., 1992. 4. Newton Steeds &Garrot, "Motor Vehicles", SAE International and Butterworth Heinemann, 2001.

Learning Assessment

	Bloom's Level of Thinking	Continuous Learning Assessment (50% weightage)								Final Examination (50% weightage)	
		CLA – 1 (10%)		CLA – 2 (15%)		CLA – 3 (15%)		CLA – 4 (10%)#			
		Theory	Practice	Theory	Practice	Theory	Practice	Theory	Practice	Theory	Practice
Level 1	Remember / Understand	20%	20%	15%	15%	15%	15%	15%	15%	15%	15%
Level 2	Apply / Analyze	20%	20%	20%	20%	20%	20%	20%	20%	20%	20%
Level 3	Evaluate / Create	10%	10%	15%	15%	15%	15%	15%	15%	15%	15%
	Total	100 %		100 %		100 %		100 %		-	

CLA – 4 can be from any combination of these: Assignments, Seminars, Tech Talks, Mini-Projects, Case-Studies, Self-Study, MOOCs, Certifications, Conf. Paper etc.,

Course Designers

Experts from Industry	Experts from Higher Technical Institutions	Internal Experts
1. Mr.SarathRamakannan, Aston Martin, sharath.ramakrishnan@astonmartin.com	1. Dr.N.Balaji, Sri Krishna College of Engineering, balajin@skcet.ac.in	1. Dr. Edwin Geo V, SRMIST
2. Mr.Franklin Darlie, HAL, franklindarlie@rediff.com	2. Dr.R.Sakthivel, Sri Venkateswara College of Engineering, rsakthivel@svce.ac.in	2. Mr.Deepak M, SRMIST

Course Code	18AUC303J	Course Name	AUTOMOTIVE ELECTRICAL AND ELECTRONIC SYSTEMS	Course Category	C	Professional Core	L	T	P	C
							3	0	2	4

Pre-requisite Courses	Nil	Co-requisite Courses	Nil	Progressive Courses	Nil
Course Offering Department	Automobile Engineering	Data Book / Codes/Standards	Nil		

Course Learning Rationale (CLR):	*The purpose of learning this course is to:*
CLR-1 :	*To acquire knowledge of about the application of electrical and electronics in automotive systems*
CLR-2 :	*Familiarize the usage of Sensors and actuators in Automobile*
CLR-3 :	*Acquire the fundamental electronics applied vehicle motion control system*
CLR-4 :	*Understanding the working of charging and lighting accessories in automobile*
CLR-5 :	*Know about various Electrical equipment diagnostics and testing methods*

Course Learning Outcomes (CLO):	*At the end of this course, learners will be able to:*	Learning 1: Level of Thinking (Bloom)	2: Expected Proficiency (%)	3: Expected Attainment (%)	PLO 1: Engineering Knowledge	2: Problem Analysis	3: Design & Development	4: Analysis, Design, Research	5: Modern Tool Usage	6: Society & Culture	7: Environment & Sustainability	8: Ethics	9: Individual & Team Work	10: Communication	11: Project Mgt. & Finance	12: Life Long Learning	13: PSO - 1	14: PSO - 2	15: PSO – 3
CLO-1 :	*Understanding battery, Cranking motor construction and testing methods.*	2	85	75	H	M	H	L	H	M	M	H	H	M	L	H	H	H	H
CLO-2 :	*Understand the principle of alternator and to test the alternator*	2	80	75	H	M	H	H	H	M	M	H	H	M	L	M	H	H	H
CLO-3 :	*Apply the Electronic Controls in Gasoline Engine*	2	90	85	H	H	H	H	L	M	M	H	M	M	M	H	H	H	M
CLO-4 :	*Understand the basics of Vehicle Motion Control and telemetric system*	2	85	80	H	M	H	H	H	H	H	H	H	H	M	H	H	H	H
CLO-5 :	*Perform OBD II test on vehicle and Program hardware using Lab view*	2	80	75	H	M	M	M	H	H	H	H	H	H	M	H	H	H	H

		Batteries and Starting Systems	Charging System and Lighting Auxiliaries	Electronic Engine Management System	Fundamentals of Vehicle Motion Control	Telematics and Vehicle Diagnostics
Duration (hour)		15	15	15	15	15
S-1	SLO-1	*Unit – I Vehicle Batteries types*	*Unit- II Charging system - Introduction*	*Unit –III Introduction – Engine management system*	*Unit – IV Introduction – Vehicle motion control*	*Unit – V Introduction – Telematics*
	SLO-2	*Lead acid battery - Principle*	*Alternator Principle Construction, Working*	*Gasoline Engine Fuel Injector*	*Cruise Control System*	*GPS Navigation*
S-2	SLO-1	*Lead acid battery - Construction, Working*	*Alternator merits over D.C Generator*	*Single point Fuel Injections*	*Adaptive Cruise Control System - Construction*	*GPS Structure*
	SLO-2	*Battery Rating*	*Alternator Charging Circuits*	*Multi Point Fuel Injections*	*Adaptive Cruise Control System - Working*	*Dead Reckoning - Construction*
S-3	SLO-1	*Lead Acid battery Charging methods*	*Rectification of AC to DC*	*Merits of MPFI*	*Throttle Actuator Stepper Motor Based Control*	*Dead Reckoning - Working*
	SLO-2	*Testing Methods*	*Alternator Testing Methods*	*Testing of Fuel Injectors*	*Antilock Braking Mechanism - Construction*	*Inertial Navigation System - Construction*
S 4-5	SLO-1 SLO-2	*Lab 1: Battery Testing –Hydrometer, Load test, Individual Cell voltage test*	*Lab 3: Alternator Testing –Continuity test, Insulation Test, Load test.*	*Lab 5: Study of Lab view Programming*	*Lab 7: PWM Signal generation*	*Lab 9: UART communication for parking sensor*
S-6	SLO-1	*Fault Diagnosis.*	*Mechanical Voltage Regulator - Principle*	*Ignition system- Introduction*	*Antilock Braking Mechanism - Working*	*Inertial Navigation System - Working*
	SLO-2	*Requirement of a starting System*	*Mechanical Voltage Regulator – construction, working*	*Conventional Ignition System*	*Tire Slip Controller*	*Invehicle infotainment systems*
S-7	SLO-1	*Starter motor Construction*	*Electronic Voltage regulator –Principle*	*Electronic Ignition System*	*Merits of ABS*	*ADAS - Introduction*
	SLO-2	*Starter motor Working.*	*Electronic Voltage Regulator – construction, working*	*Programmed ignition system*	*Electronic Suspension System- Construction*	*ADAS features*
S-8	SLO-1	*Starter Drive Mechanism - introduction*	*Lighting Fundamentals*	*Distributor less Ignition System*	*Electronic Suspension System- Working*	*Electronic Control System Diagnostics,*
	SLO-2	*Starter Drive Mechanism - types*	*Lighting Circuit example*	*Waste spark analysis*	*Variable Damping*	*OBDII - Objective*
S 9-10	SLO-1 SLO-2	*Lab 2: Starter Motor –Continuity test, Insulation Test, Load test*	*Lab 4: Study of voltage regulator, solenoids*	*Lab 6: ADC interfacing for IR Sensor*	*Lab 8: H-Bridge Motor speed and position Control*	*Lab 10: Fault Diagnosis using OBD handheld Devices*
S-11	SLO-1	*Bendix drive*	*Conventional Headlamps – Sealed bulb headlamps*	*Digital Engine Control Modes*	*Variable Spring rate*	*Comparison of OBD I and OBD II*
	SLO-2	*Folo-thru drive*	*Conventional Headlamps – Bifilament headlamps*	*EGR Control*	*Merits of Electronic suspension system*	*Diagnostics Fault Codes*

S-12	SLO-1	*Over Running Clutch drive*	*LED Lighting System*	*variable valve timing*	*Electric Power Assisted Steering Mechanism- Construction*	*Introduction to Model-based Sensor Failure Detection*
	SLO-2	*Starter switch*	*Fog lamp*	*Ignition Controlling - Introduction*	*Electric Power Assisted Steering Mechanism- working*	*Model-based Sensor Failure Detection working*
S-13	SLO-1	*Starter Motor Fault Diagnosis*	*Wiper system*	*Closed loop ignition timing*	*Four Wheel Steering*	*Case Study on MAF Sensor calibration*
	SLO-2	*New Developments in Battery Technologies and Starting System*	*Signaling and Warning system*	*Spark Advance Correction Scheme*	*Steer-by-Wire*	*Case Study on MAF Sensor calibration .Cont*
S-14-15	SLO-1 SLO-2	*Lab: Assessment 1*	*Lab: Assessment 2*	*Lab: Assessment 3*	*Lab: Review class*	*Lab: Mini Project*

Learning Resources	1. *Tom Denton "Automobile Electrical and Electronic Systems" 3rdedition, Elsiever Butterworth-Heinemann 2004.* 2. *William.B.Ribbens, "Understanding Automotive Electronics" 7th edition Butterworth-Heinemann publications, 2012.* 3. *Ed Doering "NI MYRIO Project Essential Guide" 2013,National Technology and Science Press*	4. *Allan.W.M.Bonnick "Automotive Computer Controlled System 2001,Butterworth-Heinemann* 5. *Robert Bosch Gmbh "Bosch Automotive Electric and Electronics" 5th edition Springer-2007*

Learning Assessment

	Bloom's Level of Thinking	Continuous Learning Assessment (50% weightage)								Final Examination (50% weightage)	
		CLA – 1 (10%)		CLA – 2 (15%)		CLA – 3 (15%)		CLA – 4 (10%)			
		Theory	Practice	Theory	Practice	Theory	Practice	Theory	Practice	Theory	Practice
Level 1	Remember Understand	*20%*	*20%*	*15%*	*15%*	*15%*	*15%*	*15%*	*15%*	*15%*	*15%*
Level 2	Apply Analyze	*20%*	*20%*	*20%*	*20%*	*20%*	*20%*	*20%*	*20%*	*20%*	*20%*
Level 3	Evaluate Create	*10%*	*10%*	*15%*	*15%*	*15%*	*15%*	*15%*	*15%*	*15%*	*15%*
	Total	100 %		100 %		100 %		100 %		-	

CLA – 4 can be from any combination of these: Assignments, Seminars, Tech Talks, Mini-Projects, Case-Studies, Self-Study, MOOCs, Certifications, and Conf. Paper etc.

Course Designers		
Experts from Industry	Experts from Higher Technical Institutions	Internal Experts
1. Mr.Jegan Amirthalingam, Senior Educator, KPIT a.jegan@kpit.com	*1. Mr. Sam Jebakumar, SRM IST, jebakumj@srmist.edu.in*	*1. Mr. Joshua Paul E , SRMIST*
		2. Mr.Jesu Godwin D, SRMIST

Course Code	18AUC304J	Course Name	CAD ANALYSIS FOR AUTOMOTIVE ENGINEERS	Course Category	C	Professional Core	L	T	P	C
							3	0	2	4

Pre-requisite Courses	Nil	Co-requisite Courses	Nil	Progressive Courses	Nil
Course Offering Department	Automobile Engineering	Data Book / Codes/Standards			

Course Learning Rationale (CLR):	*The purpose of learning this course is to:*
CLR-1 :	*Describe the various design concepts and modelling techniques*
CLR-2 :	*Provide knowledge on computer graphics*
CLR-3 :	*Introduce the latest developments in CAD Packages and GD&T*
CLR-4 :	*Understand the FEM concepts*
CLR-5 :	*Demonstrate the analysis tools*

Course Learning Outcomes (CLO):	*At the end of this course, learners will be able to:*	Learning 1: Level of Thinking (Bloom)	Learning 2: Expected Proficiency (%)	Learning 3: Expected Attainment (%)	PLO 1: Engineering Knowledge	PLO 2: Problem Analysis	PLO 3: Design & Development	PLO 4: Analysis, Design, Research	PLO 5: Modern Tool Usage	PLO 6: Society & Culture	PLO 7: Environment & Sustainability	PLO 8: Ethics	PLO 9: Individual & Team Work	PLO 10: Communication	PLO 11: Project Mgt. & Finance	PLO 12: Life Long Learning	PLO 13: PSO - 1	PLO 14: PSO - 2	PLO 15: PSO – 3
CLO-1 :	*Create the design models by various techniques*	1	85	80	H	M	H	M	L	M	M	H	M	H	H	H	H	H	H
CLO-2 :	*Develop the model using various features*	2	80	75	H	M	M	L	L	M	M	M	H	H	L	H	H	H	H
CLO-3 :	*Apply GD & T in design of automobile components*	3	85	80	H	H	H	H	H	M	H	M	M	M	H	H	H	H	H
CLO-4 :	*Solve the real world engineering problems using FEA.*	2	80	75	H	H	H	H	M	M	M	M	M	M	M	H	H	H	H
CLO-5 :	*Analyze the problems using FEA commercial packages.*	3	85	80	H	H	H	H	H	M	M	M	H	M	M	H	H	H	H

		Introduction to CAD	Graphics Concepts (2D and 3D)	Software Packages and Recent Technology	FEM Fundamentals	Finite element Analysis
Duration (hour)		15	15	15	15	15
S-1	SLO-1	*Introduction to CAD*	*Introduction to Coordinate system*	*Introduction to Software Packages*	*FEM Fundamentals - Introduction*	*Finite element Analysis - Introduction*
	SLO-2	*Product life cycle management*	*Model coordinate system,*	*Salient features of Software Packages*	*Degrees of freedom, h-convergence and p-convergence*	*Need for FEA in CAD Environment*
S-2	SLO-1	*Design models – pahl and beitz model*	*World coordinate system and Screen coordinate system*	*Technical comparison, Modules and tools*	*Need for Finite element method*	*Various stages of FEA - Preprocessing,*
	SLO-2	*Shigley model and Ohsuga model*	*Transformations in 2D and 3D*	*Need for data exchange standards and types*	*Nodes, element types*	*Solving and Post-processing*
S-3	SLO-1	*Geometric modelling – Introduction*	*Deriving transformation matrix for translation*	*Structure of STEP file system*	*Types of Constraints*	*Demonstration of the above using any one commercial packages*
	SLO-2	*Wireframe, surface and solid modelling*	*Deriving transformation matrix for scaling*	*Advantages and Disadvantages of STEP file system*	*Types of Boundary conditions*	*Structural analysis of beams and truss*
S 4-5	SLO-1 SLO-2	*LAB 1: Introduction to 2D sketch tool*	*LAB 3 : Introduction to various features for 3D Modelling*	*LAB 5 : 3D modelling of piston and connecting rod*	*LAB 7 : Exercises on Assembly of Knuckle joint*	*LAB 9 : Structural Analysis of trussand beams using ANSYS APDL*
S-6	SLO-1	*Constructive solid geometry*	*Deriving transformation matrix for Reflection*	*Structure of IGES file system*	*Steps in Finite element method*	*Introduction to modal analysis – Free Vibration*
	SLO-2	*Problems on Constructive solid geometry*	*Deriving transformation matrix for Rotation*	*Advantages and Disadvantages of IGES file system*	*Derivation of shape function*	*Forced Vibration*
S-7	SLO-1	*Boundary representation*	*Problems on basic transformations*	*Brief outline of feature technology*	*Solution techniques – Point collocation method*	*Brief outline of kinematic analysis*
	SLO-2	*Problems on Boundary representation*	*Concatenated and Inverse transformation*	*Classification of features*	*Sub domain and Least square method*	*Steps in Kinematic analysis*
S-8	SLO-1	*Operations – Booleans and Extrude*	*Problems on Concatenated and Inverse transformation Visibility techniques – Minimax test*	*Design by features*	*Galerkin method*	*Modelling of Four bar mechanism*
	SLO-2	*Demonstration of boolean and extrude using Solidworks*		*Applications of feature based modelling*	*Derivation of stiffness matrix*	*Kinematic analysis of Four bar mechanism*

S 9-10	SLO-1	*LAB 2 : Exercises on 2D sketch*	*LAB 4 : Exercises on 3D Modelling*	*LAB 6: Exercises on Assembly of Screw jack*	*LAB 8 : Exercises on Assembly of Universal joint*	*LAB 10 : Finite element analysis on connecting rod using ANSYS Workbench*
	SLO-2					
S-11	SLO-1	*Sweep and Revolve*	*Containment test*	*Applying features to various automotive components*	*Tutorial on Finite element problems involving stepped bar*	*Modelling of Single slider mechanism*
	SLO-2	*Demonstration of sweep and revolve using Solidworks*	*Hidden line removal – priority algorithm*	*Advantages and limitations of feature based modelling*	*Interpretation of the results*	*Kinematic analysis of Single slider mechanism*
S-12	SLO-1	*Basic entities – Line*	*Light source and Shading – Constant shading models*	*Introduction to GD & T*	*Tutorial on Finite element problems involving triangular element.*	*Modelling of an automotive components - 1*
	SLO-2	*Circle*	*Gourand and Phong shading models*	*Need of GD&T*	*Interpretation of the results*	*Finite element analysis of an automotive components - 1*
S-13	SLO-1	*Ellipse and*	*Color models – RGB and CMYK model*	*Geometrical tolerance*	*Tutorial on Finite element problems involving springs.*	*Modelling of an automotive components - 2*
	SLO-2	*Parabola*	*Rendering and Animation*	*Dimensional tolerance*	*Interpretation of the results*	*Finite element analysis of an automotive components - 2*
S-14-15	SLO-1	*Lab Assessment 1*	*Lab: Repeat class*	*Lab Assessment 2*	*Lab Assessment 3*	*LAB 11 : Kinematic Analysis of 4-bar mechanism using ANSYS Workbench*
	SLO-2					

Learning Resources	*1.Ibrahim Zeid, "CAD / CAM - Theory and Practice"., Tata Mcgraw-Hill, New Delhi, 2009* *2. Radhakrishnan. P "CAD / CAM / CIM " New age international, 2018* *3. Mikell P. Groover, "CAD / CAM"., Prentice Hall of India Private Limited, New Delhi, 2003*	*4.Newman and Sproull R. F., "Principles of interactive computer graphics", Tata Mcgraw-Hill, New Delhi, 2001* *5.Chandupatla and Belagundu, "Introduction to Finite Element Methods in Engineering", Prentice Hall of India Private Limited, New Delhi, 2002*

Learning Assessment

	Bloom's Level of Thinking	Continuous Learning Assessment (50% weightage)								Final Examination (50% weightage)	
		CLA – 1 (10%)		CLA – 2 (15%)		CLA – 3 (15%)		CLA – 4 (10%)			
		Theory	Practice	Theory	Practice	Theory	Practice	Theory	Practice	Theory	Practice
Level 1	Remember Understand	*20%*	*20%*	*15%*	*15%*	*15%*	*15%*	*15%*	*15%*	*15%*	*15%*
Level 2	Apply Analyze	*20%*	*20%*	*20%*	*20%*	*20%*	*20%*	*20%*	*20%*	*20%*	*20%*
Level 3	Evaluate Create	*10%*	*10%*	*15%*	*15%*	*15%*	*15%*	*15%*	*15%*	*15%*	*15%*
	Total	100 %		100 %		100 %		100 %		100 %	

CLA – 4 can be from any combination of these: Assignments, Seminars, Tech Talks, Mini-Projects, Case-Studies, Self-Study, MOOCs, Certifications, Conf. Paper etc.,

Course Designers

Experts from Industry	Experts from Higher Technical Institutions	Internal Experts
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Course Code	18AUC305T	Course Name	DESIGN OF AUTOMOTIVE COMPONENTS	Course Category	C	Professional Core	L	T	P	C
							3	0	0	3

Pre-requisite Courses	Nil	Co-requisite Courses	Nil	Progressive Courses	Nil
Course Offering Department	Automobile Engineering	Data Book / Codes/Standards	Design Data, PSG College of Technology, 2012		

Course Learning Rationale (CLR):	*The purpose of learning this course is to:*
CLR-1 :	*Understand the basic knowledge of automotive components respective to design*
CLR-2 :	*Provide the idea of engineering materials selection*
CLR-3 :	*Provide knowledge of basic valves design*
CLR-4 :	*Provides the knowledge on forces of connecting rod*
CLR-5 :	*Familiarize the design procedure of engine components*

Course Learning Outcomes (CLO):	*At the end of this course, learners will be able to:*	Learning 1: Level of Thinking (Bloom)	Learning 2: Expected Proficiency (%)	Learning 3: Expected Attainment (%)
CLO-1 :	*Define the requirements and understand the automotive components*	1	80	75
CLO-2 :	*Select suitable materials for automobile components*	2	85	80
CLO-3 :	*Explain the procedure involved in design*	3	85	80
CLO-4 :	*Familiarize with various design standards*	3	80	75
CLO-5 :	*Design various automotive components to suit industrial needs.*	3	85	80

Program Learning Outcomes (PLO)

	1 Engineering Knowledge	2 Problem Analysis	3 Design & Development	4 Analysis, Design, Research	5 Modern Tool Usage	6 Society & Culture	7 Environment & Sustainability	8 Ethics	9 Individual & Team Work	10 Communication	11 Project Mgt. & Finance	12 Life Long Learning	13 PSO - 1	14 PSO - 2	15 PSO – 3
CLO-1	H	M	M	M	H	M	M	H	M	M	H	H	H	H	H
CLO-2	H	H	H	M	L	M	M	M	M	M	H	H	H	H	H
CLO-3	H	H	H	H	L	M	M	M	M	M	H	H	H	H	H
CLO-4	H	H	H	H	L	M	M	M	M	M	H	H	H	H	H
CLO-5	H	H	H	H	L	M	M	M	H	M	H	H	H	H	H

		Design Of Shaft	Design of Cylinder And Piston	Design of Connecting Rod	Design of Crankshaft	Design of valves
Duration (hour)		9	9	9	9	9
S-1	SLO-1	*Materials and Manufacturing of shaft*	*Introduction to Cylinder And Piston-*	*Introduction to Connecting Rod*	*Introduction to Crankshaft*	*Introduction to valves*
	SLO-2	*Materials and Manufacturing of shaft*	*Introduction to Cylinder And Piston-*	*Introduction to Connecting Rod*	*Introduction to Crankshaft*	*Introduction to valves*
S-2	SLO-1	*General Phases of design*	*Principal Parts of an IC Engine*	*Material selection for connecting rod*	*Introduction about crank shaft and its function in an I.C Engine.*	*Valve gear mechanism*
	SLO-2	*General Phases of design*	*Principal Parts of an IC Engine*	*Material selection for connecting rod*	*Introduction about crank shaft and its function in an I.C Engine.*	*Valve gear mechanism*
S-3	SLO-1	*Standard size of transmission shafts, stresses in shafts*	*Cylinder and Cylinder Liner*	*Forces Acting on the connecting rod*	*Materials selection for crankshaft*	*Types of valves*
	SLO-2	*Standard size of transmission shafts, stresses in shafts*	*Cylinder and Cylinder Liner*	*Forces Acting on the connecting rod*	*Materials selection for crankshaft*	*Types of valves*
S-4	SLO-1	*Shafts subjected to twisting moment only*	*Design of Bore,Length ,Thickness of cylinder head, studs size of the cylinder head*	*Dimensions of cross Section of the connecting rod*	*Bearing pressures and stresses in crankshaft*	*Design of size of valve port*
	SLO-2	*Shafts subjected to twisting moment only*	*Design of Bore,Length ,Thickness of cylinder head, studs size of the cylinder head*	*Dimensions of cross Section of the connecting rod*	*Bearing pressures and stresses in crankshaft*	*Design of size of valve port*
S-5	SLO-1	*Shafts Subjected to Bending Moment Only*	*Material for piston*	*Dimensions of cross Section of the connecting rod*	*Design Procedure for Crankshaft*	*Design of the valve disc*
	SLO-2	*Shafts Subjected to Bending Moment Only*	*Material for piston*	*Dimensions of cross Section of the connecting rod*	*Design Procedure for Crankshaft*	*Design of the valve disc*
S-6	SLO-1	*Shafts Subjected to combined Twisting Moment and Bending Moment*	*Design of critical parameters of piston design*	*Dimensions of the crank pin at the big end*	*Design of Centre Crankshaft When the crank is at dead centre*	*Design of maximum lift of the valve*
	SLO-2	*Shafts Subjected to combined Twisting Moment and Bending Moment*	*Design of critical parameters of piston design*	*Dimensions of the crank pin at the big end*	*Design of Centre Crankshaft When the crank is at dead centre*	*Design of maximum lift of the valve*

S-7	SLO-1	*Shafts Subjected to combined Twisting Moment and Bending Moment*	*Piston Rings*	*Dimensions of the piston pin at the small end*	*Design of Centre Crankshaft When the crank is at angle of maximum twisting moment*	*Design of valve stem diameter*
	SLO-2	*Shafts Subjected to combined Twisting Moment and Bending Moment*	*Piston Rings*	*Dimensions of the piston pin at the small end*	*Design of Centre Crankshaft When the crank is at angle of maximum twisting moment*	*Design of valve stem diameter*
S-8	SLO-1	*Shafts Subjected to Fluctuating loads*	*Piston Skirt*	*Size of bolts for securing the big end cap*	*Design of Overhung Crankshaft When the crank is at dead centre*	*Design of Pushrod*
	SLO-2	*Shafts Subjected to Fluctuating loads*	*Piston Skirt*	*Size of bolts for securing the big end cap*	*Design of Overhung Crankshaft When the crank is at dead centre*	*Design of Pushrod*
S-9	SLO-1	*Design of Shafts on the basis of Rigidity*	*Piston Pin*	*Thickness of the big end cap*	*Design of Overhung Crankshaft When the crank is at an angle of maximum twisting moment*	*Design of cross section of the push rod by rankine's formula*
	SLO-2	*Design of Shafts on the basis of Rigidity*	*Piston Pin*	*Thickness of the big end cap*	*Design of Overhung Crankshaft When the crank is at an angle of maximum twisting moment*	*Design of cross section of the push rod by rankine's formula*

Learning Resources	*1. Kulkarni S. G, "Machine Design", Tata McGraw-Hill Education, 2008.* *2. Bhandari V, "Design of Machine Elements",Tata McGraw-Hill Education, 2010.*	*3. Khurmi, "A text book of Machine Desine", S Chand publication, 2016.* *4 Shigley J, "Mechanical Engineering Design", Tenth Edition,Mc Graw Hill, 2014.*

Learning Assessment

	Bloom's Level of Thinking	Continuous Learning Assessment (50% weightage)								Final Examination (50% weightage)	
		CLA – 1 (10%)		CLA – 2 (15%)		CLA – 3 (15%)		CLA – 4 (10%)#			
		Theory	Practice	Theory	Practice	Theory	Practice	Theory	Practice	Theory	Practice
Level 1	Remember Understand	*40 %*	-	*30 %*	-	*30 %*	-	*30 %*	-	*30%*	-
Level 2	Apply Analyze	*40 %*	-	*40 %*	-	*40 %*	-	*40 %*	-	*40%*	-
Level 3	Evaluate Create	*20 %*	-	*30 %*	-	*30 %*	-	*30 %*	-	*30%*	-
	Total	100 %		100 %		100 %		100 %		100 %	

CLA – 4 can be from any combination of these: Assignments, Seminars, Tech Talks, Mini-Projects, Case-Studies, Self-Study, MOOCs, Certifications, Conf. Paper etc.,

Course Designers

Experts from Industry	Experts from Higher Technical Institutions	Internal Experts
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2. N. Vijayakumar, Mahindra& Mahindra, vijayakumar.n@mahindra.com	*2. Prof. (Dr) A V Waghmare, AISSMS College of Engineering,avwaghmare@aissmscoe.com*	*2. Mr.M. Palanivendhnan, SRMIST,palanivm@srmist.edu.in*

Course Code	18AUC401J	Course Name	VEHICLE DYNAMICS	Course Category	C	Professional Core	L	T	P	C
							3	0	2	4

Pre-requisite Courses	Nil	Co-requisite Courses	Nil	Progressive Courses	Nil
Course Offering Department	Automobile Engineering	Data Book / Codes/Standards	Nil		

Course Learning Rationale (CLR):	The purpose of learning this course is to:
CLR-1 :	*Learn about the sources, analysis and solution of problems pertaining to vehicular vibrations.*
CLR-2 :	*Learn about the sources and effects of dynamic forces acting on a vehicle system.*
CLR-3 :	*Acquire fundamental knowledge about ride comfort, vehicle stability issues and formulate fundamental mathematical relations for such issues to achieve a better design of automotive systems.*

Course Learning Outcomes (CLO):	At the end of this course, learners will be able to:	Learning 1: Level of Thinking (Bloom)	2: Expected Proficiency (%)	3: Expected Attainment (%)
CLO-1 :	*Solve vibration problems with single degree of freedom*	*2*	*90*	*75*
CLO-2 :	*Interrelate the forces generated in the tire with tire slip phenomenon*	*2*	*80*	*80*
CLO-3 :	*Construct a mathematical model for vehicle suspension studies*	*3*	*85*	*80*
CLO-4 :	*Formulate the equation of motion of a vehicle in longitudinal direction*	*3*	*90*	*85*
CLO-5 :	*Predict the directional stability of vehicles based on driving conditions*	*2*	*85*	*80*

Program Learning Outcomes (PLO)

	1 Engineering Knowledge	2 Problem Analysis	3 Design & Development	4 Analysis, Design, Research	5 Modern Tool Usage	6 Society & Culture	7 Environment & Sustainability	8 Ethics	9 Individual & Team Work	10 Communication	11 Project Mgt. & Finance	12 Life Long Learning	13 PSO - 1	14 PSO - 2	15 PSO – 3
CLO-1	*H*	*H*	*M*	*M*	*M*	*L*	*M*	*L*	*L*	*L*	*L*	*M*	*H*	*L*	*M*
CLO-2	*H*	*M*	*M*	*L*	*H*	*L*	*M*	*L*	*L*	*L*	*L*	*M*	*H*	*L*	*M*
CLO-3	*H*	*H*	*H*	*H*	*H*	*L*	*L*	*L*	*L*	*L*	*L*	*M*	*H*	*L*	*M*
CLO-4	*H*	*H*	*M*	*M*	*H*	*L*	*L*	*L*	*L*	*L*	*L*	*M*	*H*	*L*	*M*
CLO-5	*H*	*H*	*M*	*M*	*H*	*M*	*M*	*M*	*L*	*L*	*L*	*M*	*H*	*L*	*M*

		Basics of Vibration	Tires	Vertical Dynamics	Longitudinal dynamics	Lateral dynamics
Duration (hour)		15	15	15	15	15
S-1	SLO-1	*Understand the Basic concepts of vibration*	*Define the co-ordinate system for an automotive vehicle and tire*	*List the methods for assessing human tolerance to vibration*	*List the resistive forces to longitudinal motion of vehicles*	*List the various side forces acting on a vehicle*
	SLO-2	*Classify the types of vibration*	*State the various forces and moments acting in an automotive tire*	*Describe the criteria for ride comfort*	*Explain the resistive forces to longitudinal motion of vehicles*	*Explain the effect of the side forces on the vehicle*
S-2	SLO-1	*Recall harmonic motion principles*	*List the various causes of rolling resistance of tires*	*Categorize the vertical dynamics modeling of vehicles*	*Apply Newton's law of motion for longitudinal dynamics of vehicles*	*Define steady state condition in lateral vehicle dynamics*
	SLO-2	*Explain the procedure for vibration analysis*	*State the expression for rolling resistance of tires*	*Evaluate the equation of motion for the vertical dynamic models*	*Calculate maximum tractive effort from the equation of motion for longitudinal dynamics*	*Judge the steady state handling characteristics of a vehicle based on the value of under steer co-efficient*
S-3	SLO-1	*Express and derive equation of motion for Free vibration of single degree of freedom – damped and undamped*	*Understand the phenomenon of tire slip*	*Design passive suspension system in quarter car model*	*Discuss the components in driveline*	*List the motion variables influenced by steering input*
	SLO-2	*Infer the amplitude decrement factor as logarithmic decrement*	*Recognize the generation of slip angle due to side forces*	*Analyze passive suspension system in quarter car model*	*Apply driveline dynamics in analyzing longitudinal dynamics equation*	*Analyze the influence of steering input on motion variables*
S 4-5	SLO-1 SLO-2	*Lab 1: Analysis of vibration system in Simulink\ Recall the fundamentals of vibration systems Analyze the vibration system in Simulink*	*Lab 4: Magic formula tire model State the magic formula tire model Represent the tire behavior using Magic formula*	*Lab 7: Half car model Recognize half car model of a vehicle Develop half car model in Simulink*	*Lab 10: Braking dynamics analysis using Car Maker Recall braking dynamics equation Analyze braking dynamics using Car Maker*	*Lab 13: Lateral dynamics analysis using Car Maker Recall lateral dynamics fundamentals Analyze lateral dynamics using Car Maker*
S-6	SLO-1	*Express and derive equation of motion for forced vibration of single degree of freedom – damped and undamped*	*Interpret the variation of longitudinal and lateral forces for various slip angles*	*Design semi active and active suspension systems in quarter car model*	*Calculate maximum acceleration for different drives*	*List the various tests to measure the handling characteristics of vehicles*
	SLO-2	*Apply the principle of base excitation to automotive vibration*	*Explain the concept of friction circle in tires*	*Analyze semi active and active suspension systems in quarter car model*	*Calculate reaction forces for different drives*	*Assess the handling characteristics of vehicles through various tests*

S-7	SLO-1	*Express and derive equation of motion for Free vibration of two degree of freedom – damped and undamped*	*Interrelate tractive effort with longitudinal slip of tires*	*Design passive suspension system in half car model*	*Derive an expression for load transfer while braking*	*Recognize the transient state conditions in the dynamic motion of vehicles*
	SLO-2	*Represent simple cases of automotive vibration as two degree of freedom system*	*Illustrate the relation between tractive effort and longitudinal slip of tires*	*Analyze passive suspension system in half car model*	*Derive an expression for load transfer while accelerating*	*Formulate the equation of motion in transient state*
S-8	SLO-1	*Examine automotive vibration problems as multi degree of freedom systems*	*Restate the generation of slip angle in tires*	*Design semi active and active suspension systems in half car model*	*Calculate the load distribution for three wheelers*	*Define the criteria for directional stability of vehicles*
	SLO-2	*Solve the multi degree of freedom system equation of motion for automotive vibrations*	*Diagram the cornering characteristics of tires*	*Analyze semi active and active suspension systems in half car model*	*Calculate the load distribution for four wheelers*	*Analyze the directional stability of vehicles through understeer co-efficient*
S 9-10	SLO-1 SLO-2	*Lab 2: Generation of road profile Identify the statistical method for road profile generation Create Simulink model for road profile generation*	*Lab 5: Quarter Car model Recognize quarter car model of a vehicle Develop quarter car model in Simulink*	*Lab 8: Shock absorber testing Recall the construction of a shock absorber Assess the shock absorber in a test rig*	*Lab 11: Active suspension study in Quanser test rig Recall active suspension concept Assess the active suspension test rig*	*Lab 14: Rollover analysis using Car Maker Recall vehicle roll over concept Analyze vehicle roll over using Car Maker*
S-11	SLO-1	*Understand modelling procedure*	*List the parameters for performance of tires on wet surfaces*	*Design passive suspension system in full car model*	*Predict the driving performance of vehicles from tractive effort value*	*Analyze the stability of a vehicle on a banked road*
	SLO-2	*Study the simulation of dynamic systems*	*Interpret the phenomenon of hydroplaning*	*Analyze passive suspension system in full car model*	*Analyze acceleration and braking performance of vehicles*	*Analyze the stability of a vehicle while taking turn*
S-12	SLO-1	*Show the variation of magnification factor with respect to frequency ratio*	*Demonstrate tire as a brush type model*	*Design semi active and active suspension systems in full car model*	*Diagram the ABS control loop*	*Understand the concept of roll center in vehicle dynamics*
	SLO-2	*Sketch the variation of vibrating system transmissibility with respect to frequency ratio*	*Demonstrate tire as a brush-string type model*	*Analyze semi active and active suspension systems in full car model*	*Illustrate the ABS control cycles with appropriate practical conditions*	*Understand the concept of roll axis in vehicle dynamics*
S-13	SLO-1	*Explain the principle of vibration absorbers*	*Model the tire empirically based on experimental data*	*Apply the PID control strategy to automotive suspension systems*	*Differentiate Traction Control System against ABS*	*Draw the single track model for a vehicle*
	SLO-2	*Classify the vibration measuring instruments*	*Present tire forces and moments as a function of slip phenomenon*	*Apply the skyhook and LQR control strategy to automotive suspension systems*	*Explain typical control situations for TCS action*	*Analyze the dynamics of a vehicle using single track model*
S 14-15	SLO-1 SLO-2	*Lab 3: Assessment 1*	*Lab 6: Assessment 2*	*Lab 9: Assessment 3*	*Lab 12: Repeat Class*	*Lab 15: University exam*

Learning Resources	*1. Mechanical Vibrations, Singiresu S Rao, 6th edition, 2017, Pearson Education, USA* *2. Theory of Ground Vehicles, J.Y. Wong, 4th edition, John Wiley & Sons, New Jersey*	*3. Vehicle Dynamics and Control, Rajesh Rajamani, 2nd edition, 2012, Springer, New York* *4. Simulink Manual/Documentation, Car Maker manual/ Documentation*

Learning Assessment

	Bloom's Level of Thinking	Continuous Learning Assessment (50% weightage)								Final Examination (50% weightage)	
		CLA – 1 (10%)		CLA – 2 (15%)		CLA – 3 (15%)		CLA – 4 (10%)#			
		Theory	Practice	Theory	Practice	Theory	Practice	Theory	Practice	Theory	Practice
Level 1	Remember Understand	*20%*	*20%*	*15%*	*15%*	*15%*	*15%*	*15%*	*15%*	*15%*	*15%*
Level 2	Apply Analyze	*20%*	*20%*	*20%*	*20%*	*20%*	*20%*	*20%*	*20%*	*20%*	*20%*
Level 3	Evaluate Create	*10%*	*10%*	*15%*	*15%*	*15%*	*15%*	*15%*	*15%*	*15%*	*15%*
	Total	100 %		100 %		100 %		100 %		-	

CLA – 4 can be from any combination of these: Assignments, Seminars, Tech Talks, Mini-Projects, Case-Studies, Self-Study, MOOCs, Certifications, Conf. Paper etc.,

Course Designers

Experts from Industry	Experts from Higher Technical Institutions	Internal Experts
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2.Mr.RanjithSunderraj, Xitadel, ranjithsunderraj@xitadel.com	2. Dr.P D Jeyakumar, Cresent University, pdjeyakumar@cresent.education.	2.Mr.AJD.Nanthakumar, SRMIST, nanthakd@srmist.edu.in

Course Code	18AUC402L	Course Name	VEHICLE TESTING LABORATORY	Course Category	C	Professional Core	L	T	P	C
							0	0	2	1

Pre-requisite Courses	Nil	Co-requisite Courses	Nil	Progressive Courses	Nil
Course Offering Department	Automobile Engineering	Data Book / Codes/Standards	Nil		

Course Learning Rationale (CLR):	The purpose of learning this course is to:
CLR-1 :	*Demonstrate the purpose of chassis dynamometers in vehicle testing.*
CLR-2 :	*Understand the procedures involved in HVAC testing and servicing.*
CLR-3 :	*Analyze the various procedures involved in testing the steering and wheel geometry of an automobile.*
CLR-4 :	*Study the procedures involved in measuring the tailpipe emissions of an automobile.*
CLR-5 :	*Analyze the ignition pattern in an automobile.*

Course Learning Outcomes (CLO):	At the end of this course, learners will be able to:	Learning 1 Level of Thinking (Bloom)	Learning 2 Expected Proficiency (%)	Learning 3 Expected Attainment (%)	PLO 1 Engineering Knowledge	PLO 2 Problem Analysis	PLO 3 Design & Development	PLO 4 Analysis, Design, Research	PLO 5 Modern Tool Usage	PLO 6 Society & Culture	PLO 7 Environment & Sustainability	PLO 8 Ethics	PLO 9 Individual & Team Work	PLO 10 Communication	PLO 11 Project Mgt. & Finance	PLO 12 Life Long Learning	PLO 13 PSO - 1	PLO 14 PSO - 2	PLO 15 PSO – 3
CLO-1 :	*Conduct performance tests on automobiles using chassis dynamometers.*	3	90	90	H	H	M	M	H	H	H	H	H	H	L	H	H	M	H
CLO-2 :	*Perform tests and servicing on automobile HVAC using modern equipment.*	3	90	90	H	H	M	M	H	H	H	H	M	H	L	H	H	M	H
CLO-3 :	*Identify and adjust any deviations in steering and wheel geometry of an automobile using modern tools and equipment.*	3	90	90	H	H	M	M	H	H	H	H	H	H	L	H	H	M	H
CLO-4 :	*Perform tail pipe emission testing and analyze the deviations on emissions in an automobile.*	3	90	90	H	H	M	M	H	H	H	H	M	H	L	H	H	M	H
CLO-5 :	*Interpret the ignition pattern of an automobile to find out any ignition system malfunction.*	3	90	90	H	H	M	M	H	H	H	H	M	H	L	H	H	M	H

Duration (hour)		6	6	6	6	6
S 1-2	SLO-1, SLO-2	*Lab 1: Studying the performance of a two wheeler using Eddy current chassis dynamometer.*	*Lab 4: CLA-1*	*Lab 7: Performing dynamic wheel balancing, tyre removal and fitment on the given LMV tyre.*	*Lab 10: Determination of caster, camber, toe-in and toe-out of the given HMV using computerized wheel alignment system.*	*Lab 13: Analyzing the tail pipe emissions and smoke density of the given automobile using 5-gas analyzer and smoke meter.*
S 3-4	SLO-1, SLO-2	*Lab 2: Studying the performance of a car using a four wheeler chassis dynamometer.*	*Lab 5: Determination of slide slip, suspension efficiency and brake efficiency using car test lane.*	*Lab 8: CLA-2*	*Lab 11: Performing dynamic wheel balancing, tyre removal and fitment on the given HMV tyre.*	*Lab 14: Study of secondary ignition pattern of an automobile using an oscilloscope analyzer.*
S 5-6	SLO-1, SLO-2	*Lab 3: Performing leak check and refrigerant refilling of the HVAC in an automobile.*	*Lab 6: Determination of caster, camber, toe-in and toe-out of the given LMV using 3D computerized wheel alignment system.*	*Lab 9: Performing headlight beam adjustment on the given automobile using computerized headlamp beam tester.*	*Lab 12: CLA-3*	*Lab 15: CLA-4*

Learning Resources	
1. Automotive Handbook- Robert Bosch GmbH, Wiley, 10th edition, 2018.	*2. SPACE S.r.l. Instruction manual Code M0216 - rev.1.1 (11/2012)* *3. Bosch equipment instruction manuals.*

Learning Assessment

	Bloom's Level of Thinking	CLA – 1 (10%) Theory	CLA – 1 (10%) Practice	CLA – 2 (15%) Theory	CLA – 2 (15%) Practice	CLA – 3 (15%) Theory	CLA – 3 (15%) Practice	CLA – 4 (10%)# Theory	CLA – 4 (10%)# Practice	Final Examination (50% weightage) Theory	Final Examination (50% weightage) Practice
		Continuous Learning Assessment (50% weightage)									
Level 1	Remember / Understand	-	40%	-	30%	-	30%	-	30%	-	30%
Level 2	Apply / Analyze	-	40%	-	40%	-	40%	-	40%	-	40%
Level 3	Evaluate / Create	-	20%	-	30%	-	30%	-	30%	-	30%
	Total	100 %		100 %		100 %		100 %		-	

CLA – 4 can be from any combination of these: Assignments, Seminars, Tech Talks, Mini-Projects, Case-Studies, Self-Study, MOOCs, Certifications, Conf. Paper etc.,

Course Designers

Experts from Industry	Experts from Higher Technical Institutions	Internal Experts
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2. Mr. K.Suresh, HAL, sureshhal82@gmail.com.	*2. Dr.R.Ben Ruben, Sri Krishna College of Engineering, benrubenr@skcet.ac.in*	*2. Mr.Deepak M, SRMIST*

Course Code	18AUC350T	Course Name	COMPREHENSION	Course Category	C	Professional Core	L	T	P	C
							0	1	0	1

Pre-requisite Courses	Nil	Co-requisite Courses	Nil	Progressive Courses	Nil
Course Offering Department	Automobile Engineering	Data Book / Codes/Standards	Nil		

Course Learning Rationale (CLR):	*The purpose of learning this course is to:*
CLR-1 :	*Acquire skills to solve real world problems in Engineering Graphics Design, Engineering Mechanics and Mechanics of Solids*
CLR-2 :	*Acquire skills to solve real world problems in Machines and Mechanisms, Thermodynamics and Fluid Mechanics*
CLR-3 :	*Solve problems in Manufacturing Technology, Material Technology, Applied Thermal Engineering for Automotive Engineers*
CLR-4 :	*Solve problems in Automotive Engines, Vehicular Structures, Driveline Systems and Automotive Electrical and Electronics Systems*
CLR-5 :	*Acquire skills to solve real world problems in Design of Automotive components and CAD Analysis for Automotive Engineers*
CLR-6 :	*Acquire skills to solve real world problems for competitive examinations in Automobile and Mechanical Engineering*

Course Learning Outcomes (CLO):	*At the end of this course, learners will be able to:*	Learning 1: Level of Thinking (Bloom)	2: Expected Proficiency (%)	3: Expected Attainment (%)	PLO 1: Engineering Knowledge	2: Problem Analysis	3: Design & Development	4: Analysis, Design, Research	5: Modern Tool Usage	6: Society & Culture	7: Environment & Sustainability	8: Ethics	9: Individual & Team Work	10: Communication	11: Project Mgt. & Finance	12: Life Long Learning	13: PSO - 1	14: PSO - 2	15: PSO - 3
CLO-1 :	*Practice and gain confidence, competence to solve problems in Engineering Graphics Design, Engineering Mechanics, Mechanics of Solids*	3	85	80	H	H	H	L	L	L	L	L	L	L	L	L	M	L	M
CLO-2 :	*Practice and gain confidence and competence to solve problems in Machines and Mechanisms, Thermodynamics and Fluid Mechanics*	3	85	80	H	H	M	L	L	L	L	L	L	L	L	L	M	M	M
CLO-3 :	*Solve problems in Manufacturing Technology, Material Technology and Applied Thermal Engineering for Automotive Engineers*	3	85	80	H	H	M	L	L	L	L	L	L	L	L	L	M	L	M
CLO-4 :	*Solve problems in Automotive Engines, Vehicular Structures and Driveline Systems and Automotive Electrical and Electronics Systems*	3	85	80	H	H	M	L	L	L	L	L	L	L	L	L	M	M	M
CLO-5 :	*Practice and gain confidence,competence to solve problems in Design of Automotive components, CAD Analysis for Automotive Engineers*	3	85	80	H	H	H	L	L	L	L	L	L	L	L	L	M	L	M
CLO-6 :	*Practice and gain confidence and competence to solve problems in the broad domain of Automobile and Mechanical Engineering*	3	85	80	H	H	M	L	L	L	L	L	L	L	L	L	M	M	M

Duration (hour)		3	3	3	3	3
S-1	SLO-1	*Tutorial on Engineering graphics and design*	*Tutorial on Machines and Mechanisms*	*Tutorial on Manufacturing Technology for Automotive Engineers*	*Tutorial on Automotive Engines*	*Tutorial on Design of Automotive components*
	SLO-2	*Problem Solving*	*Problem Solving*	*Problem Solving*	*Problem Solving*	*Problem Solving*
S-2	SLO-1	*Tutorial on Engineering Mechanics*	*Tutorial on Thermodynamics*	*Tutorial on Material Technology*	*Tutorial on Vehicular Structures and Driveline Systems*	*Tutorial on CAD Analysis for Automotive Engineers*
	SLO-2	*Problem Solving*	*Problem Solving*	*Problem Solving*	*Problem Solving*	*Problem Solving*
S-3	SLO-1	*Tutorial on Mechanics of Solids*	*Tutorial on Fluid mechanics*	*Tutorial on Applied Thermal Engineering for Automotive Engineers*	*Tutorial on Automotive Electrical and Electronics Systems*	*Problem Solving*
	SLO-2	*Problem Solving*	*Problem Solving*	*Problem Solving*	*Problem Solving*	*Problem Solving*

Learning Resources	*1. R.S.Khurmi, J.K.Gupta, Mechanical Engineering: Conventional and Objective Types, S.Chand& Co., 2018*	*2. R.K.Jain, Conventional & Objective Type Question & Answers on Mechanical Engineering for Competitions, Khanna Publishers, 2014*

Learning Assessment

	Bloom's Level of Thinking	Continuous Learning Assessment (100% weightage)								Final Examination	
		CLA – 1 (20%)		CLA – 2 (30%)		CLA – 3 (30%)		CLA – 4 (20%)#			
		Theory	Practice	Theory	Practice	Theory	Practice	Theory	Practice	Theory	Practice
Level 1	Remember / Understand	-	*40%*	-	*30%*	-	*30%*	-	*30%*	-	-
Level 2	Apply / Analyze	-	*40%*	-	*40%*	-	*40%*	-	*40%*	-	-
Level 3	Evaluate / Create	-	*20%*	-	*30%*	-	*30%*	-	*30%*	-	-
	Total	100 %		100 %		100 %		100 %		-	

CLA – 4 can be from any combination of these: Assignments, Seminars, Tech Talks, Mini-Projects, Case-Studies, Self-Study, MOOCs, Certifications, Conf. Paper etc.,

Course Designers

Experts from Industry	Experts from Higher Technical Institutions	Internal Experts
1. Mr. Jayaraman.R. BLG Logistics, jayaraman.r@bigparekh.com	*1. Dr. M.Parthasarathy, Vel Tech, nparthasarathy@veltech.edu.in*	*Dr. C.Prabhu, , SRMIST*
2. Mr. Shanmuga Sundaram, RNTBCI, sankaran@rntbci.com	*2. Dr.P.Nanthakumar, Amrita school of Engineering, p_nanthakumar@cb.amrita.edu*	*Dr. T.Prakash, SRMIST*

ACADEMIC CURRICULA

Professional Core Courses

BIOTECHNOLOGY

Regulations - 2018

SRM INSTITUTE OF SCIENCE AND TECHNOLOGY

(Deemed to be University u/s 3 of UGC Act, 1956)

Kattankulathur, Kancheepuram, Tamil Nadu, India

Course Code	18BTC201J	Course Name	GENE MANIPULATION AND GENOMICS	Course Category	C	Professional Core	L	T	P	C
							3	0	2	4

Pre-requisite Courses	Nil	Co-requisite Courses	Nil	Progressive Courses	Nil
Course Offering Department	Biotechnology	Data Book / Codes/Standards	Nil		

Course Learning Rationale (CLR):	The purpose of learning this course is to:
CLR-1 :	*Discuss the basic concepts and principles of utilization of different expression vectors for cloning from the perspective of engineers*
CLR-2 :	*Demonstrate the different strategies of gene cloning and construction of genomic and cDNA libraries*
CLR-3 :	*Analyse the concepts of structural and functional genomics*
CLR-4 :	*Apply advanced cutting-edge technologies*
CLR-5 :	*Assess the applications of recombinant DNA technology in animals, plants and microbial organisms*
CLR-6 :	*Prepare engineering students to develop the strategies on altering gene expression in vitro and in vivo*

Course Learning Outcomes (CLO):	At the end of this course, learners will be able to:	Learning 1 Level of Thinking (Bloom)	2 Expected Proficiency (%)	3 Expected Attainment (%)	Program Learning Outcomes (PLO) 1 Engineering Knowledge	2 Problem Analysis	3 Design & Development	4 Analysis, Design, Research	5 Modern Tool Usage	6 Society & Culture	7 Environment & Sustainability	8 Ethics	9 Individual & Team Work	10 Communication	11 Project Mgt. & Finance	12 Life Long Learning	13 PSO - 1	14 PSO - 2	15 PSO – 3
CLO-1 :	*Explain the foundations of modern biotechnology*	1	80	70		L	M	L	M				H			H	H	H	H
CLO-2 :	*Design and conduct experiments involving genetic manipulation.*	2	85	75	H	H	H	H	H				H		H	H	H	H	H
CLO-3 :	*Use versatile techniques in recombinant DNA technology.*	2	75	80	H	M	H	H	H				H		H	H	H	H	H
CLO-4 :	*Describe the steps involved in the production of biopharmaceuticals in microbial and mammalian cell systems.*	2	85	80	H	H	H	H	H		M		H		H	H	H	H	H
CLO-5 :	*Apply modern biotechnology in the different areas like medicine, microbes, environment and agriculture.*	2	80	80	H	M	H	H	H	L	H		H		H	H	H	H	H
CLO-6 :	*Design the cloning experiments using routine and specialized vectors for such applications as plant transformation, protein expression and genomic DNA library construction etc.*	2	80	75	H	H	H	H	H		M		H		H	H	H	H	H

Duration (hour)		15	15	15	15	15
S-1	SLO-1	*Overview of cloning*	*DNA Library*	*DNA sequencing*	*Analysis of gene expression*	*Applications of cloning*
	SLO-2	*DNA cloning vectors*	*Preparation of DNA Libraries*	*Principles of DNA sequencing*	*Transcription and translation*	*Medical applications*
S-2	SLO-1	*Cell based DNA cloning*	*Genomic DNA library*	*Sanger's Dideoxy sequencing method*	*Post transcriptional and post translational regulations*	*Human and genetic diseases*
	SLO-2	*Cell free DNA cloning*	*Overlapping and non-overlapping DNA fragments*	*Automated DNA sequencing*	*Methods for protein expression*	*DNA vaccines*
S-3	SLO-1	*Plasmid vectors – pBR322*	*Choice of vectors*	*Next generation sequencing*	*Analysis of gene function*	*Gene therapy*
	SLO-2	*pUC vector*	*Evaluation of genomic DNA library*	*Genome sequencing*	*Factors influencing gene expression*	*Study of gene function in vivo*
S 4-5	SLO-1 SLO-2	*Lab 1: Restriction enzyme digestion of genomic DNA*	*Lab 4: Alkaline Phosphatase treatment for cloning*	*Lab 7: Transformation of recombinant vector in to E.Coli*	*Lab 10: Repeat/Revision of experiments*	*Lab 13: Qualitative and quantitative analyses of RNA*
S-6	SLO-1	*Phage vectors – Lambda insertion*	*cDNA library*	*Emulsion PCR*	*Manipulation of gene expression*	*Embryonic stem cells*
	SLO-2	*Lambda Replacement vector*	*Purification and separation of mRNA*	*Bridge PCR*	*Transcriptomics - Non-coding RNA*	*Applications in Embryonic stem cells*
S-7	SLO-1	*Cosmids*	*cDNA synthesis*	*RNA sequencing*	*Small RNAs, siRNAs*	*Transgenics*
	SLO-2	*M13 vector*	*cDNA library construction*	*Applications of NGS*	*MicroRNAs, lncRNA*	*Methods of producing transgenic mice*
S-8	SLO-1	*Phagemid*	*Evaluation of cDNA library*	*Labeling of nucleic acids*	*Expression in prokaryotic host cells*	*Over-expression*
	SLO-2	*pBluescript*	*Screening libraries*	*Random priming*	*Purification of expressed protein*	*Gene knock-in*
S 9-10	SLO-1 SLO-2	*Lab 2: Restriction enzyme digestion of Vector*	*Lab 5: Preparation of rDNA- Ligation of DNA fragment with cloning vector*	*Lab 8: Screening- Blue white selection*	*Lab 11: Expression in eukaryotic host cells*	*Lab 14: cDNA synthesis*
S-11	SLO-1	*Yeast vectors*	*Polymerase chain reaction (PCR)*	*Nick translation and End labeling*	*Expression in eukaryotic host cells*	*Gene knock-out*
	SLO-2	*Types of yeast vector*	*Semi quantitative PCR*	*RNA labeling*	*Mammalian expression vectors*	*Conditional knock-out*
S-12	SLO-1	*YAC*	*RNA-PCR*	*Non-isotopic labeling*	*Mutagenesis*	*Genome editing*
	SLO-2	*Expression vectors*	*Real time PCR*	*Structural genomics*	*in vitro mutagenesis*	*CRISPER-Cas9*

S-13	SLO-1	*Restriction enzymes*	*Types of qRT-PCR*	*comparative genomics*	*Site directed mutagenesis*	*Guide RNA*
	SLO-2	*Linker and homopolymer tailing*	*Applications of PCR*	*Microarray*	*Methods for site directed mutagenesis*	*Gene inactivation*
S 14-15	SLO-1 SLO-2	*Lab 3: Purification of digested DNA by column purification*	*Lab 6: Preparation of Competent cell*	*Lab 9: Identification of recombinants-isolation of rDNA*	*Lab 12: RNA isolation*	*Lab 15: Quantitative PCR (Real time PCR)*

Learning Resources	*1. Jeremy W. Dale and Malcolm von Schantz, "From Genes to Genomes," John Willey and Sons Publications, 2002* *2. Sandy-b-primrose, "Principles of Gene Manipulation and Genomics" Seventh Edition, 2012*	*3. S. B. Primrose and R. M. Twyman, "Principles of Gene Manipulation and Genomics"7th Edition,Wiley-Blackwell, 2006*

Learning Assessment											
	Bloom's Level of Thinking	Continuous Learning Assessment (50% weightage)								Final Examination (50% weightage)	
		CLA – 1 (10%)		CLA – 2 (15%)		CLA – 3 (15%)		CLA – 4 (10%)#			
		Theory	Practice	Theory	Practice	Theory	Practice	Theory	Practice	Theory	Practice
Level 1	Remember Understand	*20%*	*20%*	*15%*	*15%*	*15%*	*15%*	*15%*	*15%*	*15%*	*15%*
Level 2	Apply Analyze	*20%*	*20%*	*20%*	*20%*	*20%*	*20%*	*20%*	*20%*	*20%*	*20%*
Level 3	Evaluate Create	*10%*	*10%*	*15%*	*15%*	*15%*	*15%*	*15%*	*15%*	*15%*	*15%*
	Total	100 %		100 %		100 %		100 %		100 %	

CLA – 4 can be from any combination of these: Assignments, Seminars, Tech Talks, Mini-Projects, Case-Studies, Self-Study, MOOCs, Certifications, Conf. Paper etc.,

Course Designers		
Experts from Industry	Experts from Higher Technical Institutions	Internal Experts
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Course Code	18BTC202J	Course Name	BIOPROCESS ENGINEERING	Course Category	C	Professional Core	L	T	P	C
							3	0	2	4

Pre-requisite Courses	Nil	Co-requisite Courses	Nil	Progressive Courses	Nil
Course Offering Department	Biotechnology	Data Book / Codes/Standards	Nil		

Course Learning Rationale (CLR):	*The purpose of learning this course is to:*	Learning 1	Learning 2	Learning 3	PLO 1	PLO 2	PLO 3	PLO 4	PLO 5	PLO 6	PLO 7	PLO 8	PLO 9	PLO 10	PLO 11	PLO 12	PLO 13	PLO 14	PLO 15
CLR-1 :	*Demonstrate the various operational modes of bioreactor*																		
CLR-2 :	*Illustrate about the various transport phenomena in bioprocess systems.*																		
CLR-3 :	*Demonstrate the monitoring and control of various process parameters in bioreactors.*																		
CLR-4 :	*Analyze the design and operation of various industrially important bioreactor*																		
CLR-5 :	*Illustrate the various mathematical models of biological systems*																		
CLR-6 :	*Illustrate the transformation of bioprocess engineering approaches from laboratory scale to commercial scale*																		
Course Learning Outcomes (CLO):	*At the end of this course, learners will be able to:*	Level of Thinking (Bloom)	Expected Proficiency (%)	Expected Attainment (%)	Engineering Knowledge	Problem Analysis	Design & Development	Analysis, Design, Research	Modern Tool Usage	Society & Culture	Environment & Sustainability	Ethics	Individual & Team Work	Communication	Project Mgt. & Finance	Life Long Learning	PSO - 1	PSO - 2	PSO – 3
CLO-1 :	*Analyze the various operations of the bioreactor and evaluating its performance.*	*2*	*80*	*70*	*H*	*H*	*H*	*H*			*H*		*H*		*H*	*H*	*H*	*H*	*H*
CLO-2 :	*Discuss the fundamental knowledge on mechanisms of oxygen transfer in biological systems.*	*2*	*85*	*75*	*H*	*H*	*H*	*H*			*H*		*H*		*H*	*H*	*H*	*H*	*H*
CLO-3 :	*Illustrate the procedures adopted for monitoring and control of process parameters in bioreactors.*	*2*	*75*	*80*	*H*	*H*	*H*	*M*			*H*		*H*		*H*	*H*	*H*	*H*	*H*
CLO-4 :	*Discuss on the design and operation of bioreactors for the cultivation of microbial, plant and animal cell cultures.*	*2*	*85*	*80*	*H*	*H*	*H*	*H*			*M*		*H*		*H*	*H*	*H*	*H*	*H*
CLO-5 :	*Explain the applicability of modeling preliminaries and software packages in bioprocess.*	*3*	*85*	*80*	*H*	*H*	*H*	*H*	*H*		*M*		*H*		*H*	*H*	*H*	*H*	*H*
CLO-6 :	*Explain the engineering approaches for successful commercialization of bioprocess operations.*	*2*	*80*	*75*	*H*	*H*	*H*	*H*	*H*		*M*		*H*		*H*	*H*	*H*	*H*	*H*

Duration (hour)		15	15	15	15	15
S-1	SLO-1	*Introduction to ideal reactors*	*Molecular Diffusion*	*Bioreactor Instrumentation and Control*	*Bioreactor configurations for production of metabolites from microbial sources*	*Introduction to mathematical modeling of biological systems*
	SLO-2	*Ideal reactor types*	*Role of Diffusion in Bioprocessing*	*Monitoring of biochemical parameters*	*Stirred tank reactor*	*Approaches to modelling cell growth*
S-2	SLO-1	*Ideal batch reactor - basics*	*Convective Mass Transfer*	*Instrumentation for Measurements of Active Fermentation*	*Packed bed reactor*	*A Model of Cell Growth Dynamics*
	SLO-2	*Performance equation: Ideal batch reactor*	*Oxygen Uptake in Cell Cultures*	*pH, temperature, and DO*	*Fluidized bed reactor*	*Sigle cell model*
S-3	SLO-1	*Ideal continuous reactor - basics*	*Oxygen Transfer in Fermenters*	*Chemical composition and exhaust gas analysis*	*Air lift loop reactor*	*Yeast model*
	SLO-2	*Performance equation: Ideal continuous reactor*	*Measuring Dissolved-Oxygen Concentrations*	*Water purity, pressure and mass*	*Case studies*	*Simulation software packages*
S 4-5	SLO-1 SLO-2	*Lab 1: Batch operation*	*Lab 4: Estimation of K_La by sulphite oxidation method*	*Lab 7: Enzyme Production - Medium optimization by RSM*	*Lab 10: Repeat/Revision of experiments*	*Lab 13: Analysis of various growth kinetic parameters of batch fermentation using Berkley Madonna software*
S-6	SLO-1	*Ideal plug flow reactor - basics*	*Estimating Oxygen Solubility*	*Mass flow rate, volumetric flow rate and broth level*	*Bioreactor configurations for production of metabolites from plant sources*	*Berkley Madonna software*
	SLO-2	*Performance equation: Ideal plug flow reactor*	*Mass-Transfer Correlations*	*Methods for on-line and off-line biomass estimation*	*Different types of bioreactors for plant cells, tissues and organs*	*Continuous fermentation process*
S-7	SLO-1	*Reasons for non-ideality in bioreactors*	*Measurement of K_La*	*On-line analysis of other chemical factors*	*Light Introducing Bioreactors*	*Fed batch fermentation process*
	SLO-2	*Measurement of non-ideality in bioreactors*	*Oxygen-Balance Method and Dynamic Method*	*State and parameter estimation techniques for biochemical process*	*Rotating Drum Bioreactor*	*MATLAB - Basics*
S-8	SLO-1	*Residence Time Distribution - Studies*	*Power correlation analysis for KLa*	*Control system in bioreactor*	*Balloon-type bubble bioreactors*	*Input and Output in MATLAB*
	SLO-2	*Non-ideal bioreactors*	*Oxygen Transfer in Large Vessels*	*Regulatory and multivariable control*	*Scale-up*	*Curve fitting tool*
S 9-10	SLO-1 SLO-2	*Lab 2: Fed batch operation*	*Lab 5: KLa determination by dynamic gassing method*	*Lab 8: Repeat/Revision of experiments*	*Lab 11: Wine production*	*Lab 14: Estimation of bacterial growth kinetic parameter using Curve Fitting tool in MATLAB*

S-11	SLO-1	*Axial Dispersion*	*Regime analysis of bioprocess*	*Computer-based data acquisition*	*Bioreactor configurations for production of metabolites from animal sources*	*Running simulation in MATLAB*
	SLO-2	*Dispersion Model*	*Mechanism of mixing in bioreactors*	*Artificial intelligence for the control of bioreactor systems*	*Cell culture - basics*	*Running simulation in SIMULINK*
S-12	SLO-1	*Application of dispersion model in design of continuous sterilizers*	*Scale-up of bioreactors*	*Application of Computer Control and Sensing Technologies for bioreactor systems*	*Hollow fire reactors*	*Dynamic simulation studies*
	SLO-2	*Tanks-in-Series Model*	*Scale-up of bioreactors based on power consumption – Gassed*	*Flow injection analysis – Introduction*	*Perfusion culture systems*	*Process Flow sheeting*
S-13	SLO-1	*Conversion from Tanks-in-Series Model*	*Scale-up of bioreactors based on power consumption – Ungassed*	*Various transport system - FIA*	*Sedimentation column perfusion systems*	*Examples of various primary metabolites process flow diagram*
	SLO-2	*Summary - Types of models for non-ideal (real) reactors*	*Scale-up of bioreactors based on oxygen transfer*	*FIA applications*	*Bioreactor strategies for maximizing product formation*	*Examples of various secondary metabolites process flow diagram*
S 14-15	SLO-1 SLO-2	*Lab 3: Sterilization kinetics*	*Lab 6: KLa determination by power correlation analysis*	*Lab 9: Monitoring of process and kinetics parameters in enzyme production – Shake flask studies*	*Lab 12: Prediction of flow behavior in fermentation broth*	*Lab 15: Repeat/Revision of experiments*

Learning Resources	*1. Kargi. F., Shuler. M.L., "Bioprocess Engineering: Basic Concepts", 3rd Edition. Prentice Hall, 2017.* *2. Doran. P. M., "Bioprocess Engineering Principles", Academic press, 2012* *3. Najafpour G., "Biochemical Engineering and Biotechnology", 2nd Edition, Elsevier Science, 2015*	*4. Scott F.H., "Elements of Chemical Reaction Engineering", 5th Edition, Pearson Education, Inc., 2015.* *5. Burstein L., "Matlab® in Bioscience and Biotechnology, Woodhead Publishing, 2011* *6. Schügerl K., Bellgardt K.-H., Bioreaction Engineering: Modeling and Control, Springer, 2000.*

Learning Assessment

	Bloom's Level of Thinking	Continuous Learning Assessment (50% weightage)								Final Examination (50% weightage)	
		CLA – 1 (10%)		CLA – 2 (15%)		CLA – 3 (15%)		CLA – 4 (10%)#			
		Theory	Practice	Theory	Practice	Theory	Practice	Theory	Practice	Theory	Practice
Level 1	Remember Understand	*20%*	*20%*	*15%*	*15%*	*15%*	*15%*	*15%*	*15%*	*15%*	*15%*
Level 2	Apply Analyze	*20%*	*20%*	*20%*	*20%*	*20%*	*20%*	*20%*	*20%*	*20%*	*20%*
Level 3	Evaluate Create	*10%*	*10%*	*15%*	*15%*	*15%*	*15%*	*15%*	*15%*	*15%*	*15%*
	Total	100 %		100 %		100 %		100 %		100 %	

CLA – 4 can be from any combination of these: Assignments, Seminars, Tech Talks, Mini-Projects, Case-Studies, Self-Study, MOOCs, Certifications, Conf. Paper etc.,

Course Designers

Experts from Industry	Experts from Higher Technical Institutions	Internal Experts
Dr. P. BalaKumaran, Proklean Technologies (P) Limited, Chennai, genbalu86@gmail.com	*Prof. K Subramaniam, IITM, Chennai, subbu@iitm.ac.in*	*Dr. V. Vinoth Kumar, SRMIST*
Dr. Karthik Periyasamy, Aurobindo Pharma Limited, Hyderabad, karthikmpk@gmail.com	*Prof. R. B. Narayanan, SVCE, Chennai, rbn@svce.ac.in*	*Dr. M. Venkatesh Prabhu, SRMIST*

Course Code	18BTC203J	Course Name	ANIMAL BIOTECHNOLOGY	Course Category	C	Professional Core	L	T	P	C
							3	0	2	4

Pre-requisite Courses	Nil	Co-requisite Courses	Nil	Progressive Courses	Nil
Course Offering Department	Biotechnology	Data Book / Codes/Standards	Nil		

Course Learning Rationale (CLR):	*The purpose of learning this course is to:*
CLR-1 :	*Understand animal breeding,controlling characters and disorders*
CLR-2 :	*Develop an understanding about transgenic animals*
CLR-3 :	*Inculcate the understanding of cell culture technique and production of valuable products from them*
CLR-4 :	*Emphasize on animal health thereby improving livestock production*
CLR-5 :	*Develop an understanding of alteration of animal body biological system*
CLR-6 :	*provide a basic understanding of animal biotechnology*

		Learning			Program Learning Outcomes (PLO)														
		1	2	3	1	2	3	4	5	6	7	8	9	10	11	12	13	14	15
Course Learning Outcomes (CLO):	*At the end of this course, learners will be able to:*	Level of Thinking (Bloom)	Expected Proficiency (%)	Expected Attainment (%)	Engineering Knowledge	Problem Analysis	Design & Development	Analysis, Design, Research	Modern Tool Usage	Society & Culture	Environment & Sustainability	Ethics	Individual & Team Work	Communication	Project Mgt. & Finance	Life Long Learning	PSO - 1	PSO - 2	PSO – 3
CLO-1 :	*Impart theoretical knowledge on breeding, Characteristics of animals and biological markers for genetic diseases*	*2*	*80*	*70*		*H*							*H*			*M*	*H*	*H*	*H*
CLO-2 :	*Acquire knowledge on Embryo transfer, fertilization methods and transgenic animals*	*2*	*85*	*75*		*H*	*H*				*H*	*M*				*M*	*H*	*H*	*H*
CLO-3 :	*Illustrate on various cell culture techniques and their applications*	*2*	*85*	*80*	*H*		*H*	*M*	*H*		*H*	*H*	*H*		*H*	*H*	*H*	*H*	*H*
CLO-4 :	*Explain on microbial infections of animal thereby rendering prophylaxis*	*2*	*85*	*80*	*H*		*H*		*H*		*M*		*H*		*H*		*H*	*H*	*H*
CLO-5 :	*Gain knowledge about improvement of animals to increase the yield and quality of animal products*	*3*	*85*	*80*	*H*	*H*	*H*	*H*	*H*		*M*		*H*		*H*		*H*	*H*	*H*
CLO-6 :	*Assess the knowledge on animal biotechnology for its applications*	*2*	*80*	*75*	*H*	*H*	*H*	*H*	*H*		*M*		*H*		*H*		*H*	*H*	*H*

Duration (hour)		15	15	15	15	15
S-1	SLO-1	*Breed*	*Artificial insemination*	*Principles of sterile techniques and cell propagation*	*Vaccines for animal health*	*Use of biotechnology in livestock production*
	SLO-2	*Species*	*Super ovulation*	*Primary cell culture*	*Diseases in cattle:*	*Effects of Growth hormone*
S-2	SLO-1	*Different types of breeding: Pros & Cons*	*In vitro fertilization*	*secondary cell culture*	*Bacterial disease- symptoms and prevention*	*Manipulation of Growth hormone*
	SLO-2	*Inbreeding, Outbreeding*	*Embryo transfer*	*continuous cell lines*	*Viral disease -symptoms and prevention*	*Somatotropic hormone*
S-3	SLO-1	*Types of cross breeding*	*Embryo sexing*	*suspension cultures*	*Parasitic disease -symptoms and prevention*	*Recombinant Bovine Growth Hormone*
	SLO-2	*Up grading*	*Splitting and quality analysis of embryo*	*Chemically defined and serum free media for cell culture*	*Diseases in sheep & goat:*	*Thyroid hormone*
S 4-5	SLO-1 SLO-2	*Lab 1: Sterilization techniques for animal cell culture*	*Lab 4: Isolation and culture of Hepatocytes*	*Lab 7: Cell passaging*	*Lab 10: Mitochondrial staining by Rhodamine 123*	*Lab 13: Cytotoxicity-LDH assay*
S-6	SLO-1	*ChoosingTraits in farm animals*	*Pregnancy diagnosis*	*Scaling up of monolayer culture*	*Bacterial disease- symptoms and prevention*	*Probiotics as growth promoters:*
	SLO-2	*Quantitative trait loci*	*Cryopreservation of embryo*	*Scaling up of suspension culture*	*Viral disease -symptoms and prevention*	*Ideal characteristics*
S-7	SLO-1	*Marker assisted selection*	*Vitrification*	*Contamination: sources, types and eradication*	*Parasitic disease -symptoms and prevention*	*Mode of action of probiotics*
	SLO-2	*Single locus marker- RFLP*	*Slow programmed freezing*	*Preservation of animal cells*	*Introduction to animal vaccination*	*uses of probiotics*
S-8	SLO-1	*Multilocus marker- AFLP, SSR*	*Cloning for conservation of endangered species- Pros & Cons*	*characterization of animal cells*	*Vaccine production using animal cells*	*Manipulation of lactation*
	SLO-2	*RAPD in farm animals*	*Gene transfer techniques*	*Species identification*	*Live vaccines*	*Mammogenesis*
S 9-10	SLO-1 SLO-2	*Lab 2: Preparation of cell culture media*	*Lab 5: Cell counting and Viability*	*Lab 8: Cryopreservation of cells*	*Lab 11: Nuclear staining by Propidium iodide*	*Lab 14: Culture and differentiation of L6 cells*
S-11	SLO-1	*DNA Finger printing in animals*	*Transgenic animals – importance & methods of producing it*	*Organotypic culture*	*killed vaccines*	*Lactogenesis*
	SLO-2	*Applications of molecular markers*	*Transgenic mice*	*Types of organ culture*	*Conjugate vaccines*	*Galactopoiesis*

S-12	SLO-1	*Chromosomal aberrations*	*Transgenic fish*	*Application of animal cell culture*	*Anti Idiotypic vaccines*	*Manipulation of rumen microbial digestive system*
	SLO-2	*Genetic disorders: Cattle*	*Molecular farming*	*Cell cytotoxicity and viability assays*	*Subunit vaccines*	*Methods for manipulation*
S-13	SLO-1	*Sheep & Goat*	*Expression of therapeutic proteins*	*Cell culture as source of therapeutic products*	*Recombinant vaccines*	*Manipulation of wool growth*
	SLO-2	*Horse*	*Animal as a bioreactor*	*Tissue plasminogen activator*	*DNA vaccines*	*Factors affecting wool quality in sheep*
S 14-15	SLO-1	*Lab 3: Isolation and culture of Splenocytes*	*Lab 6: Primary culture using Chick embryo*	*Lab 9: Revival of Cryopreserved cells*	*Lab 12: Cell viability assay using MTT*	*Lab 15: Determination of glucose assay by GOD-POD method*
	SLO-2					

Learning Resources	1. Animal Biotechnology: Recent concepts and developments - P.Ramadas, MJP Publications, 2015. 2. Animal Biotechnology – M.M.Ranga, IIIrd edition, 2007	3. Culture of animal cells; a manual of basic technique - R.Ian Freshney, Vth edition, Wiley publications, 2006. 4. Textbook of Animal Biotechnology – P.Ramadas & S.Meerarani, IInd edition, 2002.

Learning Assessment

	Bloom's Level of Thinking	Continuous Learning Assessment (50% weightage)								Final Examination (50% weightage)	
		CLA – 1 (10%)		CLA – 2 (15%)		CLA – 3 (15%)		CLA – 4 (10%)#			
		Theory	Practice	Theory	Practice	Theory	Practice	Theory	Practice	Theory	Practice
Level 1	Remember Understand	*20%*	*20%*	*15%*	*15%*	*15%*	*15%*	*15%*	*15%*	*15%*	*15%*
Level 2	Apply Analyze	*20%*	*20%*	*20%*	*20%*	*20%*	*20%*	*20%*	*20%*	*20%*	*20%*
Level 3	Evaluate Create	*10%*	*10%*	*15%*	*15%*	*15%*	*15%*	*15%*	*15%*	*15%*	*15%*
	Total	100 %		100 %		100 %		100 %		100 %	

CLA – 4 can be from any combination of these: Assignments, Seminars, Tech Talks, Mini-Projects, Case-Studies, Self-Study, MOOCs, Certifications, Conf. Paper etc.,

Course Designers

Experts from Industry	Experts from Higher Technical Institutions	Internal Experts
Dr. G. N. Ramchand, Saksin Life sciences Pvt Ltd, Chennai, ramchand@saksinlife.com	*Prof.. K Subramaniam, IITM, Chennai, subbu@iitm.ac.in*	*Dr. S.Sujatha, SRMIST*
Dr. Karthik Periyasamy, Scientist I, Aurozymes Unit, Aurobindo Pharma Limited, Hyderabad, karthikmpk@gmail.com	*Prof. R. B. Narayanan, SVCE, Chennai, rbn@svce.ac.in*	*Dr. S.Subhashini, SRMIST*

Course Code	18BTC204T	Course Name	PROTEIN ENGINEERING AND PROTEOMICS	Course Category	C	Professional Core	L	T	P	C
							3	0	0	3

Pre-requisite Courses	Nil	Co-requisite Courses	Nil	Progressive Courses	Nil
Course Offering Department	Biotechnology	Data Book / Codes/Standards	Nil		

Course Learning Rationale (CLR):	*The purpose of learning this course is to:*
CLR-1 :	*Distinguish the organizational levels of protein structure.*
CLR-2 :	*Appraise the structure-function correlation in selected proteins.*
CLR-3 :	*Interpret the structural basis of catalytic mechanism of proteolytic enzymes.*
CLR-4 :	*Construct 3D structure of protein from amino acid sequence.*
CLR-5 :	*Discuss on the experimetal techniques available for protein structure characterization.*
CLR-6 :	*Express the structural similarities existing at basal level in a group of proteins with similar functions*

Course Learning Outcomes (CLO):	*At the end of this course, learners will be able to:*	Learning 1	Learning 2	Learning 3	Program Learning Outcomes (PLO) 1	2	3	4	5	6	7	8	9	10	11	12	13	14	15
		Level of Thinking (Bloom)	Expected Proficiency (%)	Expected Attainment (%)	Engineering Knowledge	Problem Analysis	Design & Development	Analysis, Design, Research	Modern Tool Usage	Society & Culture	Environment & Sustainability	Ethics	Individual & Team Work	Communication	Project Mgt. & Finance	Life Long Learning	PSO - 1	PSO - 2	PSO – 3
CLO-1 :	*Interpret the properties of protein based on the sequence*	*1*	*80*	*80*	*H*	*H*	*H*	*H*		*M*	*L*	*H*	*H*	*H*	*H*	*H*	*H*	*H*	*H*
CLO-2 :	*Recognize the 3D orientation of proteins and its correlation to the function oft the protein*	*2*	*85*	*75*	*H*	*H*	*H*	*H*			*M*	*H*	*H*	*H*	*H*	*H*	*H*	*H*	*H*
CLO-3 :	*Design mutated proteins to obtain proteins with desired function*	*2*	*75*	*80*	*M*	*H*	*M*	*H*	*M*	*M*		*M*	*H*	*H*	*H*	*H*	*H*	*H*	*H*
CLO-4 :	*Restate the biological significance of select group of proteins*	*2*	*85*	*80*	*H*	*H*	*H*	*H*			*H*	*L*	*H*	*H*	*H*	*H*	*H*	*H*	*H*
CLO-5 :	*Explain the basics of available experimental techniqes for resolving protein structure*	*3*	*85*	*75*	*H*	*H*	*H*	*H*		*M*	*H*	*H*	*H*	*L*	*H*	*H*	*H*	*H*	*H*
CLO-6 :	*Devise strategies for prediction, modification and design novel proteins*	*2*	*80*	*80*	*H*	*H*	*H*	*H*	*L*	*M*	*M*	*M*	*H*	*H*	*H*	*H*	*H*	*H*	*H*

Duration (hour)		9	9	9	9	9
S-1	SLO-1	*Structure of amino acids*	*Role of Transcription factors in gene expression*	*Types and uses of proteases*	*Difficulties in generating crystals of Protein*	*Introduction to proteomics*
	SLO-2	*Properties of amino acids*	*Significance of TATA-box binding proteins (TBP)*	*Mechanism of action of serine proteases*	*Methods of generating crystals*	*Difference between functional genomics and proteomics*
S-2	SLO-1	*Role of Glycine and Proline in structure determination*	*Structural elucidation of TBP*	*Significance of Catalytic triad in serine proteases*	*Braggs law*	*Importance of sequencing of prtoein*
	SLO-2	*Ramachandran plot and its significance.*	*Nature of interaction between TBP and DNA*	*Importance of oxyanion hole for the catalytic activity*	*Instrumentation setup for diffraction studies*	*Edmund sequencing method*
S-3	SLO-1	*Interactions that stabilize secondary structures*	*Structural elucidation of p53*	*Specificity of Trypsin towards cleavage of lysine and arginine amino acid bonds*	*Phase determination*	*Array based proteomics*
	SLO-2	*Structural features of alpha helix*	*Nature of interaction between p53 and DNA*	*Specificity of Chymotrypsin and subtilisin*	*Role of Fourier transformation to overcome phase problem*	*Two hybrid system*
S-4	SLO-1	*Types of alpha helices*	*Effect of mutations in the DNA binding domain of p53*	*Domains of Immunoglobulin*	*Multi-wavelength Anomalous Diffraction experiments*	*2D gel electrophoresis*
	SLO-2	*Parallel beta-strand structure*	*Effects of mutations in the oligomerization and Nuclear localization region*	*Class-switching in Immunoglobulins*	*Recent advances in diffraction studies*	*Advantages and limitations of 2D gel electrophoresis*
S-5	SLO-1	*Anti-parallel beta-strand structure*	*Structural elucidation of leucine zipper*	*Immunoglobulin fold*	*NMR principle*	*Mass Spectrometry - Principle*
	SLO-2	*Beta turns, loops and other secondary structures*	*Interaction of leucine zipper and DNA*	*Secondary structures in hyper-variable loop region*	*Instrumentation in NMR*	*Instrumental setup in MS*
S-6	SLO-1	*Super-secondary structures*	*Structure-function correlation in actin*	*Structural orientation in antigen binding site*	*NOE & NOE-COSY*	*Ionisation by MALDI*
	SLO-2	*Difference between motiffs & domains*	*Structure-function correlation in myosin*	*Nature of interaction between antigen and antibody*	*Coupling constants*	*Ionisation by ESI & EI*
S-7	SLO-1	*Types of motiffs*	*Role of ATP in muscular contraction*	*Significance of CDR3 loop in antibody*	*Chemical Shifts*	*Time of Flight concept & peptide mass fingerprinting*
	SLO-2	*Types of domains*	*Structural elucidation of GPCR*	*Mechanism of activation of T-Cell*	*Dipolar Coupling constants*	*Tandem MS and MS/MS*

S-8	SLO-1	*Monomeric and polymeric proteins*	*Types of GPCR*	*Prediction of 3D structure from amino acid sequence*	*Isothermal Titration Calorimetry (ITC) Principle*	*SALSA algorithm*
	SLO-2	*hydrophobic collapse & theories of folding*	*Mechanism of activation of GPCR*	*Homology modelling and threading*	*Instrumentation of ITC*	*De novo algorithms*
S-9	SLO-1	*Levinthal paradox*	*Structural elucidation of Tyrosine kinase receptor*	*Enhancing binding affinity of T4 lysozyme*	*Determination enthalpy, entropy and free energy*	*Revision of entire units*
	SLO-2	*Role of chaperons and heat shock proteins*	*Interactions that activate Tyrosine kinase receptor*	*Enhancing stability in T4 lysozyme*	*Prediction of binding energy and multiple binding sites by ITC*	*Revision of entire units*

Learning Resources	*1. Brandon.C, Tooze.J, "Introduction to Protein Structure", 2nd Edition - Garland Publishing, Taylor & Francis group, 1999.* *2. Twyman. R. M, "Principles of Proteomics", Garland Scientific Publishers, 2004.* *3. Chatwal. G. R, "Instrumental methods of Chemical Analysis", Himalaya Publishing House, 5th Edition, 2011.*

Learning Assessment

	Bloom's Level of Thinking	Continuous Learning Assessment (50% weightage)								Final Examination (50% weightage)	
		CLA – 1 (10%)		CLA – 2 (15%)		CLA – 3 (15%)		CLA – 4 (10%) #			
		Theory	Practice	Theory	Practice	Theory	Practice	Theory	Practice	Theory	Practice
Level 1	Remember Understand	*20%*	*20%*	*15%*	*15%*	*15%*	*15%*	*15%*	*15%*	*15%*	*15%*
Level 2	Apply Analyze	*20%*	*20%*	*20%*	*20%*	*20%*	*20%*	*20%*	*20%*	*20%*	*20%*
Level 3	Evaluate Create	*10%*	*10%*	*15%*	*15%*	*15%*	*15%*	*15%*	*15%*	*15%*	*15%*
	Total	100 %		100 %		100 %		100 %		100 %	

CLA – 4 can be from any combination of these: Assignments, Seminars, Tech Talks, Mini-Projects, Case-Studies, Self-Study, MOOCs, Certifications, Conf. Paper etc.,

Course Designers

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Dr. Karthik Periyasamy, Aurobindo Pharma Limited, Hyderabad, karthikmpk@gmail.com	*Prof. R. B. Narayanan, SVCE, Chennai, rbn@svce.ac.in*	*Dr. Vasantha Rekha, SRMIST*

Course Code	18BTC301J	Course Name	BIOSEPARATION TECHNOLOGY	Course Category	C	Professional core	L	T	P	C
							3	0	2	4

Pre-requisite Courses	Nil	Co-requisite Courses	Nil	Progressive Courses	Nil
Course Offering Department	Biotechnology	Data Book / Codes/Standards	Nil		

Course Learning Rationale (CLR):	*The purpose of learning this course is to:*	Learning			Program Learning Outcomes (PLO)														
		1	2	3	1	2	3	4	5	6	7	8	9	10	11	12	13	14	15
CLR-1:	*Know the importance of bio separation and its recovery economically*																		
CLR-2:	*Learn the separation of product from solid –liquid phase*																		
CLR-3:	*Know the techniques of isolation of bio-products*																		
CLR-4:	*Learn the methods of purification of products*																		
CLR-5:	*Learn the methods of polishing and formulation of products for packaging*																		
CLR-6:	*Familiarize with separation, isolation, purification, polishing and formulation techniques*																		
Course Learning Outcomes (CLO):	*At the end of this course, learners will be able to:*	Level of Thinking (Bloom)	Expected Proficiency (%)	Expected Attainment (%)	Engineering Knowledge	Problem Analysis	Design & Development	Analysis, Design, Research	Modern Tool Usage	Society & Culture	Environment & Sustainability	Ethics	Individual & Team Work	Communication	Project Mgt. & Finance	Life Long Learning	PSO - 1	PSO - 2	PSO – 3
CLO-1:	*Categories the products into various sectors*	*H*	*80*	*70*	*H*	*H*	*H*	*H*	*L*				*H*	*H*	*H*	*H*	*H*	*H*	*H*
CLO-2:	*Identify the unit operation for separation*	*H*	*90*	*80*	*H*	*H*	*H*	*H*	*L*				*H*	*H*	*H*	*H*	*H*	*H*	*H*
CLO-3:	*Adapt the best methods of isolation of products*	*H*	*80*	*80*	*H*	*H*	*H*	*H*	*L*				*H*	*H*	*H*	*H*	*H*	*H*	*H*
CLO-4:	*Identify the sophisticated equipment for purification*	*H*	*80*	*80*	*H*	*H*	*H*	*H*	*L*				*H*	*H*	*H*	*H*	*H*	*H*	*H*
CLO-5:	*Know the polishing and formulation of the products*	*H*	*80*	*90*	*H*	*H*	*H*	*H*	*L*				*H*	*H*	*H*	*H*	*H*	*H*	*H*
CLO-6:	*Acquired knowledge in down streaming of Biomaterials*	*H*	*90*	*90*	*H*	*H*	*H*	*H*	*L*				*H*	*H*	*H*	*H*	*H*	*H*	*H*

Duration (hour)		15	15	15	15	15
S-1	SLO-1	*Introduction to Bio- separation process*	*Solid –Liquid Separation*	*Isolation of products*	*Purification of products*	*Product Formulation*
	SLO-2	*Importance of bioseparation in biotechnological processes*	*Biomass and particulate debris separation techniques*	*Adsorption-Chemistry of adsorption*	*Diafiltration*	*Crystallization- Basic concepts*
S-2	SLO-1	*Problems and requirements of bio-product purification*	*Flocculation-Pretreatment of broth*	*Batch Adsorption*	*Electro dialysis*	*Crystallization principles*
	SLO-2	*Different sectors of products in biotechnology*	*The electric double layer*	*Problems*	*Isoelectric focusing*	*Batch crystallizers*
S-3	SLO-1	*Engineering analysis in Bio separation- Stages of Bio separation*	*Forces Between Particles and Flocculation by Electrolytes*	*Continuous stirred tank adsorption*	*Electrophoretic separation of protein*	*Continuous crystallizers*
	SLO-2	*Basic principles of Engineering analysis*	*The Schulze–Hardy Rule Flocculation Rate Polymeric Flocculants*	*Fixed bed adsorption*	*Solving Problems*	*Solving Problems*
S-4-5	SLO-1 SLO-2	*Lab1. Cell disruption by Sonication*	*Lab 4. Separation of cells by Flocculation*	*Lab 7. Extraction of protein by aqueous two phase extraction*	*Lab 10. Detection and Estimation of Ethanol by Gas Chromatography*	*Lab 13. Crystallization of bioproducts*
S-6	SLO-1	*Process and product quality*	*Sedimentation Principles*	*Extraction*	*Chromatography principles*	*Crystallizer design*
	SLO-2	*Criteria for process development*	*Sedimentation Methods and coefficients*	*Chemistry of Extraction*	*Instruments and practice*	*Scale-up*
S-7	SLO-1	*Process Economics and Cost analysis*	*Centrifugation*	*Batch Extraction*	*Normal phase chromatography*	*Drying- principles*
	SLO-2	*Solving Problems*	*Tubular centrifuge*	*staged Extraction*	*Reversed phase chromatography,*	*Adiabatic and Conduction drying*
S-8	SLO-1	*Chemical and application range of Bioproducts*	*Disk Centrifuge*	*Differential Extraction- aqueous two phase.*	*Ion exchange chromatography*	*Dryer description and operations-Vacuum shelf dryer*
	SLO-2	*Sectors of Products*	*Ultra Centrifuge*	*Three phase Extraction Super critical Extraction*	*Gel permeation chromatography*	*Batch Vacuum rotary dryer*
S 9-10	SLO-1 SLO-2	*Lab 2. Cell disruption by Enzymatic method*	*Lab 5. Cell separation by Batch Filtration*	*Lab 8. Protein separation by Ultra filtration*	*Lab 11. Protein separation by column chromatography*	*Lab 14. Freeze drying of Biomaterial*
S-11	SLO-1	*Cell disruption methods for intracellular products*	*Filtration*	*Precipitation*	*Bio affinity chromatography*	*Freeze dryer*

	SLO-2	*Physical Cell Disruption*	*Filter Media and Equipment's*	*Precipitation by salt, Non solvents and large scale precipitation*	*Hydrophobic interaction chromatography*	*Spray dryer*
S-12	SLO-1	*Chemical and Enzymatic cell disruption*	*Theory of filtration*	*Cross flow filtration*	*Chiral chromatography*	*Conduction drying*
	SLO-2	*Solving Problems*	*Batch Filtration*	*Micro and Ultra filtration*	*Analysis of purity*	*Problems*
S-13	SLO-1	*Mechanical Cell Disruption*	*Continuous Rotary filters*	*Design of Ultra filtration*	*Scale-up in chromatography*	*Adiabatic drying*
	SLO-2	*Solving Problems*	*Solving Problems*	*Solving Problems*	*Solving Problems*	*Solving Problems*
S14-15	SLO-1 SLO-2	*Lab 3. Cell disruption by High pressure Homogenizer*	*Lab 6. Cell separation by Centrifugation*	*Lab 9. Protein Concentration by salting out method*	*Lab 12. Protein separation by Gel Electrophoresis*	*Lab 15. Drying of Bioproducts*

Learning Resources	*1. Harrison. R.G., Todd. P., Rudge S.R, Petrides. D.P, "Bioseparation Science and Engineering" Oxford University press, 2003.* *2. Belter. P.A., Cussler, E., "Bioseparations", Wiley, 1985.* *3. Nooralabettu Krishna Prasad, "Downstream Process Technology: A New Horizon In Biotechnology", PHI Learning Private Limited 2013*

Learning Assessment

	Bloom's Level of Thinking	Continuous Learning Assessment (50% weightage)								Final Examination (50% weightage)	
		CLA – 1 (10%)		CLA – 2 (15%)		CLA – 3 (15%)		CLA – 4 (10%)#			
		Theory	Practice	Theory	Practice	Theory	Practice	Theory	Practice	Theory	Practice
Level 1	Remember Understand	*20%*	*20%*	*15%*	*15%*	*15%*	*15%*	*15%*	*15%*	*15%*	*15%*
Level 2	Apply Analyze	*20%*	*20%*	*20%*	*20%*	*20%*	*20%*	*20%*	*20%*	*20%*	*20%*
Level 3	Evaluate Create	*10%*	*10%*	*15%*	*15%*	*15%*	*15%*	*15%*	*15%*	*15%*	*15%*
	Total	100 %		100 %		100 %		100 %		100 %	

CLA – 4 can be from any combination of these: Assignments, Seminars, Tech Talks, Mini-Projects, Case-Studies, Self-Study, MOOCs, Certifications, Conf. Paper etc.,

Course Designers		
Experts from Industry	Experts from Higher Technical Institutions	Internal Experts
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Dr. Karthik Periyasamy, Aurobindo Pharma Limited, Hyderabad, karthikmpk@gmail.com	*Prof. R. B. Narayanan, SVCE, Chennai, rbn@svce.ac.in*	*2 Dr. Y.Ravichandran* *SRM IST*

Course Code	18BTC350T	Course Name	COMPREHENSION	Course Category	C	Professional Core	L	T	P	C
							0	1	0	1

Pre-requisite Courses	Nil	Co-requisite Courses	Nil	Progressive Courses	Nil
Course Offering Department	Biotechnology	Data Book / Codes/Standards	Nil		

Course Learning Rationale (CLR):	*The purpose of learning this course is to:*
CLR-1 :	*Acquire skills to develop knowledge in biochemical principles*
CLR-2 :	*Acquire skills to solve real world problems in medical biotechnology*
CLR-3 :	*Acquire skills in gene manipulation and recombinant DNA technology*
CLR-4 :	*Acquire skills in enzyme technology and bioremeddiation*
CLR-5 :	*Acquire skills in bioseparation technology*
CLR-6 :	*Acquire skills to solve real world problems in the broad domain of biotechnology*

Course Learning Outcomes (CLO):	*At the end of this course, learners will be able to:*	Learning 1: Level of Thinking (Bloom)	2: Expected Proficiency (%)	3: Expected Attainment (%)	PLO 1: Engineering Knowledge	2: Problem Analysis	3: Design & Development	4: Analysis, Design, Research	5: Modern Tool Usage	6: Society & Culture	7: Environment & Sustainability	8: Ethics	9: Individual & Team Work	10: Communication	11: Project Mgt. & Finance	12: Life Long Learning	13: PSO - 1	14: PSO - 2	15: PSO - 3
CLO-1 :	*Practice and gain confidence and competence to solve problems in biochemical principles*	3	85	80	H	H	H	L	L	L	L	L	L	L	L	L	M	L	M
CLO-2 :	*Practice and gain confidence and competence to solve problems in medical biotechnology*	3	85	80	H	H	M	L	L	L	L	L	L	L	L	L	M	M	M
CLO-3 :	*Practice and gain confidence and competence to solve problems in gene manipulation and recombinant DNA technology*	3	85	80	H	H	M	L	L	L	L	L	L	L	L	L	M	L	M
CLO-4 :	*Practice and gain confidence and competence to solve problems in enzyme technology and bioremeddiation*	3	85	80	H	H	M	L	L	L	L	L	L	L	L	L	M	M	M
CLO-5 :	*Practice and gain confidence and competence to solve problems in bioseparation technology*	3	85	80	H	H	H	L	L	L	L	L	L	L	L	L	M	L	M
CLO-6 :	*Practice and gain confidence, competence to solve problems in the domain of biotechnology and competitive examinations in biotechnology*	3	85	80	H	H	M	L	L	L	L	L	L	L	L	L	M	M	M

Duration (hour)		3	3	3	3	3
S-1	SLO-1	*Tutorial on biochemistry*	*Tutorial on genetics and gene mainpulation*	*Tutorial on microbiology*	*Tutorial on bioprocess technology*	*Tutorial on bioinformatics*
	SLO-2	*Problem Solving*	*Problem Solving*	*Problem Solving*	*Problem Solving*	*Problem Solving*
S-2	SLO-1	*Tutorial on cell biology and molecular biology*	*Tutorial on immunology*	*Tutorial on plant biotechnology*	*Tutorial on medical biotechnology*	*Problem environmental biotechnology*
	SLO-2	*Problem Solving*	*Problem Solving*	*Problem Solving*	*Problem Solving*	*Problem Solving*
S-3	SLO-1	*Tutorial on bioseparation technology*	*Tutorial on pharmaceutical biotechnology*	*Tutorial on animal biotechnology*	*Tutorial on protein engineering*	*Tutorial on fermentation technology*
	SLO-2	*Problem Solving*	*Problem Solving*	*Problem Solving*	*Problem Solving*	*Problem Solving*

Learning Resources	*2. Pranav Kumar and Usha Mina,Life Sciences, Fundamentals and Practice, Pathfinder Publication, 2016*

Learning Assessment

	Bloom's Level of Thinking	Continuous Learning Assessment (100% weightage)								Final Examination	
		CLA – 1 (20%)		CLA – 2 (30%)		CLA – 3 (30%)		CLA – 4 (20%)#			
		Theory	Practice	Theory	Practice	Theory	Practice	Theory	Practice	Theory	Practice
Level 1	Remember / Understand	-	*40%*	-	*30%*	-	*30%*	-	*30%*	-	-
Level 2	Apply / Analyze	-	*40%*	-	*40%*	-	*40%*	-	*40%*	-	-
Level 3	Evaluate / Create	-	*20%*	-	*30%*	-	*30%*	-	*30%*	-	-
	Total	100 %		100 %		100 %		100 %		-	

CLA – 4 can be from any combination of these: Assignments, Seminars, Tech Talks, Mini-Projects, Case-Studies, Self-Study, MOOCs, Certifications, Conf. Paper etc.,

Course Designers		
Experts from Industry	Experts from Higher Technical Institutions	Internal Experts
1. Dr. C. N. Ramchand, Saksin Life sciences Pvt Ltd, Chennai, ramchand@saksinlife.com	*1. Prof. K Subramaniam, IITM, Chennai, subbu@iitm.ac.in*	*1. Dr.Vinoth Kumar, SRMIST*
2. Dr. Karthik Periyasamy, Aurobindo Pharma Limited, Hyderabad, karthikmpk@gmail.com	*2. Prof. R. B. Narayanan, SVCE, Chennai, rbn@svce.ac.in*	*2.Dr.Samuel Jacob, SRMIST*

ACADEMIC CURRICULA

Professional Core Courses

CHEMICAL ENGINEERING

Regulations - 2018

SRM INSTITUTE OF SCIENCE AND TECHNOLOGY

(Deemed to be University u/s 3 of UGC Act, 1956)

Kattankulathur, Kancheepuram, Tamil Nadu, India

Course Code	18CHC301T	Course Name	CHEMICAL ENGINEERING THERMODYNAMICS	Course Category	C	Professional Core	L	T	P	C
							3	0	0	3

Pre-requisite Courses	Nil	Co-requisite Courses	Nil	Progressive Courses	Nil
Course Offering Department	Chemical Engineering	Data Book / Codes/Standards	Nil		

Course Learning Rationale (CLR):	*The purpose of learning this course is to:*
CLR-1 :	*Understand the thermodynamics of mixtures and partial molar properties*
CLR-2 :	*acquire knowledge on fugacity and fugacity coefficient*
CLR-3 :	*Analyze the phase equilibrium for ideal and non-ideal mixtures*
CLR-4 :	*Acquire knowledge on fundamentals of reaction equilibrium and equilibrium constant*
CLR-5 :	*Expose to application of specific topics in phase and reaction equilibrium*
CLR-6 :	*Understand the phase and chemical reaction equilibrium*

Course Learning Outcomes (CLO):	*At the end of this course, learners will be able to:*	Learning 1: Level of Thinking (Bloom)	Learning 2: Expected Proficiency (%)	Learning 3: Expected Attainment (%)	PLO 1: Engineering Knowledge	PLO 2: Problem Analysis	PLO 3: Design & Development	PLO 4: Analysis, Design, Research	PLO 5: Modern Tool Usage	PLO 6: Society & Culture	PLO 7: Environment & Sustainability	PLO 8: Ethics	PLO 9: Individual & Team Work	PLO 10: Communication	PLO 11: Project Mgt. & Finance	PLO 12: Life Long Learning	PLO 13: PSO - 1	PLO 14: PSO - 2	PLO 15: PSO – 3
CLO-1 :	*derive the partial molar properties in a mixture*	*1*	*80*	*70*	*H*	*H*											*H*	*L*	
CLO-2 :	*Estimate the fugacity and fugacity coefficient*	*2*	*80*	*70*		*H*	*H*										*H*	*H*	*L*
CLO-3 :	*Estimate the degrees of freedom and intensive variable for phase equilibrium*	*2*	*70*	*65*		*H*	*H*										*H*	*H*	
CLO-4 :	*To find the equilibrium rate constant in a chemical reaction*	*2*	*80*	*70*	*H*	*H*	*L*										*H*	*H*	
CLO-5 :	*Comprehend the phase equilibrium and multi-reaction equilibrium*	*2*	*70*	*65*	*H*	*H*		*L*									*M*	*L*	
CLO-6 :	*Comprehend the applications of phase and reaction equilibrium*	*2*	*75*	*65*	*H*	*H*	*H*	*L*									*H*	*M*	*M*

Duration (hour)		9	9	9	9	9
S-1	SLO-1	*Review of fundamentals laws of thermodynamics and property relations.*	*Fugacity and Fugacity coefficient for pure species*	*Introduction to Phase Equilibrium*	*Introduction to Reaction Equilibrium*	*Reacting systems – Phase rule and Duhem's Theorem*
	SLO-2	*Review of fundamentals laws of thermodynamics and property relations.*	*Fugacity and Fugacity coefficient for pure species*	*Introduction to Phase Equilibrium*	*Introduction to Reaction Equilibrium*	*Reacting systems – Phase rule and Duhem's Theorem*
S-2	SLO-1	*Introduction to solution thermodynamics*	*Fugacity and Fugacity coefficient for species in solution*	*Duhem's Theorem*	*Reaction Coordinate*	*Multi reaction Equilibrium*
	SLO-2	*Introduction to solution thermodynamics*	*Fugacity and Fugacity coefficient for species in solution*	*Duhem's Theorem*	*Reaction Coordinate*	*Multi reaction Equilibrium*
S-3	SLO-1	*Partial molar properties – analytical and graphical*	*Fugacity coefficient correlations*	*VLE – qualitative behavior*	*Criteria for Reaction Equilibrium*	*Multi reaction Equilibrium*
	SLO-2	*Partial molar properties – analytical and graphical*	*Fugacity coefficient correlations*	*VLE – qualitative behavior*	*Criteria for Reaction Equilibrium*	*Multi reaction Equilibrium*
S-4	SLO-1	*Partial molar properties – analytical and graphical*	*Problem solving in fugacity evaluation*	*Simple models of Vapour Liquid Equilibrium*	*Standard Gibbs's Energy change and Equilibrium Constant*	*Applications of Phase Equilibrium*
	SLO-2	*Partial molar properties – analytical and graphical*	*Problem solving in fugacity evaluation*	*Simple models of Vapour Liquid Equilibrium*	*Standard Gibbs's Energy change and Equilibrium Constant*	*Applications of Phase Equilibrium*
S-5	SLO-1	*Problem solving in PMM*	*Ideal Solution Model*	*Problem solving on simple VLE*	*Effect of Temperature on Equilibrium Constant*	*Gamma/Phi formulation of VLE*
	SLO-2	*Problem solving in PMM*	*Ideal Solution Model*	*Problem solving on simple VLE*	*Effect of Temperature on Equilibrium Constant*	*Gamma/Phi formulation of VLE*
S-6	SLO-1	*Chemical potential and applications*	*Ideal Solution Model*	*Vapour Liquid Equilibrium with modified Raoult's Law*	*Evaluation of Equilibrium Constants*	*VLE from cubic equations of state*
	SLO-2	*Chemical potential and applications*	*Ideal Solution Model*	*Vapour Liquid Equilibrium with modified Raoult's Law*	*Evaluation of Equilibrium Constants*	*VLE from cubic equations of state*

S-7	SLO-1	*Ideal-gas mixture model*	*Lewis-Randall Rule*	*VLE from K-values*	*Equilibrium Conversions for single reactions*	*VLE from cubic equations of state*
	SLO-2	*Ideal-gas mixture model*	*Lewis-Randall Rule*	*VLE from K-values*	*Equilibrium Conversions for single reactions*	*VLE from cubic equations of state*
S-8	SLO-1	*Ideal-gas mixture model*	*Excess properties*	*Flash Calculations*	*Problem solving on reaction equilibrium*	*Equilibrium and Stability*
	SLO-2	*Ideal-gas mixture model*	*Excess properties*	*Flash Calculations*	*Problem solving on reaction equilibrium*	*Equilibrium and Stability*
S-9	SLO-1	*Problem solving with ideal gas mixture model*	*Excess Gibbs Energy and Activity coefficient*	*Problem solving*	*Problem solving on reaction equilibrium*	*Applications of Phase Equilibrium*
	SLO-2	*Problem solving with ideal gas mixture model*	*Excess Gibbs Energy and Activity coefficient*	*Problem solving*	*Problem solving on reaction equilibrium*	*Applications of Phase Equilibrium*

Learning Resources	*1. Smith. J.M., Van Ness. H.C, and Abbott, M.M., "Introduction to Chemical Engineering Thermodynamics", 7th Edition. McGraw Hill International Edition, 2005.* *2. Rao .Y.V.C, "Chemical Engineering Thermodynamics", University Press (I) Ltd., Hyderabad, 1997.* *3. Sandler. S "Chemical, Biochemical and Engineering Thermodynamics", 4th Edition, Wiley India, 2006.*

SLO – Session Learning Outcome

Learning Assessment

	Bloom's Level of Thinking	Continuous Learning Assessment (50% weightage)								Final Examination (50% weightage)	
		CLA – 1 (10%)		CLA – 2 (15%)		CLA – 3 (15%)		CLA – 4 (10%)#			
		Theory	Practice	Theory	Practice	Theory	Practice	Theory	Practice	Theory	Practice
Level 1	Remember Understand	*40 %*	-	*30 %*	-	*30 %*	-	*30 %*	-	*30%*	-
Level 2	Apply Analyze	*40 %*	-	*40 %*	-	*40 %*	-	*40 %*	-	*40%*	-
Level 3	Evaluate Create	*20 %*	-	*30 %*	-	*30 %*	-	*30 %*	-	*30%*	-
	Total	100 %		100 %		100 %		100 %		100 %	

CLA – 4 can be from any combination of these: Assignments, Seminars, Tech Talks, Mini-Projects, Case-Studies, Self-Study, MOOCs, Certifications, Conf. Paper etc.,

Course Designers

Experts from Industry	Experts from Higher Technical Institutions	Internal Experts
1. Mr. A. Subramaniam, PESCO Beam Environmental Solutions Pvt. Ltd.,	*1. Dr. Lima Rose Miranda, Anna University, email: limamiranda2007@gmail.com*	*1 Dr. S. Sam David* *SRM Inst. of Science & Technology,* *samdavis@srmist.edu.in*
2. Mr. S. T. Kalaimani, CPCL, Chennai	*2. Dr. T. R. Sundararaman, Rajalakshmi Engineering College*	*2 Mr. V. Ganesh* *SRM Inst. of Science & Technology,* *ganesv@srmist.edu.in*

Course Code	18CHC302T	Course Name	CHEMICAL REACTION ENGINEERING	Course Category	C	Professional core	L	T	P	C
							3	0	0	3

Pre-requisite Courses	Nil	Co-requisite Courses	Nil	Progressive Courses	Nil
Course Offering Department	Chemical Engineering	Data Book / Codes/Standards	Nil		

Course Learning Rationale (CLR):	*The purpose of learning this course is to:*
CLR-1 :	*Understand the classifications and kinetics of chemical reactions*
CLR-2 :	*acquire knowledge on design aspects of ideal reactors*
CLR-3 :	*Comprehend size comparison of reactors for single reactions and apprehend performance of multiple reactor system*
CLR-4 :	*Familiarize product distribution and contacting patterns for multiple reactions*
CLR-5 :	*Expose to the concept of thermodynamic aspects of chemical reactions*
CLR-6 :	*understand the kinetics of chemical reaction, design aspects of reactors, multiple reaction kinetics and thermodynamics of reactions*

Course Learning Outcomes (CLO):	*At the end of this course, learners will be able to:*	Learning 1: Level of Thinking (Bloom)	Learning 2: Expected Proficiency (%)	Learning 3: Expected Attainment (%)
CLO-1 :	*derive the rate equations and calculating kinetic parameters for various types of reactions*	*1*	*80*	*70*
CLO-2 :	*derive performance equations and understand design aspects of ideal reactors*	*2*	*80*	*70*
CLO-3 :	*compare the performance of single reactors and understand multiple reactors system*	*2*	*70*	*65*
CLO-4 :	*identify the favorable conditions and suitable contacting patterns for multiple reactions*	*2*	*80*	*70*
CLO-5 :	*realize the effect of temperature and pressure on chemical reactions*	*2*	*70*	*65*
CLO-6 :	*calculate kinetic parameters, reactor design variables, multiple reactor performance, multiple reaction kinetics and thermodynamic parameters*	*2*	*80*	*70*

Program Learning Outcomes (PLO)	1 Engineering Knowledge	2 Problem Analysis	3 Design & Development	4 Analysis, Design, Research	5 Modern Tool Usage	6 Society & Culture	7 Environment & Sustainability	8 Ethics	9 Individual & Team Work	10 Communication	11 Project Mgt. & Finance	12 Life Long Learning	13 PSO - 1	14 PSO - 2	15 PSO – 3
CLO-1	*H*	*H*											*H*	*L*	
CLO-2		*H*	*H*										*H*	*H*	*L*
CLO-3		*H*	*H*										*H*	*H*	
CLO-4	*H*	*H*	*L*										*H*	*H*	
CLO-5	*H*	*H*		*L*									*M*	*L*	
CLO-6	*H*	*H*	*L*	*L*									*H*	*H*	*L*

Duration (hour)		9	9	9	9	9
S-1	SLO-1	*Classification of chemical reactions and variables affecting the reaction rate*	*Integrated rate expressions for first order reaction for varying volume systems*	*problems based on plug flow reactor*	*Problems based on reactors of different types in series*	*Favorable contacting patterns for irreversible reaction in series*
	SLO-2	*Rate equation, concentration and temperature dependency of rate equation*	*Integrated rate expressions for zero order reaction for varying volume systems*	*problems based on plug flow reactor*	*Concept of recycle ratio and its relation to flow conditions*	*Series reaction: Quantitative Treatment in Plug Flow or Batch Reactor; derivation of optimum time and maximum concentration of desired product*
S-2	SLO-1	*Concept of constant volume batch reactor and fractional conversion*	*Problems based on varying volume system*	*Relationship between Holding Time and Space Time for Flow Reactors*	*Derivation of performance equation for recycle reactor*	*Quantitative Treatment, Mixed Flow Reactor*
	SLO-2	*Analysis of total pressure data obtained in a constant-volume System*	*Problems based on varying volume system*	*Space time and space velocity calculations*	*Recycle reactor problems*	*Problems based on series reactions*
S-3	SLO-1	*Method of Analysis of kinetic data*	*General aspects of reactor design*	*necessity for size comparison of reactors*	*objectives for analyzing multiple reactions*	*Heats of Reaction from Thermodynamics*
	SLO-2	*Method of Analysis of kinetic data*	*Broad classification of reactor types and applications*	*Comparison of performance of single mixed flow and plug flow reactors for the n^{th} order reactions*	*Qualitative discussion about product distribution in parallel reactions*	*Relation between heats of reaction and temperature*
S-4	SLO-1	*Integrated rate expressions for first order, second order and zero order reactions*	*Characteristics of three types of ideal reactors*	*Plug flow reactors in series and parallel*	*Contacting patterns for parallel reactions in non continuous operations*	*Equilibrium constants from thermodynamics*
	SLO-2	*Integrated rate expressions for first order, second order and zero order reactions*	*Material balance equation for a system with reaction*	*problems based on PFR in series and parallel*	*Contacting patterns for parallel reactions in continuous flow operations*	*Effect of temperature on equilibrium conversion*
S-5	SLO-1	*Problems based on kinetic datas*	*Derivation of performance equation for batch reactor*	*quantitatively evaluating the behavior of a series of 'N' equal-size mixed flow reactors for first order reaction*	*Quantitative Treatment of Product Distribution in parallel reactions*	*Problems based on heat of reaction and equilibrium conversion*
	SLO-2	*Problems based on kinetic datas*	*problems based on batch reactor*	*Effect of number of reactors on the performance*	*Concept of fractional yield and selectivity for parallel reactions*	*Problems based on heat of reaction and equilibrium conversion*
S-6	SLO-1	*Rate expression for First-Order Reversible Reactions*	*problems based on batch reactor*	*Mixed Flow Reactors of Different Sizes in Series – procedure for finding the outlet composition*	*Problems based on parallel reactions*	*General graphical design procedure for reactors*

	SLO-2	*Rate expression for First-Order Reversible Reactions*	*Space time and space velocity concept*	*Problems based on MFR in series*	*Problems based on parallel reactions*	*Optimum Temperature Progression; Operating lines for minimum reactor size.*
S-7	SLO-1	*Empirical Rate Equations of n^{th} Order reactions and calculation of time of complete conversion*	*Derivation of performance equation for mixed flow reactor (MFR)*	*Problems based on MFR in series*	*Problems based on parallel reactions*	*Fractional conversion in adiabatic operations*
	SLO-2	*Empirical Rate Equations of n^{th} Order reactions and calculation of time of complete conversion*	*problems based on mixed flow reactor*	*Problems based on MFR in series*	*Problems based on parallel reactions*	*Fractional conversion in adiabatic operations*
S-8	SLO-1	*Determination of overall order of irreversible reactions from the half – life data*	*problems based on mixed flow reactor*	*Determining the Best System for a Given Conversion using Maximization of Rectangles principle*	*Irreversible first order reaction in series and its rate equation*	*Fractional conversion in Non - adiabatic operations*
	SLO-2	*Problems based on constant volume system*	*nature and conditions for plug flow*	*Reactors of Different Types in Series; Conditions for best arrangement of a Set of Ideal reactors*	*Qualitative Discussion About Product Distribution for series reaction*	*Graphical representation of energy balance equation for adiabatic operation*
S-9	SLO-1	*Problems based on constant volume system*	*Derivation of performance equation for plug flow reactor (PFR)*	*Problems based on reactors of different types in series*	*Qualitative Discussion About Product Distribution for series reaction*	*Problem based on kinetic data for reversible reaction*
	SLO-2	*Introduction to varying volume batch reactor and expansion factor calculation*	*problems based on plug flow reactor*	*Problems based on reactors of different types in series*	*rule governing favorable product distribution for reactions in series*	*Problem based on kinetic data for reversible reaction*

Learning Resources	*1. Octave Levenspiel, "Chemical Reaction Engineering", 3rd edition, John Wiley & Sons, 2011.* *2. H. Scott Fogler, "Elements of Chemical Reaction Engineering", 4th edition, Prentice Hall PTR, 2006.* *3. J. M. Smith, "Chemical Engineering Kinetics", 3rd edition, McGraw Hill International editions, New Delhi, 1981.*

Learning Assessment

	Bloom's Level of Thinking	Continuous Learning Assessment (50% weightage)								Final Examination (50% weightage)	
		CLA – 1 (10%)		CLA – 2 (15%)		CLA – 3 (15%)		CLA – 4 (10%)#			
		Theory	Practice	Theory	Practice	Theory	Practice	Theory	Practice	Theory	Practice
Level 1	Remember Understand	*40 %*	-	*30 %*	-	*30 %*	-	*30 %*	-	*30%*	-
Level 2	Apply Analyze	*40 %*	-	*40 %*	-	*40 %*	-	*40 %*	-	*40%*	-
Level 3	Evaluate Create	*20 %*	-	*30 %*	-	*30 %*	-	*30 %*	-	*30%*	-
	Total	100 %		100 %		100 %		100 %		100 %	

CLA – 4 can be from any combination of these: Assignments, Seminars, Tech Talks, Mini-Projects, Case-Studies, Self-Study, MOOCs, Certifications, Conf. Paper etc.,

Course Designers

Experts from Industry	Experts from Higher Technical Institutions	Internal Experts
1. Mr. A. Subramaniam, PESCO Beam Environmental Solutions Pvt. Ltd.,	*1. Dr. Lima Rose Miranda, Anna University, email: limamiranda2007@gmail.com*	*1. Dr. M. Magesh Kumar* *SRM Inst. of Science & Technology,* *mageshkm@srmist.edu.in*
2. Mr. S. T. Kalaimani, CPCL, Chennai	*2. Dr. T. R. Sundararaman, Rajalakshmi Engineering College*	*2.Mr. V. Ganesh* *SRM Inst. of Science & Technology,* *ganeshv@srmist.edu.in*

Course Code	18CHC303T	Course Name	MASS TRANSFER APPLICATIONS	Course Category	C	Professional Core	L	T	P	C
							3	0	0	3

Pre-requisite Courses	Nil	Co-requisite Courses	Nil	Progressive Courses	Nil
Course Offering Department	Chemical Engineering	Data Book / Codes/Standards	NIL		

Course Learning Rationale (CLR):	*The purpose of learning this course is to:*	Learning			Program Learning Outcomes (PLO)														
		1	2	3	1	2	3	4	5	6	7	8	9	10	11	12	13	14	15
CLR-1 :	*Understand the basic principles of distillation, methods and types of distillation.*																		
CLR-2 :	*Gain knowledge on the design methods of distillation column.*																		
CLR-3 :	*Analyze the difference between liquid – liquid extraction and leaching.*																		
CLR-4 :	*Have an insight on mechanism of adsorption and crystallization.*																		
CLR-5 :	*Understand the difference between MF,UF,NF and RO.*																		
CLR-6:	*Gain knowledge on the mass transfer process principles*																		
Course Learning Outcomes (CLO):	*At the end of this course, learners will be able to:*	Level of Thinking (Bloom)	Expected Proficiency (%)	Expected Attainment (%)	Engineering Knowledge	Problem Analysis	Design & Development	Analysis, Design, Research	Modern Tool Usage	Society & Culture	Environment & Sustainability	Ethics	Individual & Team Work	Communication	Project Mgt. & Finance	Life Long Learning	PSO - 1	PSO - 2	PSO – 3
CLO-1 :	*Calculate product rates and composition based on batch and flash distillation.*	*2*	*80*	*75*	*H*	*H*	*H*	*H*									*H*	*H*	
CLO-2 :	*Apply McCabe Thiele method and determine number of stages in a distillation column.*	*2*	*80*	*75*	*H*	*H*	*H*	*H*									*H*	*H*	*M*
CLO-3 :	*Calculate percentage recovery of solute and number of stages for liquid – liquid extraction operation.*	*2*	*80*	*70*	*H*	*H*	*H*	*H*									*H*	*H*	
CLO-4 :	*Select adsorbents for appropriate applications.*	*2*	*80*	*75*	*H*	*H*	*H*	*H*									*H*	*H*	
CLO-5 :	*Analyze and apply appropriate membrane separation operation.*	*2*	*80*	*75*	*H*	*H*	*H*	*H*									*H*	*H*	
CLO-6:	*Express the knowledge of mass transfer and its applications*	*2*	*80*	*75*	*H*	*H*	*H*	*H*									*H*	*H*	*M*

Duration (hour)		9	9	9	9	9
S-1	SLO-1	*Introduction to Distillation*	*Design of distillation column - McCabe-Thiele method, Assumptions*	*Introduction to liquid – liquid extraction, General principles of extraction*	*Introduction to adsorption*	*Introduction to membrane separation processes*
	SLO-2	*Principle, Relative Volatility*	*Enriching section operating line*	*Choice of solvent*	*Characteristics of adsorbents*	
S-2	SLO-1	*Equilibrium Curve*	*Stripping section operating line*	*Working principle of extraction equipments: mixer-settlers*	*Commercial adsorbents, preparation*	*Classification of membrane separation processes*
	SLO-2	*Methods of Distillation: without reflux and with reflux, Types of distillation*	*q line*	*Packed tower extractors*	*Application, regeneration*	
S-3	SLO-1	*Flash Distillation*	*Feed conditions*	*Agitated tower extractors*	*Langmuir Adsorption isotherms*	*Membrane modules*
	SLO-2	*Equation of operating line*	*Condensor and reboiler duty*	*Pulsed column extractors.*	*Freundlich Adsorption isotherms*	
S-4	SLO-1	*Problem Solving*	*Reflux ratio, total reflux, minimum reflux and optimum reflux*	*Percentage extraction calculation for single stage operations when liquids are insoluble.*	*Fixed bed adsorbers.*	*Microfiltration and its applications*
	SLO-2	*Problem Solving*	*Fenske's equation*	*Percentage extraction calculation for multistage crosscurrent operations when liquids are insoluble.*		
S-5	SLO-1	*Simple batch Distillation*	*Problem Solving*	*Minimum solvent rate for counter current operations.*	*Introduction to crystallization*	*ultra filtration and its applications*
	SLO-2	*Rayleigh's equation*	*Problem Solving*	*Number of theoretical stages for continuous countercurrent, multistage extraction operation when liquids are insoluble.*	*Yield concept, methods of super saturation. Nucleation and Crystal growth.*	
S-6	SLO-1	*Problem Solving*	*Problem Solving*	*Problem Solving*	*Continuous vacuum crystallizer, construction, working and applications.*	*Nano filtration and its applications*
	SLO-2	*Problem Solving*	*Problem Solving*	*Problem Solving*		
S-7	SLO-1	*Steam Distillation*	*Introduction to Ponchon -Savarit method*	*Problem Solving*	*Draft tube-baffle crystallizer, construction, working and applications.*	*Osmosis – Reverse Osmosis and its applications*
	SLO-2	*Conditions, Applications*		*Problem Solving*		
S-8	SLO-1	*Vacuum Distillation*	*Azeotropic distillation*	*Problem Solving*	*Swenson-walker crystallizer, construction, working and applications.*	*Dialysis - Electro Dialysis and its applications*
	SLO-2	*Conditions, Applications*	*Selection of Entrainer and solvent*	*Problem Solving*		

S-9	SLO-1	*Continuous distillation*	*Extractive distillation*	*Introduction to Leaching, factors affecting leaching.*	*Material and Energy balance calculations in batch crystallizers*	*Ion Exchange principles, types and its applications*
	SLO-2	*Working of a continuous distillation column*	*Comparison of Azeotropic Distillation and Extractive Distillation*	*Bollman extractor*		

Learning Resources	1. *Robert E. Treybal, "Mass-Transfer Operations", 3rd Edn., McGraw Hill Education (India) Edition, 2012* 2. *Warren L. McCabe, Julian C. Smith and Peter Harriott, "Unit Operations of Chemical Engineering", 7th Edn., McGraw Hill Education (India) Edition, 2014 .* 3. *Christie John Geankoplis, "Transport Processes and Separation Process Principles (Includes Unit Operations)", 4thEdn., Pearson India Education Services Pvt. Ltd., 2015* 4. *Binay K. Dutta, "Principles of Mass transfer and Separation Processes", Prentice- Hall of India, New Delhi, 2007.*

Learning Assessment

	Bloom's Level of Thinking	Continuous Learning Assessment (50% weightage)								Final Examination (50% weightage)	
		CLA – 1 (10%)		CLA – 2 (15%)		CLA – 3 (15%)		CLA – 4 (10%)#			
		Theory	Practice	Theory	Practice	Theory	Practice	Theory	Practice	Theory	Practice
Level 1	Remember / Understand	*40 %*	-	*30 %*	-	*30 %*	-	*30 %*	-	*30%*	-
Level 2	Apply / Analyze	*40 %*	-	*40 %*	-	*40 %*	-	*40 %*	-	*40%*	-
Level 3	Evaluate / Create	*20 %*	-	*30 %*	-	*30 %*	-	*30 %*	-	*30%*	-
	Total	100 %		100 %		100 %		100 %		100 %	

CLA – 4 can be from any combination of these: Assignments, Seminars, Tech Talks, Mini-Projects, Case-Studies, Self-Study, MOOCs, Certifications, Conf. Paper etc.,

Course Designers

Experts from Industry	Experts from Higher Technical Institutions	Internal Experts
1. Mr. A. Subramaniam, PESCO Beam Environmental Solutions Pvt. Ltd.,	*1. Dr. Lima Rose Miranda, Anna University, email: limamiranda2007@gmail.com*	*1 Ms.E.POONGUZHALI* *SRM Inst. of Science & Technology,* *poonguze@srmist.edu.in*
2. Mr. S. T. Kalaimani, CPCL, Chennai	*2. Dr. T. R. Sundararaman, Rajalakshmi Engineering College*	*2 .Dr. K.SOFIYA* *SRM Inst. of Science & Technology,* *sofiyak@ srmist.edu.in*

Course Code	18CHC304T	Course Name	CHEMICAL PROCESS TECHNOLOGY	Course Category	C	Professional Course	L	T	P	C
							4	0	0	4

Pre-requisite Courses	Nil	Co-requisite Courses	Nil	Progressive Courses	Nil
Course Offering Department	Chemical Engineering	Data Book / Codes/Standards	Nil		

Course Learning Rationale (CLR):	*The purpose of learning this course is to:*
CLR-1 :	*Provide an overview of the essential features of chemical process industries*
CLR-2 :	*Expose the leaners to read and abstract the process flow diagrams*
CLR-3 :	*Enable the leaners to apply the concept of upstream and downstream processes associated in industrial production processes*
CLR-4 :	*Familiarize the sequence of unit operations and unit processes in converting a raw material into consumer products*
CLR-5 :	*Understand the various raw materials, processing methods and the applications of end products.*
CLR-6 :	*Outline the general principles applied in studying a chemical process industry in which the process industries start with an ore or other raw material and end up with a product of useful to consumers through series of chemical and physical changes*

Course Learning Outcomes (CLO):	*At the end of this course, learners will be able to:*	Learning 1: Level of Thinking (Bloom)	Learning 2: Expected Proficiency (%)	Learning 3: Expected Attainment (%)	PLO 1: Engineering Knowledge	PLO 2: Problem Analysis	PLO 3: Design & Development	PLO 4: Analysis, Design, Research	PLO 5: Modern Tool Usage	PLO 6: Society & Culture	PLO 7: Environment & Sustainability	PLO 8: Ethics	PLO 9: Individual & Team Work	PLO 10: Communication	PLO 11: Project Mgt. & Finance	PLO 12: Life Long Learning	PLO 13: PSO - 1	PLO 14: PSO - 2	PLO 15: PSO – 3
CLO-1 :	*Realize the role of chemical engineers in process industries*	*1*	*80*	*75*	*M*								*H*	*L*			*M*	*L*	*M*
CLO-2 :	*Represent the process of conversion of raw material into useful products through process flow diagram*	*2*	*80*	*70*	*H*											*H*	*H*	*L*	*M*
CLO-3 :	*Recognize the significance of unit operations and unit processes*	*1*	*80*	*75*	*H*	*L*	*L*										*L*	*L*	*L*
CLO-4 :	*Apply the general principles, read, analyze, abstract and draw the process flow diagrams*	*3*	*80*	*70*	*H*	*L*	*L*										*M*	*L*	*L*
CLO-5 :	*Understand the big picture of chemical industries and the operations carried out in it*	*1*	*80*	*75*	*H*								*H*				*H*	*L*	*M*
CLO-6 :	*Appreciate the importance of chemical engineers role in diverse chemical industries*	*1*	*80*	*75*	*M*	*L*	*L*						*H*	*M*		*L*	*H*	*L*	*M*

Duration (hour)		12	12	12	12	12
S-1	SLO-1	*Overview of chemical industry – Global and Indian Scenario*	*Overview of fertilizer manufacturing sectors in India*	*Introduction to natural products industries*	*Overview of the petroleum refineries and its products*	*Introduction to polymer industries*
	SLO-2	*Overview of chemical industry – Global and Indian Scenario*	*Overview of fertilizer manufacturing sectors in India*	*Edible and essential oils*	*Overview of the petroleum refineries and its products*	*Monomers and polymers*
S-2	SLO-1	*Description of block and process flow diagrams in chemicals production*	*Introduction to commercial methods available to produce ammonia and its applications*	*Process description of edible oil extraction*	*Flow sheet of refinery operations*	*Thermosetting and Thermoplastic polymers*
	SLO-2	*Description of block and process flow diagrams in chemicals production*	*Manufacture of synthetic ammonia*	*Process description for extraction and purification of edible oil*	*Pyrolysis, Cracking, Reforming*	*Thermosetting and Thermoplastic polymers*
S-3	SLO-1	*Unit operations involved in chemicals production*	*Nitric acid – commercial methods available to produce nitric acid and its applications*	*Process description for the hydrogenation of edible oil to produce vanaspathi*	*Overview of synthetic organic chemicals*	*Polymerization and various types of polymerization*
	SLO-2	*Unit processes involved in chemicals production*	*Manufacture of nitric acid*	*Process description for the hydrogenation of vegetable oil to produce vanaspathi*	*Overview of synthetic organic chemicals*	*Polymerization and various types of polymerization*
S-4	SLO-1	*Introduction to inorganic chemicals – Chlor-alkali industries*	*Urea - commercial methods available to produce urea and its applications*	*Outline of soaps, detergents and glycerin*	*Introduction to Methane and synthesis gas*	*Polymers and their engineering applications*
	SLO-2	*Applications of different products from Chlor- alkali industries*	*Manufacture of urea*	*Manufacture of soaps and glycerin*	*Steam reforming for synthesis gas*	*Polymers and their engineering applications*
S-5	SLO-1	*Different processes involved in the manufacture of soda ash*	*Overview of phosphorus industries*	*Short notes on detergents*	*Manufacture of Ethylene, acetylene and propylene*	*Polyethylene and its uses*
	SLO-2	*Manufacture of soda ash by Solvay process*	*Phosphate rock and the products from phosphate rock*	*Summary of edible oil, soaps, and detergents*	*Properties and end uses of*	*Manufacture of polyethylene*
S-6	SLO-1	*Processes involved in the manufacturechlorine and caustic soda*	*Manufacture of ammonium phosphate*	*Introduction to pulp and paper industries*	*Manufacture of aromatic compounds BTX*	*Polypropylene and its applications*
	SLO-2	*Manufacture of Chlorine and caustic soda by electrolysis process*	*End uses of ammonium phosphates*	*Introduction to pulp and paper industries*	*Overview of the BTX and their applications*	*Manufacture of polypropylene*

S-7	SLO-1	Mining of sulfur: Frasch Process	Manufacture of diammonium phosphate	Preparation of wood pulp by sulfate (kraft) process	Production of aromatic chemicals - Benzene, toluene, xylene.	Manufacture of Phenol Formaldehyde
	SLO-2	Applications of Sulfur	End uses of diammonium phosphates	Manufacture of Pulp and Paper from Kraft process	Production of aromatic chemicals - Benzene, toluene, xylene.	Overview of polyamides and polyesters
S-8	SLO-1	Introduction to sulfuric acid	Superphosphate and its applications	Chemical recovery from black liquor	Overview of synthetic, intermediate and end chemicals	Manufacture of Polyamides (Nylon 66)
	SLO-2	Various processes involved in sulfuric acid production	Manufacture of Super phosphate	Paper formation in Paper machine section of pulp and paper industry	Overview of synthetic, intermediate and end chemicals	Uses of Nylon 66
S-9	SLO-1	Manufacture of sulfuric acid	Triple super phosphate and its applications	Summary of pulp and paper production	Methanol and its uses	Manufacture of Polyester
	SLO-2	Manufacture of sulfuric acid	Manufacture of Triple super phosphate	Summary of pulp and paper production	Manufacture of Methanol	Uses of polyester
S-10	SLO-1	Introduction to silicate industries	Introduction to Potassium chloride industries	Overview of sugar production	Manufacture of Formaldehyde	Manufacture of Viscose rayon
	SLO-2	Ceramics and Glass products from silicate industries	Introduction to Potassium chloride industries	Manufacture of sugar from cane sugar	Formaldehyde and its uses	End uses of viscose rayon
S-11	SLO-1	Overview of cement and cement industries	Potassium chloride and its uses	Maize and its application	Ethylene dichloride and its applications	About natural and synthetic rubber
	SLO-2	Ore beneficiation for cement industries	Manufacture of potassium chloride	Manufacture of maize	Manufacture of ethylene dichloride	Processes for the production of SBR
S-12	SLO-1	Manufacture of Portland cement	Potassium sulphate and its uses	Summary of edible oil, soaps, pulp and paper and	Manufacture of vinyl chloride	Summary of all the manufacturing processes studied in the course
	SLO-2	Manufacture of Portland cement	Manufacture of potassium chloride	Summary of edible oil, soaps, pulp and paper and	Applications of vinyl chloride	Summary of all the manufacturing processes studied in the course

Learning Resources	1. GopalaRao. M. and Marshall Sittig, "Dryden's Outlines of Chemical Technology", 3rd Edn., East- West Press, New Delhi, 2008 2. George .T Austin, "Shreve's Chemical Process Industries", 5th Edn., 5th Reprint, McGraw-Hill International Editions, Singapore, 2015 3. Kirck-Othmer, Encyclopedia of Chemical Technology,27 Volume set, John Wiley, 2004. 4. Jacob A. Moulijn, MichielMakkee, Annelies E. van Diepen, "Chemical Process Technology", 2nd Edition, John Wiley, 2013

Learning Assessment

	Bloom's Level of Thinking	Continuous Learning Assessment (50% weightage)								Final Examination (50% weightage)	
		CLA – 1 (10%)		CLA – 2 (15%)		CLA – 3 (15%)		CLA – 4 (10%)#			
		Theory	Practice	Theory	Practice	Theory	Practice	Theory	Practice	Theory	Practice
Level 1	Remember Understand	40 %	-	30 %	-	30 %	-	30 %	-	30%	-
Level 2	Apply Analyze	40 %	-	40 %	-	40 %	-	40 %	-	40%	-
Level 3	Evaluate Create	20 %	-	30 %	-	30 %	-	30 %	-	30%	-
	Total	100 %		100 %		100 %		100 %		100 %	

CLA – 4 can be from any combination of these: Assignments, Seminars, Tech Talks, Mini-Projects, Case-Studies, Self-Study, MOOCs, Certifications, Conf. Paper etc.,

Course Designers

Experts from Industry	Experts from Higher Technical Institutions	Internal Experts
1. Mr. A. Subramaniam, PESCO Beam Environmental Solutions Pvt. Ltd.,	1. Dr. Lima Rose Miranda, Anna University, email: limamiranda2007@gmail.com	1 Dr. S. Balasubramanian SRM Inst. of Science & Technology, balasubs@srmist.edu.in
2. Mr. S. T. Kalaimani, CPCL, Chennai	2. Dr. T. R. Sundararaman, Rajalakshmi Engineering College	2 Mr. K. Selvam SRM Inst. of Science & Technology, selvamk@srmist.edu.in

Course Code	18CHC305L	Course Name	CHEMICAL ENGINEERING LAB II	Course Category	C	Professional Core	L	T	P	C
							0	0	4	2

Pre-requisite Courses	Nil	Co-requisite Courses	Nil	Progressive Courses	Nil
Course Offering Department	Chemical Engineering	Data Book / Codes/Standards	Heat and mass transfer data book		

Course Learning Rationale (CLR):	*The purpose of learning this course is to:*
CLR-1 :	*Provide the students the first hand experience of verifying various theoretical concepts learnt in heat and mass transfer. To Understand heat transfer mechanism, and determine thermal conductivity.*
CLR-2 :	*Determine the heat transfer coefficient in natural and forced convection. Design the double pipe and shell and tube heat exchanger. Determine the effectiveness of the heat exchanger.*
CLR-3 :	*Determine the Stefan-Boltzmann law constant and emissivity of a real surface (gray surface).*
CLR-4 :	*Verify the Rayleigh's equation in simple bath distillation. Determine the vapour efficiency for steam distillation. Determine the VLE data*
CLR-5 :	*Study the drying characteristics. Determine the recovery of solute by simple leaching process. Verify the Freundlich Adsorption isotherm.*
CLR-6 :	*Understand the Equilateral triangular diagram for three component system.*

Course Learning Outcomes (CLO):	*At the end of this course, learners will be able to:*	Learning 1 Level of Thinking (Bloom)	2 Expected Proficiency (%)	3 Expected Attainment (%)	PLO 1 Engineering Knowledge	2 Problem Analysis	3 Design & Development	4 Analysis, Design, Research	5 Modern Tool Usage	6 Society & Culture	7 Environment & Sustainability	8 Ethics	9 Individual & Team Work	10 Communication	11 Project Mgt. & Finance	12 Life Long Learning	13 PSO - 1	14 PSO - 2	15 PSO – 3
CLO-1 :	*Determine thermal conductivity of a material.*	2	80	75	H	H	M	M									H	H	L
CLO-2 :	*Determine the heat transfer coefficient for natural and forced convection. Determine the effectiveness of a heat exchanger*	2	80	75	H	H	M	M									H	H	L
CLO-3 :	*Determine the Stefan-Boltzmann law constant and emissivity*	2	80	75	H	H	M	M									H	H	L
CLO-4 :	*Verify the Rayleigh's equation. Determine the vapour efficiency*	2	80	75	H	H	M	M									H	H	L
CLO-5 :	*Determine the recovery of solute by leaching. Verify the adsorption isotherm*	2	80	75	H	H	M	M									H	H	L
CLO-6 :	*Draw the equilateral triangular diagram for three component system.*	2	80	75	H	H	M	M									H	H	L

Duration (hour)		12	12	12	12	12
S 1-4	SLO-1	*Introduction to all the experiments*	*Heat transfer by natural convection*	*Determination of emissivity*	*Drying characteristics*	*Verification of Freundlich Adsorption isotherm*
	SLO-2					
S 5-8	SLO-1	*Heat transfer through Composite lagged pipe*	*Shell and tube heat exchanger*	*Stefan-Boltzmann apparatus*	*Estimation of percentage recovery of solute for single stage leaching*	*Phase diagram for three component system*
	SLO-2					
S 9-12	SLO-1	*Heat transfer by forced convection*	*Parallel flow and counter current flow Heat exchanger*	*Verification of Rayleigh equation for simple batch distillation*	*Estimation of percentage recovery of solute for multi stage leaching*	*Determination of vapor efficiency for simple steam distillation*
	SLO-2					

Learning Resources	
	1. *Warren L. McCabe, Julian C. Smith and Peter Harriott, "Unit Operations of Chemical Engineering", 7th Edn., McGraw Hill Education (India) Edition, 2014* 2. *Robert E. Treybal," Mass-Transfer Operations", 3rd Edn., McGraw Hill Education (India) Edition, 2012* 3. *Binay K Dutta, "Heat Transfer: Principles and Applications", PHI Publishers, Delhi,2010* 4. *Laboratory Manual*

Learning Assessment											
	Bloom's Level of Thinking	Continuous Learning Assessment (50% weightage)								Final Examination (50% weightage)	
		CLA – 1 (10%)		CLA – 2 (15%)		CLA – 3 (15%)		CLA – 4 (10%)#			
		Theory	Practice	Theory	Practice	Theory	Practice	Theory	Practice	Theory	Practice
Level 1	Remember Understand	-	*40 %*	-	*30 %*	-	*30 %*	-	*30 %*	-	*30%*
Level 2	Apply Analyze	-	*40 %*	-	*40 %*	-	*40 %*	-	*40 %*	-	*40%*
Level 3	Evaluate Create	-	*20 %*	-	*30 %*	-	*30 %*	-	*30 %*	-	*30%*
	Total	100 %		100 %		100 %		100 %		100 %	

CLA – 4 can be from any combination of these: Assignments, Seminars, Tech Talks, Mini-Projects, Case-Studies, Self-Study, MOOCs, Certifications, Conf. Paper etc.,

Course Designers		
Experts from Industry	Experts from Higher Technical Institutions	Internal Experts
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2. Mr. S. T. Kalaimani, CPCL, Chennai	*2. Dr. T. R. Sundararaman, Rajalakshmi Engineering College*	*2 Dr. K.Sofiya SRM Inst. of Science & Technology, sofiyak@.srmist.edu.in*

Course Code	18CHC306T	Course Name	TRANSPORT PHENOMENA	Course Category	C	Professional Core	L	T	P	C
							3	0	0	3

Pre-requisite Courses	Nil	Co-requisite Courses	Nil	Progressive Courses	Nil
Course Offering Department	Chemical Engineering	Data Book / Codes/Standards	Nil		

Course Learning Rationale (CLR):	*The purpose of learning this course is to:*
CLR-1 :	*Understand the chemical and physical transport processes and their mechanism.*
CLR-2 :	*Familiarize various aspects of velocity, temperature and a concentration distribution in laminar and turbulent flow.*
CLR-3 :	*To do heat, mass and momentum transfer analysis.*
CLR-4 :	*Analyze industrial problems along with appropriate approximations and boundary conditions.*
CLR-5 :	*Formulate the differential forms of the equations of change for momentum, heat and mass transfer problems for steady-state flows.*
CLR-6 :	*Understand the conservation equations and its application for any process*

Course Learning Outcomes (CLO):	*At the end of this course, learners will be able to:*	Learning 1: Level of Thinking (Bloom)	Learning 2: Expected Proficiency (%)	Learning 3: Expected Attainment (%)	PLO 1: Engineering Knowledge	PLO 2: Problem Analysis	PLO 3: Design & Development	PLO 4: Analysis, Design, Research	PLO 5: Modern Tool Usage	PLO 6: Society & Culture	PLO 7: Environment & Sustainability	PLO 8: Ethics	PLO 9: Individual & Team Work	PLO 10: Communication	PLO 11: Project Mgt. & Finance	PLO 12: Life Long Learning	PLO 13: PSO - 1	PLO 14: PSO - 2	PLO 15: PSO – 3
CLO-1 :	*Identify and describe mechanisms of transport phenomena in laminar flow systems.*	2	85	75	H			H									H	M	M
CLO-2 :	*Make appropriate connections between the equations of change and physical phenomena in given systems involving momentum.*	2	80	75	H	M		H									H	M	M
CLO-3 :	*Ability to analyze velocity distributions in turbulent flow and industrial problems along with appropriate approximations.*	2	85	75	H	M	M	H	M								H		
CLO-4 :	*Formulate and solve differential equations of heat transfer to calculate temperature distributions.*	2	85	80	H	M	M	H	M								H	M	L
CLO-5 :	*Formulate and solve differential equations of mass transfer to calculate concentration distributions.*	2	85	80	H	M	M	H	M								H	M	M
CLO-6 :	*Apply the conservation equation for the micro and macro systems*	3	80	70	H	M	M	H	M								H	M	M

Duration (hour)		9	9	9	9	9
S-1	SLO-1	*Velocity distribution in laminar flow*	*Equation of change for isothermal process*	*Velocity distribution in turbulent flow*	*Thermal conductivity and the mechanisms of energy transport*	*Diffusivity and the Mechanisms of Mass Transport*
	SLO-2	*Introduction - Generalization of Newton's Law of Viscosity*	*Equation of change for isothermal process*	*Interphase transport in isothermal systems*	*Temperature and pressure dependence of thermal conductivity*	*Fick's law of binary diffusion (Molecular Mass Transport)*
S-2	SLO-1	*Pressure and temperature dependence of viscosity.*	*The equation of continuity*	*Comparisons of laminar and turbulent flows*	*Shell energy balances and temperature distributions in Solids and laminar flow, boundary conditions*	*Temperature and pressure dependence of diffusivities*
	SLO-2	*Shell momentum balances, boundary conditions, introduction to vector analysis*	*The equation of continuity*	*Comparisons of laminar and turbulent flows*	*Shell energy balances and temperature distributions in Solids and laminar flow, boundary conditions*	*Concentration distributions in solids and in laminar flow, boundary conditions*
S-3	SLO-1	*Shell momentum balances and velocity distributions: flow of a falling film.*	*The equation of motion: Eulers equation*	*Time-smoothed equations of continuity for incompressible fluids*	*Heat conduction with an electrical heat source*	*Diffusion through a stagnant gas film*
	SLO-2	*Shell momentum balances and velocity distributions: flow of a falling film.*	*The equation of motion: Eulers equation*	*Time-smoothed equations of continuity for incompressible fluids*	*Heat conduction with an electrical heat source*	*Diffusion through a stagnant gas film*
S-4	SLO-1	*Shell momentum balances and velocity distributions: flow through a circular tube*	*The equations of change in terms of the substantial derivative : Navier Stokes equation*	*Time-smoothed equations of motion for incompressible fluids*	*Heat conduction through composite plane wall*	*Diffusion with a homogeneous chemical reaction*
	SLO-2	*Shell momentum balances and velocity distributions: flow through a circular tube*	*The equations of change in terms of the substantialderivative : Navier Stokes equation*	*Time-smoothed equations of motion for incompressible fluids*	*Heat conduction through composite plane wall*	*Diffusion with a homogeneous chemical reaction*
S-5	SLO-1	*Shell momentum balances and velocity distributions: flow through an annulus*	*Applications of equation of motion*	*Empirical expressions for the turbulent momentum flux*	*Heat conduction through composite cylindrical wall*	*Diffusion and chemical reaction inside a porous catalyst*
	SLO-2	*Shell momentum balances and velocity distributions: flow through an annulus*	*Applications of equation of motion*	*Empirical expressions for the turbulent momentum flux*	*Heat conduction through composite cylindrical wall*	*Diffusion and chemical reaction inside a porous catalyst*

S-6	SLO-1	*Shell momentum balances and velocity distributions: flow of two adjacent immiscible fluids*	*Applications of equation of motion*	*Universal velocity profile for turbulent flow in a tube*	*Heat conduction in a cooling fin*	*Equations of change for multicomponent systems*
	SLO-2	*Shell momentum balances and velocity distributions: flow of two adjacent immiscible fluids*	*Applications of equation of motion*	*Universal velocity profile for turbulent flow in a tube*	*Heat conduction in a cooling fin*	*Equations of change for multicomponent systems*
S-7	SLO-1	*Shell momentum balances and velocity distributions: flow in a narrow slit*	*Solving problem*	*Definition of friction factors*	*The equations of change for non-isothermal systems*	*Analogies between momentum, heat and mass transport*
	SLO-2	*Shell momentum balances and velocity distributions: flow in a narrow slit*	*Solving problem*	*Friction factors for flow in tubes*	*The equations of change for non-isothermal systems*	*Analogies between momentum, heat and mass transport*
S-8	SLO-1	*Solving problem*	*Solving problem*	*Friction factors for flow around spheres*	*Steady state heat conduction problem*	*Solving problem*
	SLO-2	*Solving problem*	*Solving problem*	*Friction factors for flow in a narrow slit*	*Steady state heat conduction problem*	*Solving problem*
S-9	SLO-1	*Solving problem*	*Dimensional analysis of the equations of change*	*Friction factors for packed columns*	*Solving problem*	*Solving problem*
	SLO-2	*Solving problem*	*Dimensional analysis of the equations of change*	*Solving problem*	*Solving problem*	*Solving problem*

Learning Resources	1. *Byron R.Bird., Warren E. Stewart and Edwin N. Lightfoot, "Transport Phenomena", 2nd edition, John Wiley & Sons, New York, 2007.* 2. *Christie John Geankoplis"Transport Processes and Separation Process Principles (Includes Unit Operations)", 4thEdition,Pearson Education, Prentice Hall, 2003.* 3. *James R. Welty., Charles E. Wicks.,Robert E. Wilson. and Gregory L. Rorrer "Fundamentals of Momentum, Heat, and Mass Transfer",5nd edition, John Wiley &Sons, New York, 2007.* 4. *Robert S. Brodkeyand Harry C.Hershey., Transport Phenomena - A Unified Approach,Volume 2,Brodkey Publishing, Columbus, 2001.*

SLO – Session Learning Outcome

Learning Assessment

	Bloom's Level of Thinking	Continuous Learning Assessment (50% weightage)								Final Examination (50% weightage)	
		CLA – 1 (10%)		CLA – 2 (15%)		CLA – 3 (15%)		CLA – 4 (10%)#			
		Theory	Practice	Theory	Practice	Theory	Practice	Theory	Practice	Theory	Practice
Level 1	Remember Understand	*40 %*	-	*30 %*	-	*30 %*	-	*30 %*	-	*30%*	-
Level 2	Apply Analyze	*40 %*	-	*40 %*	-	*40 %*	-	*40 %*	-	*40%*	-
Level 3	Evaluate Create	*20 %*	-	*30 %*	-	*30 %*	-	*30 %*	-	*30%*	-
	Total	100 %		100 %		100 %		100 %		100 %	

CLA – 4 can be from any combination of these: Assignments, Seminars, Tech Talks, Mini-Projects, Case-Studies, Self-Study, MOOCs, Certifications, Conf. Paper etc.,

Course Designers

Experts from Industry	Experts from Higher Technical Institutions	Internal Experts
1. Mr. A. Subramaniam, PESCO Beam Environmental Solutions Pvt. Ltd.,	*1. Dr. Lima Rose Miranda, Anna University, email: limamiranda2007@gmail.com*	*1. Dr. S. Sam David SRM Inst. of Science & Technology, samdavis@srmist.edu.in*
2. Mr. S. T. Kalaimani, CPCL, Chennai	*2. Dr. T. R. Sundararaman, Rajalakshmi Engineering College*	*2. Dr.AshishKapoor SRM Inst. of Science & Technology, ashishko@srmist.edu.in*

Course Code	18CHC307T	Course Name	REACTOR ANALYSIS AND CATALYSIS	Course Category	C	Professional Core	L	T	P	C
							3	0	0	3

Pre-requisite Courses	Nil	Co-requisite Courses	Nil	Progressive Courses	Nil
Course Offering Department	Chemical Engineering	Data Book / Codes/Standards	Nil		

Course Learning Rationale (CLR):	*The purpose of learning this course is to:*
CLR-1 :	*Understand the basics of non ideal flow in reactors*
CLR-2 :	*acquire knowledge on mechanism and rate of solid catalyzed reactions*
CLR-3 :	*assimilate the basics of kinetics of fluid – particle reactions*
CLR-4 :	*Familiarize design aspects of reactors for fluid – particle reactions*
CLR-5 :	*Expose to the catalyst preparation method, properties of catalyst and its determination*
CLR-6:	*understand the performance of non ideal reactor, rate of catalyzed reactions, kinetics of fluid – particle reactions, reactor design and estimation of catalyst properties*

Course Learning Outcomes (CLO):	*At the end of this course, learners will be able to:*	Learning 1: Level of Thinking (Bloom)	Learning 2: Expected Proficiency (%)	Learning 3: Expected Attainment (%)	PLO 1: Engineering Knowledge	PLO 2: Problem Analysis	PLO 3: Design & Development	PLO 4: Analysis, Design, Research	PLO 5: Modern Tool Usage	PLO 6: Society & Culture	PLO 7: Environment & Sustainability	PLO 8: Ethics	PLO 9: Individual & Team Work	PLO 10: Communication	PLO 11: Project Mgt. & Finance	PLO 12: Life Long Learning	PLO 13: PSO - 1	PLO 14: PSO - 2	PLO 15: PSO – 3
CLO-1 :	*explain the reasons and calculate extent of deviation from ideal flow behavior*	*1*	*80*	*70*	*H*	*H*											*H*	*L*	
CLO-2 :	*Understand mechanism and derive rate equation for catalytic reactions*	*2*	*80*	*70*	*H*	*H*	*H*										*H*	*H*	
CLO-3 :	*describe models and rate controlling mechanism for fluid – particle reactions*	*2*	*80*	*70*	*H*	*H*	*H*										*H*	*H*	
CLO-4 :	*appreciate designing of heterogeneous non – catalytic reactors*	*3*	*80*	*70*	*H*	*H*	*L*										*H*	*H*	*L*
CLO-5 :	*determine catalyst properties and explain preparation techniques*	*3*	*80*	*70*	*H*	*H*		*L*									*M*	*L*	
CLO-6 :	*calculate conversion in real reactor, rate of solid catalyzed reaction, kinetics of fluid – particle reactions, reactor design variables and properties of catalyst*	*2*	*80*	*70*	*H*	*H*		*L*									*H*	*M*	*L*

Duration (hour)		9	9	9	9	9
S-1	SLO-1	*Reasons for deviation from ideal flow*	*Problems based on tanks – in – series model*	*Problems based on catalytic reactors*	*Problems based on fluid – particle reaction kinetics*	*Concept of instantaneous reactions – favorable contacting patterns*
	SLO-2	*Residence time distribution (RTD): basics and reasons*	*Problems based on tanks – in – series model*	*Problems based on catalytic reactors*	*Problems based on fluid – particle reaction kinetics*	*Concept of instantaneous reactions – favorable contacting patterns*
S-2	SLO-1	*E curve – methods for finding 'E'*	*characteristics of catalyst and mechanism for the action of a catalyst*	*Importance of fluid – particle reactions*	*factors control the design of a fluid-solid reactor*	*Pertinent properties for a catalyst particle ; General characteristics of catalysis*
	SLO-2	*Concept of tracer and types of input*	*spectrum of kinetic regimes*	*behavior of reacting solid particles*	*types of contacting ingas-solid operations*	*Pertinent properties for a catalyst particle ; General characteristics of catalysis*
S-3	SLO-1	*The pulse experiment*	*Steps in a catalytic reaction*	*Models for fluid – particle reactions*	*Fraction of solid reactant unconverted for mixture of particles of different but unchanging sizes following Plug Flow pattern*	*Determination of surface area by gas adsorption method*
	SLO-2	*The step experiment; concept of F curve*	*Factors affecting rate of each step*	*Steps in shrinking core model for unchanging size spherical particles*	*problems based on plug flow of different size solids*	
S-4	SLO-1	*Conversion in non – ideal flow reactors*	*Rate equation for surface kinetics – single site and dual site mechanism*	*Derivation of rate equation for spherical particles of unchanging size if diffusion through gas film controls*	*Derivation for fraction unconverted for Mixed Flow of Particles of a Single Unchanging Size if gas film resistance is rate controlling*	*problems based on surface area determination*
	SLO-2	*problems based on tracer study data's: development of E curve and calculation of mean time of distribution*				*problems based on surface area determination*
S-5	SLO-1	*problems based on conversion in non – ideal reactors*	*Derivation of reactant concentration for pore diffusion resistance combined with surface kinetics*	*Derivation of rate equation for spherical particles of unchanging size if diffusion through ash layer controls*	*Expression for fraction unconverted for Mixed Flow of Particles of a Single Unchanging Size if surface reaction and ash layer diffusion controls*	*Pore volume distribution by gas desorption method*
	SLO-2	*E curve for ideal PFR and MFR*				*Pore volume distribution by mercury penetration method*
S-6	SLO-1	*Models for non – ideal reactors: dispersion model concepts*	*Effectiveness factor, Thiele modulus and Wagner modulus*		*Derivation for fraction unconverted for mixed flow of a size mixture of particles of*	

	SLO-2		*Derivation of Effectiveness factor for a first order reaction*	*Derivation of rate equation for spherical particles of unchanging size if surface chemical reaction is rate controlling*	*unchanging size if gas film diffusion controls*	*void volume and solid density determination; problems based on void volume and solid density*
S-7	SLO-1	*Parameter estimation using dispersion model*	*Performance equation for plug flow reactor containing porous catalyst particles*	*Problems based on shrinking core model*	*Expression for fraction unconverted for mixed flow of a size mixture of particles of unchanging size if surface chemical reaction and ash diffusion controls*	*Classification of catalysts; Promoters, inhibitors and accelerators*
	SLO-2		*Performance equation for mixed flow reactor containing porous catalyst particles*			
S-8	SLO-1	*Problems based on dispersion model*	*Experimental methods for finding rates of catalytic reactions*	*Reactions involving shrinking spherical particles: factors affecting rate and steps involved*	*Problems based on conversion of a single – sized feed in a mixed flow reactor*	*Catalyst preparation methods*
	SLO-2	*Problems based on dispersion model*	*Experimental methods for finding rates of catalytic reactions*	*Development of rate equation if chemical reaction controls the overall rate*	*Problems based on conversion of a feed mixture in a mixed flow reactor*	
S-9	SLO-1	*Derivation of RTD function equation (E) by tanks – in – series model*	*Problems based on finding the rate of catalytic reactions*	*Derivation of rate equation for shrinking spherical particles if diffusion through gas film controls*	*Problems based on finding the size of a fluidized bed and fluid – particle reactors*	*Types of catalyst poisons*
	SLO-2	*Derivation of RTD function equation (E) by tanks – in – series model*	*Problems based on finding the rate of catalytic reactions*	*Derivation of rate equation for shrinking spherical particles if diffusion through gas film controls*	*Problems based on finding the size of a fluidized bed and fluid – particle reactors*	*Types of catalyst poisons*

Learning Resources	1. *Octave Levenspiel, "Chemical Reaction Engineering", 3rd edition, John Wiley & Sons, 2011.* 2. *H. Scott Fogler, "Elements of Chemical Reaction Engineering", 4th edition, Prentice Hall PTR, 2006.* 3. *J. M. Smith, "Chemical Engineering Kinetics", 3rd edition, McGraw Hill International editions, New Delhi, 1981.*

Learning Assessment

	Bloom's Level of Thinking	Continuous Learning Assessment (50% weightage)								Final Examination (50% weightage)	
		CLA – 1 (10%)		CLA – 2 (15%)		CLA – 3 (15%)		CLA – 4 (10%)#			
		Theory	Practice	Theory	Practice	Theory	Practice	Theory	Practice	Theory	Practice
Level 1	Remember Understand	*40 %*	-	*30 %*	-	*30 %*	-	*30 %*	-	*30%*	-
Level 2	Apply Analyze	*40 %*	-	*40 %*	-	*40 %*	-	*40 %*	-	*40%*	-
Level 3	Evaluate Create	*20 %*	-	*30 %*	-	*30 %*	-	*30 %*	-	*30%*	-
	Total	100 %		100 %		100 %		100 %		100 %	

CA – 4 can be from any combination of these: Assignments, Seminars, Tech Talks, Mini-Projects, Case-Studies, Self-Study, MOOCs, Certifications, Conf. Paper etc.,

Course Designers

Experts from Industry	Experts from Higher Technical Institutions	Internal Experts
1. Mr. A. Subramaniam, PESCO Beam Environmental Solutions Pvt. Ltd.,	*1. Dr. Lima Rose Miranda, Anna University, email: limamiranda2007@gmail.com*	*1) Dr. M. Magesh Kumar SRM Inst. of Science & Technology, mageshkm@srmist.edu.in*
2. Mr. S. T. Kalaimani, CPCL, Chennai	*2. Dr. T. R. Sundararaman, Rajalakshmi Engineering College*	*2) Mr. V. Ganesh SRM Inst. of Science & Technology, ganeshv@srmist.edu.in*

Course Code	18CHC308T	Course Name	PROCESS DYNAMICS, CONTROL AND INSTRUMENTATION	Course Category	C	PROFESSIONAL CORE	L	T	P	C
							3	0	0	3

Pre-requisite Courses	Nil	Co-requisite Courses	Nil	Progressive Courses	Nil
Course Offering Department	Chemical Engineering	Data Book / Codes/Standards	Nil		

Course Learning Rationale (CLR):	The purpose of learning this course is to:
CLR-1 :	*Understand the importance of process control in industrial process plants.*
CLR-2 :	*Understand the use of block diagrams & the mathematical basis for the design and stability of control systems*
CLR-3 :	*Understand the application of good instrumentation for the effective design of process control loops for process engineering plants.*
CLR-4 :	*Draw a Process & Instrumentation Diagram and devise simple but effective plant wide control strategies using appropriate methods.*
CLR-5 :	*Design and tune process controllers and specify the required final elements to ensure that well-tuned control is achieved.*
CLR-6 :	*Understand the process dynamics and control in process industries*

Course Learning Outcomes (CLO):	At the end of this course, learners will be able to:	Learning 1: Level of Thinking (Bloom)	Learning 2: Expected Proficiency (%)	Learning 3: Expected Attainment (%)	PLO 1: Engineering Knowledge	PLO 2: Problem Analysis	PLO 3: Design & Development	PLO 4: Analysis, Design, Research	PLO 5: Modern Tool Usage	PLO 6: Society & Culture	PLO 7: Environment & Sustainability	PLO 8: Ethics	PLO 9: Individual & Team Work	PLO 10: Communication	PLO 11: Project Mgt. & Finance	PLO 12: Life Long Learning	PLO 13: PSO - 1	PLO 14: PSO - 2	PLO 15: PSO – 3
CLO-1 :	*Use Laplace method to obtain transfer functions related to the first and higher order system.*	2	85	75	H	H											H	M	
CLO-2 :	*Define linear closed loop control system, controllers, final control elements and use them in the problem solving.*	2	80	70	H	H											H	M	
CLO-3 :	*Analyze stability of open- and closed-loop control systems.*	2	85	80	H	M	M		M								H	M	
CLO-4 :	*Identify possible control schemes in chemical Engineering plants.*	2	90	85			M		M								H	M	M
CLO-5 :	*Understand the instrumentation and automation of modern chemical operation.*	2	80	75				M									H	M	H
CLO-6 :	*Apply and evaluate the various control schemes and systems*	2	75	65	H	M	H	M	L								H	M	M

Duration (hour)		9	9	9	9	9
S-1	SLO-1	*Basic Concepts of process control, Block diagram*	*Linear closed loop systems*	*Concept of stability*	*Control system with single loops*	*Principles of measurements*
	SLO-2	*Linear open loop systems*	*Controllers and final control element*	*Stability criterion*	*Feedback control systems with examples*	*Classification of process control instruments*
S-2	SLO-1	*Laplace transform of simple functions*	*Principles of pneumatic and electronic controllers*	*Stability for linear system: Routh-Hurwitz stability criterion*	*Control systems with multiple loops*	*Elements of instruments*
	SLO-2	*Laplace transform of derivatives*	*Transfer function of controllers*	*Stability for linear system: Routh-Hurwitz stability criterion*	*Cascade control scheme with example*	*Parts of instruments*
S-3	SLO-1	*Properties of Laplace transform*	*Dynamic behavior of controllers*	*Solving Problem*	*Selective control systems*	*Static characteristics*
	SLO-2	*Physical examples of first-order systems*	*Closed loop response*	*Solving Problem*	*Override control*	*dynamic characteristics*
S-4	SLO-1	*Transfer function approach*	*Servo problem*	*Root locus diagrams*	*Auctioneering Control*	*Temperature measuring instruments*
	SLO-2	*Linearization of nonlinear system*	*Solving Problem*	*Root locus diagrams*	*Split-range control with examples*	*Temperature measuring instruments*
S-5	SLO-1	*Solving Problem*	*Solving Problem*	*Solving Problem*	*Feedforward control scheme with examples*	*Liquid-level measuring instruments*
	SLO-2	*Solving Problem*	*Solving Problem*	*Solving Problem*	*Control of distillation column: control of composition*	*Liquid-level measuring instruments*
S-6	SLO-1	*Response of first-order systems*	*Solving Problem*	*Design of control system using frequency response: Bode diagram-stability criterion*	*Control of distillation column: control of pressure*	*Pressure measuring instruments*
	SLO-2	*Response of first- order systems in series*	*Regulatory problem*		*Introduction to digital control*	*Pressure measuring instruments*
S-7	SLO-1	*Solving Problem*	*Solving Problem*	*phase and gain margins*	*Microprocessor-based controllers*	*Composition measuring instruments*
	SLO-2	*Solving Problem*	*Solving Problem*	*Solving Problem*	*Hardware Components*	*Composition measuring instruments*
S-8	SLO-1	*Higher order systems: Second-order*	*Solving Problem*	*Solving*	*Tasks of a Microprocessor based controller*	*Measurements of viscosity*

	SLO-2	*Transportation lag*	*Solving Problem*	*Solving*	*Special features of Microprocessor based controller*	*Measurements of pH*
S-9	SLO-1	*Solving Problem*	*Mechanism of control valves*	*Ziegler Nichols controller settings*	*Introduction to PLC's*	*Measurements of thermal conductivity*
	SLO-2	*Solving Problem*	*Valve characteristics*	*Solving Problem*	*Introduction to DCS*	*Measurements of humidity of gases*

Learning Resources	1. *Donald R. Coughanowr., Steven E. LeBlanc., "Process system Analysis & Control", 3rd edition., McGraw Hill, New york, 2009.* 2. *George Stephanopoulos, "Chemical Process Control: An Introduction to Theory and Practice", Prentice Hall, New Delhi, 1984.* 3. *Peter Harriott, "Process Control" Tata McGraw Hill, New Delhi, 1972.* 4. *William L. Luyben, "Process modeling, simulation, and control for Chemical Engineers ", 2nd edition, McGraw Hill, New York, 1996.* 5. *Donald P. Eckman, "Industrial Instrumentation", Wiley Eastern Limited, 2004.*

SLO – Session Learning Outcome

Learning Assessment											
	Bloom's Level of Thinking	Continuous Learning Assessment (50% weightage)								Final Examination (50% weightage)	
		CLA – 1 (10%)		CLA – 2 (15%)		CLA – 3 (15%)		CLA – 4 (10%)#			
		Theory	Practice	Theory	Practice	Theory	Practice	Theory	Practice	Theory	Practice
Level 1	Remember Understand	*40 %*	-	*30 %*	-	*30 %*	-	*30 %*	-	*30%*	-
Level 2	Apply Analyze	*40 %*	-	*40 %*	-	*40 %*	-	*40 %*	-	*40%*	-
Level 3	Evaluate Create	*20 %*	-	*30 %*	-	*30 %*	-	*30 %*	-	*30%*	-
	Total	100 %		100 %		100 %		100 %		100 %	

CLA – 4 can be from any combination of these: Assignments, Seminars, Tech Talks, Mini-Projects, Case-Studies, Self-Study, MOOCs, Certifications, Conf. Paper etc.,

Course Designers		
Experts from Industry	Experts from Higher Technical Institutions	Internal Experts
1. Mr. A. Subramaniam, PESCO Beam Environmental Solutions Pvt. Ltd.,	*1. Dr. Lima Rose Miranda, Anna University, email: limamiranda2007@gmail.com*	*1 Dr. K.Sofiya* *SRM Inst. of Science & Technology, sofiyak@.srmist.edu.in*
2. Mr. S. T. Kalaimani, CPCL, Chennai	*2. Dr. T. R. Sundararaman, Rajalakshmi Engineering College*	*2 Dr.P.Muthamilselvi* *SRM Inst. of Science & Technology, muthamip@srmist.edu.in*

Course Code	18CHC309L	Course Name	CHEMICAL ENGINEERING LAB III	Course Category	C	Professional Core	L	T	P	C
							0	0	4	2

Pre-requisite Courses	Nil	Co-requisite Courses	Nil	Progressive Courses	Nil
Course Offering Department	Chemical Engineering	Data Book / Codes/Standards	Nil		

Course Learning Rationale (CLR):	*The purpose of learning this course is to:*
CLR-1 :	*Provide the firsthand experience on verifying various theoretical concepts learnt in CRE and Process control.*
CLR-2 :	*Develop the skills in conducting experiments and to verify the theoretical concepts learnt in Chemical Reaction Engineering and Reactor analysis & catalysis courses.*
CLR-3 :	*Evaluate the performance of single and multiple reactors*
CLR-4 :	*Develop the skills in conducting experiments and to verify the theoretical concepts learnt in .process dynamics, control & instrumentation course.*
CLR-5 :	*Understand the flapper- nozzle system and valve characteristics used for control system*
CLR-6 :	*Understand the characteristics of different mode of controllers P,PI,PD,PID, and tuning process*

Course Learning Outcomes (CLO):	*At the end of this course, learners will be able to:*	Learning 1: Level of Thinking (Bloom)	Learning 2: Expected Proficiency (%)	Learning 3: Expected Attainment (%)
CLO-1 :	*Operate batch and continuous reactors.*	*2*	*80*	*75*
CLO-2 :	*Understand the performance of combined reactor system.*	*2*	*80*	*75*
CLO-3 :	*Understand the non-ideality behavior of the continuous reactors.*	*2*	*80*	*75*
CLO-4 :	*Understand process control concepts while performing the experiments*	*2*	*80*	*75*
CLO-5 :	*study the response of different forcing functions*	*2*	*80*	*75*
CLO-6 :	*Determine the controller tuning parameters*	*2*	*80*	*75*

Program Learning Outcomes (PLO)

	1 Engineering Knowledge	2 Problem Analysis	3 Design & Development	4 Analysis, Design, Research	5 Modern Tool Usage	6 Society & Culture	7 Environment & Sustainability	8 Ethics	9 Individual & Team Work	10 Communication	11 Project Mgt. & Finance	12 Life Long Learning	13 PSO - 1	14 PSO - 2	15 PSO – 3
CLO-1	*H*	*H*	*M*	*M*									*H*	*M*	*M*
CLO-2	*H*	*H*	*H*	*H*									*H*	*M*	
CLO-3	*H*	*M*	*M*	*M*									*H*	*M*	*L*
CLO-4	*H*	*M*	*M*	*M*									*H*	*M*	
CLO-5	*H*	*M*	*M*										*H*	*M*	*L*
CLO-6	*H*	*H*	*M*	*M*									*H*	*M*	

Duration (hour)		12	12	12	12	12
S 1-4	SLO-1, SLO-2	*Kinetic study in a batch reactor*	*Performance study of a tubular flow reactor.*	*Performance study of a mixed flow reactor.*	*Performance study of (i)tubular flow reactor followed by mixed flow Reactor (ii) mixed flow reactor followed by tubular flow Reactor*	*Study of an adiabatic reactor.*
S 5-8	SLO-1, SLO-2	*Performance study of a semi batch reactor*	*RTD studies in a tubular flow reactor.*	*RTD studies in a mixed flow reactor.*	*Current to pressure and pressure to current converter*	*Study of step response of first order system*
S 9-12	SLO-1, SLO-2	*Study of interacting and non-interacting system*	*Control Valve characteristics*	*Study of level controller*	*Study of pressure process controller*	*Optimum controller tuning on level controller*

Learning Resources	
	1. *Laboratory Manual* 2. *Octave Levenspiel, "Chemical Reaction Engineering", 3rd edition, John Wiley & Sons India edition, 2011.* 3. *George Stephanopoulos, "Chemical Process Control: An Introduction to Theory and Practice", Prentice Hall, New Delhi, 1984.*

Learning Assessment											
	Bloom's Level of Thinking	Continuous Learning Assessment (50% weightage)								Final Examination (50% weightage)	
		CLA – 1 (10%)		CLA – 2 (15%)		CLA – 3 (15%)		CLA – 4 (10%)#			
		Theory	Practice	Theory	Practice	Theory	Practice	Theory	Practice	Theory	Practice
Level 1	Remember Understand	-	*40 %*	-	*30 %*	-	*30 %*	-	*30 %*	-	*30%*
Level 2	Apply Analyze	-	*40 %*	-	*40 %*	-	*40 %*	-	*40 %*	-	*40%*
Level 3	Evaluate Create	-	*20 %*	-	*30 %*	-	*30 %*	-	*30 %*	-	*30%*
	Total	100 %		100 %		100 %		100 %		100 %	

CLA – 4 can be from any combination of these: Assignments, Seminars, Tech Talks, Mini-Projects, Case-Studies, Self-Study, MOOCs, Certifications, Conf. Paper etc.,

Course Designers		
Experts from Industry	Experts from Higher Technical Institutions	Internal Experts
1. Mr. A. Subramaniam, PESCO Beam Environmental Solutions Pvt. Ltd.,	*1. Dr. Lima Rose Miranda, Anna University, email: limamiranda2007@gmail.com*	*1 Dr. K.Sofiya SRM Inst. of Science & Technology, sofiyak@.srmist.edu.in*
2. Mr. S. T. Kalaimani, CPCL, Chennai	*2. Dr. T. R. Sundararaman, Rajalakshmi Engineering College*	*2 Dr.P.Muthamilselvi SRM Inst. of Science & Technology, muthamip@srmist.edu.in*

Course Code	18CHC401J	Course Name	PROCESS EQUIPMENT DESIGN AND DRAWING	Course Category	C	Professional Course	L	T	P	C
							2	0	2	3

Pre-requisite Courses	18CHC207T 18CHC303T	Co-requisite Courses	Nil	Progressive Courses	Nil
Course Offering Department	Chemical Engineering	Data Book / Codes/Standards	Perry's Chemical Engineers Hand Book		

Course Learning Rationale (CLR):	*The purpose of learning this course is to:*	Learning			Program Learning Outcomes (PLO)														
		1	2	3	1	2	3	4	5	6	7	8	9	10	11	12	13	14	15
		Level of Thinking (Bloom)	Expected Proficiency (%)	Expected Attainment (%)	Engineering Knowledge	Problem Analysis	Design & Development	Analysis, Design, Research	Modern Tool Usage	Society & Culture	Environment & Sustainability	Ethics	Individual & Team Work	Communication	Project Mgt. & Finance	Life Long Learning	PSO - 1	PSO - 2	PSO – 3
CLR-1 :	*Outline the importance of drawing conventions and representation of equipment's through process flow sheeting, dimensioning and labeling the parts of equipment's*																		
CLR-2 :	*Provide the basics of proportioning, various types of selection of enclosures, flanges, nozzles and supports for process vessels*																		
CLR-3 :	*Recap the unit operations and unit process equipment's and the theoretical design and drawing of reaction/agitated vessels, basket centrifuge, gravity thickener and cyclone separator*																		
CLR-4 :	*Outline the principles of heat transfer and theoretical design and drawing of heat transfer equipment's such as shell and tube heat exchanger, evaporator and crystallizer*																		
CLR-5 :	*Overview of the principles of mass transfer process and theoretical design and drawing of distillation column, absorption column and rotary drier*																		
CLR-6 :	*consolidate the fundamental concepts and theoretical relationships useful in theoretical design and drawing of process equipment applied to chemical process industries*																		
Course Learning Outcomes (CLO):	*At the end of this course, learners will be able to:*																		
CLO-1 :	*Draw the simple process flow sheets and use appropriate dimensioning and labeling the parts of equipment's*	*1*	*80*	*75*	*H*	*M*	*M*	*L*					*M*	*M*		*L*	*H*	*L*	*L*
CLO-2 :	*Choose appropriate enclosures, flanges, nozzles and supports for process vessels*	*2*	*80*	*70*	*H*	*M*	*M*	*M*					*M*	*M*		*H*	*H*	*M*	
CLO-3 :	*Perform the theoretical design and drawing of reaction/agitated vessels, basket centrifuge, gravity thickener and cyclone separator*	*3*	*80*	*75*	*H*	*H*	*M*	*M*					*M*	*M*		*H*	*H*	*M*	
CLO-4 :	*Analyze and theoretically design and draw the heat transfer equipment's such as shell and tube heat exchanger, evaporator and crystallizer*	*3*	*80*	*70*	*H*	*H*	*M*	*M*					*M*	*M*		*H*	*H*	*M*	
CLO-5 :	*Relate the principles of mass transfer and theoretically design and draw the distillation column, absorption column and rotary drier*	*3*	*80*	*75*	*H*	*H*	*M*	*M*					*M*	*M*		*H*	*H*	*M*	
CLO-6 :	*Apply the integrated knowledge acquired in different core chemical engineering courses to theoretically design and draw the chemical process equipment*	*3*	*80*	*75*	*H*	*H*	*M*	*M*					*M*	*M*		*H*	*H*	*M*	

Duration (hour)		12	12	12	12	12
S-1	SLO-1	*Drawing conventions, equipment representation dimensioning and labeling the parts*	*Classification of enclosures (heads or cover) used for the pressure vessels*	*Overview of reaction/agitated vessels*	*Drawing of gravity thickener*	*Practice drawing session of single effect evaporator evaporators and crystallizers*
	SLO-2	*Illustrative examples of Drawing conventions*		*Introduction, classification and design consideration of reaction vessel.*		
S-2	SLO-1	*Process flow sheeting*	*Numerical Problem on various types of enclosures*	*Numerical problem on the design of reaction/agitated vessel*	*Practice session for reaction/agitated vessel*	*Theory of crystallizers –Types and their applications.*
	SLO-2	*Illustrative example*				*Numerical problem on the design of crystallizers*
S-3	SLO-1	*General design procedure, materials of construction and design considerations*	*Specification for various types of enclosures*	*Drawing of reaction/agitated vessel*	*Practice session for basket centrifuge*	*Practice drawing session of crystallizers*
	SLO-2					
S-4	SLO-1	*Pressure vessels - classification, applications and design considerations*	*Drawing of various enclosures (heads or covers) used for the process vessels.*	*Introduction to basket centrifuge*	*Practice drawing session for gravity thickener*	*Overview of distillation column, absorption column and rotary drier*
	SLO-2	*Factors influencing the design of vessels, design pressure, design temperature, factor safety and welding joint efficiency*				*Theory and design aspects of distillation column*
S-5	SLO-1				*Outline of Heat exchangers*	

	SLO-2	*Numerical problem on design of pressure vessel subjected to internal pressure*	*Introduction to flanges, nozzles and supports*	*Numerical problem on the design of basket centrifuge*		*Numerical problem on the design of distillation for binary system*
S-6	SLO-1	*Numerical problem on design of pressure vessel subjected to external pressure*	*Selection criteria for flanges, nozzles and supports*	*Drawing of basket centrifuge*	*Principles of heat transfer types of heat exchangers and design procedure for 1-2 shell and tube heat exchanger*	*Drawing and practice session of distillation columnfor binary system*
	SLO-2		*Numerical problem on flanges, nozzles and supports.*	*Drawing of basket centrifuge separator*		
S-7	SLO-1	*Practice session on drawing of pressure vessel subjected to internal pressure*	*Drawing of Flanges, and nozzles*	*Introduction to gravity thickener*	*Numerical problem on design of shell and tube heat exchanger*	*Theory and design aspects of absorption column*
	SLO-2		*Drawing of supports*			
S-8	SLO-1	*Practice session on drawing of pressure vessel subjected to external pressure*	*Practice session on drawing of enclosures (heads or cover)s used for the process vessels*	*Numerical problem on the design of gravity thickener*	*Drawing of 1-2 shell and tube heat exchanger*	*Numericalproblem on the design of absorption column*
	SLO-2					
S-9	SLO-1	*Summary of pressure vessel design*	*Practice session on drawing of flanges and nozzles*	*Practice drawing session of gravity thickener*	*Practice drawing session of 1-2 shell and tube heat exchanger*	*Drawing of absorption column*
	SLO-2					
S-10	SLO-1	*Introduction to various types of enclosures, flanges, nozzles and supports*	*Practice session on drawing of supports*	*Theory on design of cyclone separator*	*Theory of Evaporators – Types and their applications*	*Practice drawing session of absorber*
	SLO-2					
S-11	SLO-1	*Enclosures and their applications with Illustrative examples*	*Practice session on drawing of flanges, nozzles and supports for pressure vessel subjected to internal pressure*	*Numerical problem on the design of gravity thickener*	*Numerical problem on design of single effect evaporator*	*Theory and design aspects of rotary drier*
	SLO-2					*Numerical problem on the design of rotary drier*
S-12	SLO-1	*Classification of enclosures (heads or cover) used for the pressure vessels*	*Summary of enclosures, flanges, nozzles and supports for pressure vessel subjected to internal pressure*	*Drawingof gravity thickener*	*Drawing of single effectevaporator*	*Drawing and Practice drawing session of rotary dryer*
	SLO-2					

Learning Resources	1. *Sinnott. R.K, Coulson & Richardson's, "Chemical Engineering", Volume 6, 3rd Edn., Butterworth Heinemann, New Delhi, 1999.* 2. *Perry. R.H., et al., Perry's, "Chemical Engineers Handbook," 7th Edn., McGraw Hill, NewYork, 1997.* 3. *Bownell, L.E., and Young, E.M., "Process Equipment Design", Wiley Eastern, 1968.* 4. *Joshi. M.V, and Mahajani. V.V, "Process Equipment Design," 3rd Edn., Macmillan India Limited, New Delhi, 1996* 5. *Maidargi, Suresh C., "Chemical ProcessEquipment: Design and Drawing (Vol. I)" 2ndEdn. Prentice Hall India, 2015* 6. *Bhattacharyy, B C., "Introduction to Chemical Equipment Design: Mechanical Aspects", 1stEdn. CBS Publisher, 2012*

Learning Assessment

	Bloom's Level of Thinking	Continuous Learning Assessment (50% weightage)								Final Examination (50% weightage)	
		CLA – 1 (10%)		CLA – 2 (15%)		CLA – 3 (15%)		CLA – 4 (10%)#			
		Theory	Practice	Theory	Practice	Theory	Practice	Theory	Practice	Theory	Practice
Level 1	Remember Understand	*20%*	*20%*	*15%*	*15%*	*15%*	*15%*	*15%*	*15%*	*15%*	*15%*
Level 2	Apply Analyze	*20%*	*20%*	*20%*	*20%*	*20%*	*20%*	*20%*	*20%*	*20%*	*20%*
Level 3	Evaluate Create	*10%*	*10%*	*15%*	*15%*	*15%*	*15%*	*15%*	*15%*	*15%*	*15%*
	Total	100 %		100 %		100 %		100 %		100 %	

CA – 4 can be from any combination of these: Assignments, Seminars, Tech Talks, Mini-Projects, Case-Studies, Self-Study, MOOCs, Certifications, Conf. Paper etc.,

Course Designers

Experts from Industry	Experts from Higher Technical Institutions	Internal Experts
1. Mr. A. Subramaniam, PESCO Beam Environmental Solutions Pvt. Ltd.,	*1. Dr. Lima Rose Miranda, Anna University, email: limamiranda2007@gmail.com*	*1 Dr. S. Balasubramanian SRM Inst. of Science & Technology, balasubs@srmist.edu.in*
2. Mr. S. T. Kalaimani, CPCL, Chennai	*2. Dr. T. R. Sundararaman, Rajalakshmi Engineering College*	*2 Mr. V. Ganesh SRM Inst. of Science & Technology, ganeshv@srmist.edu.in*

Course Code	18CHC402T	Course Name	PROCESS ECONOMICS AND PROJECT MANAGEMENT	Course Category	C	Professional Core	L	T	P	C
							3	0	0	3

Pre-requisite Courses	Nil	Co-requisite Courses	Nil	Progressive Courses	Nil
Course Offering Department	Chemical Engineering	Data Book / Codes/Standards	Nil		

Course Learning Rationale (CLR):	*The purpose of learning this course is to:*
CLR-1 :	*Present the fundamental concepts of time value of money*
CLR-2 :	*Provide the essential features of balance sheet and profit-loss statements applied to a typical process industry*
CLR-3 :	*Impart knowledge on the basics of selection of alternatives in process plants using theoretical economic equations*
CLR-4 :	*Explain concepts of the economic balance applied the cyclic process in the manufacture of chemicals in match mode*
CLR-5 :	*Illustrate the role played by the process engineers in chemical engineering project management*
CLR-6 :	*Present the basic theoretical process engineering economic principles, elementary accounting procedures and project management as applied in chemical process industries*

Course Learning Outcomes (CLO): *At the end of this course, learners will be able to:*		Learning 1: Level of Thinking (Bloom)	Learning 2: Expected Proficiency (%)	Learning 3: Expected Attainment (%)	PLO 1: Engineering Knowledge	PLO 2: Problem Analysis	PLO 3: Design & Development	PLO 4: Analysis, Design, Research	PLO 5: Modern Tool Usage	PLO 6: Society & Culture	PLO 7: Environment & Sustainability	PLO 8: Ethics	PLO 9: Individual & Team Work	PLO 10: Communication	PLO 11: Project Mgt. & Finance	PLO 12: Life Long Learning	PLO 13: PSO - 1	PLO 14: PSO - 2	PLO 15: PSO – 3
CLO-1 :	*Apply the concept of time value of money to solve process economic problems*	*2*	*80*	*75*	*M*	*H*							*M*			*M*	*H*	*H*	*H*
CLO-2 :	*Interpret and explain the balance sheet and profit-loss statement for a typical chemical process industry*	*1*	*80*	*70*	*L*	*M*							*M*		*L*	*M*	*H*	*L*	*M*
CLO-3 :	*Analyze the chemical engineering processes and illustrate the economic principles used in it towards the economic selection of alternatives*	*2*	*80*	*70*	*H*	*H*	*M*						*L*		*L*	*M*	*H*	*H*	*H*
CLO-4 :	*Perform economic balance calculations for batch (or cyclic) processes*	*2*	*75*	*70*	*H*	*H*	*M*						*M*				*H*	*H*	*M*
CLO-5 :	*Explain the importance of project management applied to chemical engineering projects*	*1*	*80*	*75*	*M*	*M*							*H*	*M*	*H*	*M*	*H*	*M*	*M*
CLO-6 :	*Apply the knowledge of economics and management principles, methods and illustrate their applications to chemical engineering*	*2*	*80*	*70*	*M*	*M*							*H*	*M*	*H*	*M*	*H*	*H*	*H*

Duration (hour)		09	09	09	09	09
S-1	SLO-1	*Introduction to time value of money*	*Overview of Balance sheet and cost accounting*	*Economics of selecting alternative*	*Economic balance*	*Project management for chemical engineers*
	SLO-2	*Terminologies used in time value of money and illustrative examples*	*Capital requirements for process plants*	*Various methods in economics of selecting alternatives*	*Illustrative examples of Economic balance applied to process industries*	*Importance of management in practice for chemical engineers*
S-2	SLO-1	*Simple and compound Interest theory and illustrative examples*	*Cost index problems for equipment's and plants*	*Annual cost method and Illustrative example*	*Problem session in single variable economic balance*	*Project, principles and initiation*
	SLO-2	*Nominal and effective interest rates theory and illustrative examples*	*Illustrative example of cost index problems*	*Illustrative example of annual cost method*	*Problem session in single variable economic balance*	*Project strategy and organization*
S-3	SLO-1	*Practice problem session in time value of money*	*Conceptual basis for Balance sheet*	*Practice problem session in annual cost method*	*Problem session in multi variable economic balance*	*Process specification*
	SLO-2	*Practice problem session in various interest rates*	*Illustrative example of preparation of Balance sheet*	*Practice problem session in annual cost method*	*Problem session in multi variable economic balance*	*Process Specification-illustrative example*
S-4	SLO-1	*The concept of equivalence and illustrative examples*	*Practice problem session of balance sheet preparation*	*Present worth method and illustrative example*	*Deriving optimum diameter of pipe for fluid transport using the concept of economic balance*	*Detail design strategy*
	SLO-2	*Theoretical equations for economic studies*	*Practice problem session in balance sheet preparation*	*Illustrative example of Present worth method*	*Practice session for the above mentioned derivation*	*Illustrative example in detailed design strategy*
S-5	SLO-1	*Problems using theoretical equations for economic studies*	*Earnings, process and returns (Income statement)*	*Practice problem session in present worth method*	*Economic balance in batch operations*	*Risk analysis and management*
	SLO-2	*Problems using theoretical equations for economic studies*	*Illustrative example of income statement*	*Practice problem session in present worth method*	*Illustrative example*	*Quantitative test for risk analysis and management*
S-6	SLO-1	*Amortization concept with illustrative example*	*Practice problem session in income statement*	*Replacement: Rate-of-return*	*Economic balance in cyclic*	*Scoping, planning and getting approvals prior to starting physical work*

	SLO-2	*Problem practice session on Amortization*	*Practice problem session in income statement*	*Illustrative example of rate-of- return method*	*Illustrative example*	*Contracting for engineering and construction activities*
S-7	SLO-1	*Concept of Depreciation Types of depreciation problems*	*Concepts of Economic production – break-even analysis*	*Replacement: Pay-out time method*	*Problem practice session on economic balance in cyclic processes for the manufacture of a typical chemical in batches*	*Project execution with regards to health, safety and environment*
	SLO-2	*Illustrative example in depreciation*	*Illustrative example of break-even analysis*	*Illustrative example of pay-out time method*	*Problem practice session on economic balance in cyclic processes for the manufacture of a typical chemical in batches*	*Cost, quality and schedule Illustrative example*
S-8	SLO-1	*Practice problem session in depreciation*	*Practice problem session in break-even Analysis*	*Illustrative example on combination of four methods of economics of alternative selection*	*Economic balance in multiple equipment units and an illustrative example*	*Special features of small projects*
	SLO-2	*Practice problem session in depreciation*	*Practice problem session in break-even analysis*	*Illustrative example on combination of four methods of economics of alternative selection*	*Economic analysis of an operating plant - Appraisal value, earning value, stock and bond Value*	*Illustrative example of salient features of small projects*
S-9	SLO-1	*Concept of depletion Practice problem on depletion*	*Cost accounting - pre construction cost estimation- Allocation of cost*	*Practice problem session in combination of four methods of economics of alternative selection*	*Practice problem session in appraisal value and construction of data sheet for economic analysis of a process plant.*	*Value engineering – Illustrative example*
	SLO-2	*Summary of time value of money*	*Summary of balance sheet and cost accounting*	*Summary of economic selection of alternatives*	*Summary of economic balance and economic analysis of complete process plant*	*Summary of project management applied to chemical engineering*

Learning Resources	1. *Max. S,Peters and Klaus. D Timmerhaus, "Plant Design and Economics for Chemical Engineers", 5th Edn.,McGraw Hill International Editions, New York, 2004.* 2. *Schweyer. H.E, "Process Engineering Economics", McGraw Hill, 1969* 3. *F.C. Jelen and J.H. Black, "Cost and Optimization Engineering", McGraw Hill, 3rd Edn., 1992.* 4. *Peachey B., R. Evitts and Hill G.,"Project Management for Chemical Engineers", Trans IChemE, Part D, 2007* 5. *Paul C. Dinsmore, PMP, Jeannette Cabanis- Brewin,"The AMA Handbook of Project Management",3rdEdn.,2011* 6. *Gillian Lawson, Stephen Wearne, Peter Iles-Smith, "Project management for the Process Industries",IChemE, UK, 1999*

Learning Assessment

	Bloom's Level of Thinking	Continuous Learning Assessment (50% weightage)								Final Examination (50% weightage)	
		CLA – 1 (10%)		CLA – 2 (15%)		CLA – 3 (15%)		CLA – 4 (10%)#			
		Theory	Practice	Theory	Practice	Theory	Practice	Theory	Practice	Theory	Practice
Level 1	Remember Understand	*40 %*	-	*30 %*	-	*30 %*	-	*30 %*	-	*30%*	-
Level 2	Apply Analyze	*40 %*	-	*40 %*	-	*40 %*	-	*40 %*	-	*40%*	-
Level 3	Evaluate Create	*20 %*	-	*30 %*	-	*30 %*	-	*30 %*	-	*30%*	-
	Total	100 %		100 %		100 %		100 %		100 %	

CA – 4 can be from any combination of these: Assignments, Seminars, Tech Talks, Mini-Projects, Case-Studies, Self-Study, MOOCs, Certifications, Conf. Paper etc.,

Course Designers

Experts from Industry	Experts from Higher Technical Institutions	Internal Experts
1. Mr. A. Subramaniam, PESCO Beam Environmental Solutions Pvt. Ltd.,	*1. Dr. Lima Rose Miranda, Anna University, email: limamiranda2007@gmail.com*	*1 Dr. S. BALASUBRAMANIAN SRM Inst. of Science & Technology, balasubs@srmist.edu.in*
2. Mr. S. T. Kalaimani, CPCL, Chennai	*2. Dr. T. R. Sundararaman, Rajalakshmi Engineering College*	*2 Dr. K. ANBALAGAN SRM Inst. of Science & Technology, anbalagk@srmist.edu.in*

Course Code	18CHC403J	Course Name	PROCESS MODELING AND SIMULATION	Course Category	C	Professional Core	L	T	P	C
							2	0	2	3

Pre-requisite Courses	Nil	Co-requisite Courses	Nil	Progressive Courses	Nil
Course Offering Department	Chemical Engineering	Data Book / Codes/Standards	Nil		

Course Learning Rationale (CLR):	The purpose of learning this course is to:
CLR-1 :	*Understand the terms involved in Conservation of Mass, Momentum and Energy equations.*
CLR-2 :	*Review the phase equilibrium, Chemical equilibrium and Chemical Kinetics.*
CLR-3 :	*Apply the conservation of mass and energy equation for simple chemical engineering systems.*
CLR-4 :	*provide the training to develop process model equations for Chemical Engineering systems.*
CLR-5 :	*provide training to solve the process model equation using SCILAB and commercial software (Aspen Plus).*
CLR-6 :	*Understand the overview of process modeling*

Course Learning Outcomes (CLO):	At the end of this course, learners will be able to:	Learning 1: Level of Thinking (Bloom)	Learning 2: Expected Proficiency (%)	Learning 3: Expected Attainment (%)	PLO 1: Engineering Knowledge	PLO 2: Problem Analysis	PLO 3: Design & Development	PLO 4: Analysis, Design, Research	PLO 5: Modern Tool Usage	PLO 6: Society & Culture	PLO 7: Environment & Sustainability	PLO 8: Ethics	PLO 9: Individual & Team Work	PLO 10: Communication	PLO 11: Project Mgt. & Finance	PLO 12: Life Long Learning	PLO 13: PSO - 1	PLO 14: PSO - 2	PLO 15: PSO – 3
CLO-1 :	*Understand the modeling concept in Molecular and Convective transport terms.*	2	80	70	H	H	L										H		
CLO-2 :	*Understand the interface and reaction modeling concepts in Chemical Engineering systems.*	2	80	70	H	H	L										H	M	L
CLO-3 :	*Understand the pseudo and unsteady state modeling concepts*	2	75	70	H	H	L										H		
CLO-4 :	*Propose the process modeling equations for simple and complex chemical Engineering systems.*	3	80	70	H	H	L	M									H	M	
CLO-5 :	*Solve the model equations using open source software (SCILAB) and Commercial software (Aspen Plus).*	3	70	60	H	H	L	H									H	M	M
CLO-6 :	*Model a given process and simulate*	2	70	65	H	H	M	M									H	L	M

Duration (hour)		12	12	12	12	12
S-1	SLO-1	*Inventory rate equation of the conserved quantities*	*Interphase transport*	*Pseudo-Steady-State Approximation*	*Continuous Stirred Tank Reactor with constant holdup*	*Gravity flow tank*
S-2	SLO-1	*Steady state, Uniform, Equilibrium and Flux with suitable examples*	*Transfer coefficient, diffusivity and flux ratio for the transport of conserved quantities*	*Conservation of chemical species, momentum, energy and total mass for unsteady state*	*Continuous Stirred Tank Reactor with variable holdup*	*Modeling of Ideal Binary Distillation column*
S-3	SLO-1	*Mathematical formulation of the conserved quantities (Mass, Momentum and Energy equations)*	*Rate of generation in mass transport*	*Interacting and non-interacting system using single component*	*Two heated tanks*	*Estimation of boiling point of multicomponent ideal solution*
S-4	SLO-1	*Analogous molecular flux in constitutive equations for mass, momentum and energy*	*Rate of generation in momentum and energy transport*	*Unsteady state mass balance in a mixing tank*	*Gas phase pressurized CSTR*	*Modeling of multicomponent distillation column*
S-5	SLO-1	*Determine the molar flux from the plate surface under steady state*	*Equilibrium conversion for multiple reactions occur simultaneously using SCILAB*	*Unsteady state energy balance around a Continuous Stirred Tank*	*Multi-Component Flash Drum*	*Steady state simulation of multicomponent distillation using Aspen Plus*
S-6	SLO-1	*Identical problem solve using SCILAB code*	*Solve the identical problem using Aspen Plus*	*Solving unsteady state problems without reactions using SCILAB*	*Solve the model equations for multi-component flash drum using SCILAB*	*Dynamic simulation of ideal binary distillation using SCILAB*
S-7	SLO-1	*Determine the wall heat flux and heat transfer coefficient using experimental data*	*Solve the similar problem using Aspen Plus*	*Solving unsteady state problems without reactions using SCILAB*	*Identical problem solve using Aspen Plus*	*Steady state simulation of ideal distillation using Aspen Plus*
S-8	SLO-1	*Convective flux*	*Steady state macroscopic balances*	*Estimate the transient conversion and temperature in batch reactor using SCILAB*	*Non-isothermal CSTR with single reaction*	*Modeling of batch distillation column*
S-9	SLO-1	*Analogous terms in total flux expressions for various types of transport in one-dimension*	*Composition of species in mixing tanks*	*Estimate the transient conversion and temperature in batch reactor using Aspen Plus*	*Modeling of single phase vaporizer*	*Steady state simulation of batch distillation using Aspen plus*

S-10	SLO-1	*Properties estimation using Aspen Plus*	*Steady state energy balance around a continuous stirred reactor*	*Unsteady state steam Heating of a liquid*	*Modeling of mass transfer with reaction*	*Flow sheeting concepts using sequential modular approach*
S-11	SLO-1	*Solve the similar problems using Aspen Plus*	*Problem in continuous stirred reactor with reaction*	*Unsteady single stage solvent extraction*	*Steady state simulation of series of isothermal reactors*	*Demonstrate the simple flow sheet using Aspen Plus*
S-12	SLO-1	*Solve the similar problems using Aspen Plus*	*Solve the similar problems using SCILAB*	*Problem in extraction*	*Steady state simulation of series of non-isothermal reactors using Aspen Plus*	*Demonstrate the chemical plant simulation using Aspen plus*

Learning Resources	1. *William L. Luyben, Process Modeling Simulation and Control for Chemical Engineers, 2ndEdn., McGraw Hill International Editions, New York, 1990.* 2. *Ismail Tosun, Modeling in Transport Phenomena – A Conceptual Approach, 2ndEdn., Elsevier Publications 2007* 3. *Y.V.C. Rao, Chemical Engineering Thermodynamics, Universities press, 1997.* 4. *Steven C. Chapra and Raymond P. Canale, Numerical Methods for Engineers, 6thEdn., McGraw Hill International Editions, New York, 2010* 5. *H. Scott Fogler, Elements of Chemical Reaction Engineering, 4th Edition, Prentice Hall International Series*

Learning Assessment

	Bloom's Level of Thinking	Continuous Learning Assessment (50% weightage)								Final Examination (50% weightage)	
		CLA – 1 (10%)		CLA – 2 (15%)		CLA – 3 (15%)		CLA – 4 (10%)#			
		Theory	Practice	Theory	Practice	Theory	Practice	Theory	Practice	Theory	Practice
Level 1	Remember Understand	*20%*	*20%*	*15%*	*15%*	*15%*	*15%*	*15%*	*15%*	*15%*	*15%*
Level 2	Apply Analyze	*20%*	*20%*	*20%*	*20%*	*20%*	*20%*	*20%*	*20%*	*20%*	*20%*
Level 3	Evaluate Create	*10%*	*10%*	*15%*	*15%*	*15%*	*15%*	*15%*	*15%*	*15%*	*15%*
	Total	100 %		100 %		100 %		100 %		100 %	

CA – 4 can be from any combination of these: Assignments, Seminars, Tech Talks, Mini-Projects, Case-Studies, Self-Study, MOOCs, Certifications, Conf. Paper etc.,

Course Designers

Experts from Industry	Experts from Higher Technical Institutions	Internal Experts
1. Mr. A. Subramaniam, PESCO Beam Environmental Solutions Pvt. Ltd.,	*1. Dr. Lima Rose Miranda, Anna University, email: limamiranda2007@gmail.com*	*1. Dr. K. Suresh, SRMIST, Sureshk@srmist.edu.in*
2. Mr. S. T. Kalaimani, CPCL, Chennai	*2. Dr. T. R. Sundararaman, Rajalakshmi Engineering College*	*2. Dr. S. Balasubramaninan, SRMIST, balasubs@srmist.edu.in*

Course Code	18CHC350T	Course Name	COMPREHENSION	Course Category	C	Professional Core	L	T	P	C
							0	1	0	1

Pre-requisite Courses	Nil	Co-requisite Courses	Nil	Progressive Courses	Nil
Course Offering Department	Chemical Engineering	Data Book / Codes/Standards	Nil		

Course Learning Rationale (CLR):	The purpose of learning this course is to:
CLR-1 :	*Acquire skills to comprehend and solve problems in Chemical Process Calculations and Thermodynamics*
CLR-2 :	*Acquire skills to comprehend and solve problems in Mechanical Operations and Fluid Mechanics*
CLR-3 :	*Acquire skills to comprehend and solve problems in Heat Transfer and Mass Transfer*
CLR-4 :	*Acquire skills to comprehend and solve problems in Reaction Engineering and Process Control*
CLR-5 :	*Acquire skills to comprehend and solve problems for competitive examinations in Chemical Engineering*
CLR-6 :	*Acquire skills to comprehend and solve real world problems in the broad domain of Chemical Engineering*

Course Learning Outcomes (CLO):	At the end of this course, learners will be able to:	Learning 1: Level of Thinking (Bloom)	2: Expected Proficiency (%)	3: Expected Attainment (%)	PLO 1: Engineering Knowledge	2: Problem Analysis	3: Design & Development	4: Analysis, Design, Research	5: Modern Tool Usage	6: Society & Culture	7: Environment & Sustainability	8: Ethics	9: Individual & Team Work	10: Communication	11: Project Mgt. & Finance	12: Life Long Learning	13: PSO - 1	14: PSO - 2	15: PSO - 3
CLO-1 :	*Practice and gain competence to solve problems in Chemical Process Calculations and Thermodynamics*	3	80	75	H	H	H	M	M	L	L	L	L	L	L	L	H	H	M
CLO-2 :	*Practice and gain competence to solve problems in Mechanical Operations and Fluid Mechanics*	3	80	75	H	H	M	M	M	L	L	L	L	L	L	L	H	H	M
CLO-3 :	*Practice and gain competence to solve problems in Heat Transfer and Mass Transfer*	3	80	75	H	H	M	M	M	L	L	L	L	L	L	L	H	H	M
CLO-4 :	*Practice and gain competence to solve problems in Reaction Engineering and Process Control*	3	80	75	H	H	M	M	M	L	L	L	L	L	L	L	H	H	M
CLO-5 :	*Practice and gain competence to solve problems for competitive examinations in Chemical Engineering*	3	80	75	H	H	H	M	M	L	L	L	L	L	L	L	M	M	M
CLO-6 :	*Practice and gain confidence and competence to solve problems in broad domain of Chemical Engineering*	3	75	70	H	H	M	M	M	L	L	L	L	L	L	L	M	M	M

Duration (hour)		3	3	3	3	3
S-1	SLO-1	*Tutorial on Chemical Process Calculations*	*Tutorial on Mechanical Operations*	*Tutorial on Heat Transfer*	*Tutorial on Reaction Engineering*	*Problem Solving - Practice*
	SLO-2	*Tutorial on Chemical Process Calculations*	*Tutorial on Mechanical Operations*	*Tutorial on Heat Transfer*	*Tutorial on Reaction Engineering*	*Problem Solving - Practice*
S-2	SLO-1	*Tutorial on Thermodynamics*	*Tutorial on Fluid Mechanics*	*Tutorial on Mass transfer*	*Tutorial on Process Control*	*Problem Solving - Practice*
	SLO-2	*Tutorial on Thermodynamics*	*Tutorial on Fluid Mechanics*	*Tutorial on Mass transfer*	*Tutorial on Process Control*	*Problem Solving - Practice*
S-3	SLO-1	*Problem Solving*	*Problem Solving*	*Problem Solving*	*Problem Solving*	*Problem Solving - Practice*
	SLO-2	*Problem Solving*	*Problem Solving*	*Problem Solving*	*Problem Solving*	*Problem Solving - Practice*

Learning Resources	
	1. *M. Subbu, An Insight Into Chemical Engineering, Rishal Publications*

Learning Assessment

	Bloom's Level of Thinking	Continuous Learning Assessment (100% weightage) CLA – 1 (20%) Theory	CLA – 1 (20%) Practice	CLA – 2 (30%) Theory	CLA – 2 (30%) Practice	CLA – 3 (30%) Theory	CLA – 3 (30%) Practice	CLA – 4 (20%)# Theory	CLA – 4 (20%)# Practice	Final Examination Theory	Final Examination Practice
Level 1	Remember / Understand	-	*40%*	-	*30%*	-	*30%*	-	*30%*	-	-
Level 2	Apply / Analyze	-	*40%*	-	*40%*	-	*40%*	-	*40%*	-	-
Level 3	Evaluate / Create	-	*20%*	-	*30%*	-	*30%*	-	*30%*	-	-
	Total	100 %		100 %		100 %		100 %		-	

CLA – 4 can be from any combination of these: Assignments, Seminars, Tech Talks, Mini-Projects, Case-Studies, Self-Study, MOOCs, Certifications, Conf. Paper etc.,

Course Designers		
Experts from Industry	Experts from Higher Technical Institutions	Internal Experts
1. Mr. A. Subramaniam, PESCO Beam Environmental Solutions Pvt. Ltd	*1. Dr. Lima Rose Miranda, Anna University, email: limamiranda2007@gmail.com*	*Mr. V. Ganesh, SRMIST*
2. Mr. S. T. Kalaimani, CPCL, Chennai	*2. Dr. T. R. Sundararaman, Rajalakshmi Engineering College*	

ACADEMIC CURRICULA

Professional Core Courses

CIVIL ENGINEERING

Regulations - 2018

SRM INSTITUTE OF SCIENCE AND TECHNOLOGY

(Deemed to be University u/s 3 of UGC Act, 1956)

Kattankulathur, Kancheepuram, Tamil Nadu, India

Course Code	18CEC301T	Course Name	HYDROLOGY AND WATER RESOURCES ENGINEERING	Course Category	C	Professional Core	L	T	P	C
							3	1	0	4

Pre-requisite Courses	Nil	Co-requisite Courses	Nil	Progressive Courses	18CEE311T, 18CEE312T, 18CEE313T
Course Offering Department	CIVIL ENGINEERING	Data Book / Codes/Standards	Nil		

Course Learning Rationale (CLR):	The purpose of learning this course is to:
CLR-1 :	*Provide knowledge on various processes in the hydrologic cycle*
CLR-2 :	*Address the occurrence, movement and augmentation of groundwater*
CLR-3 :	*Provide deep understanding of various impounding and diversion structures*
CLR-4 :	*Create insights on the importance and characteristics of rivers and reservoirs*
CLR-5 :	*Address concepts related to necessity of irrigation, methods of applying water to the fields and evapotranspiration*
CLR-6 :	*Introduce various hydraulic structures and exploit their practical importance*

Course Learning Outcomes (CLO):	At the end of this course, learners will be able to:	Learning 1: Level of Thinking (Bloom)	2: Expected Proficiency (%)	3: Expected Attainment (%)	PLO 1: Engineering Knowledge	2: Problem Analysis	3: Design & Development	4: Analysis, Design, Research	5: Modern Tool Usage	6: Society & Culture	7: Environment & Sustainability	8: Ethics	9: Individual & Team Work	10: Communication	11: Project Mgt. & Finance	12: Life Long Learning	13: PSO - 1	14: PSO - 2	15: PSO – 3
CLO-1 :	*Understand the interaction among various processes in the hydrologic cycle*	2	85	80	H	H	M	M	-	-	M	-	-	-	-	-	H	-	-
CLO-2 :	*Intellectualize the basic aquifer parameters and estimate groundwater resources for different hydro-geological boundary conditions*	3	85	75	H	H	-	-	-	-	M	-	-	-	-	-	H	-	-
CLO-3 :	*Understand the importance, features and uses of diversion and impounding structures*	3	80	75	H	-	-	-	-	-	M	-	-	-	-	-	H	-	-
CLO-4 :	*Perceive the importance of rivers, reservoirs and silt control*	2	85	80	H	-	-	-	-	-	M	-	-	-	-	-	H	-	-
CLO-5 :	*Understand the basics of irrigation, soil-water relationships and consumptive use*	2	85	75	H	H	M	M	-	-	M	-	-	-	-	-	H	-	-
CLO-6 :	*Identify the functions and importance of various hydraulic structures*	3	80	75	H	H	-	-	-	-	M	-	-	-	-	-	H	-	-

Duration (hour)		SURFACE WATER HYDROLOGY	GROUND WATER HYDROLOGY	DIVERSION AND IMPOUNDING STRUCTURES	RIVERS AND RESERVOIRS	IRRIGATION AND DISTRIBUTION SYSTEMS
		12	12	12	12	12
S-1	SLO-1	*Introduction, hydrologic cycle*	*Occurrence of ground water, porosity*	*Weirs and barrages*	*Rivers: types and characteristics*	*Irrigation, necessity, advantages and disadvantages*
	SLO-2	*World water balance, applications in engineering*	*Permeability and transmissibility*	*Gravity and non-gravity weirs*	*Classification based on the basis of the topography of the river basin*	*Methods of applying water to the fields*
S-2	SLO-1	*Precipitation, forms and types*	*Zones of subsurface water*	*Diversion head works and its components*	*Classification based on the basis of flood hydrographs*	*Surface, subsurface, sprinkler and drip irrigation*
	SLO-2	*Measurement of precipitation, rain gauge network*	*Movement of groundwater, Darcy's law*	*Functions of weir proper, under sluices, divide wall, fish ladder and canal head regulator*	*Indian rivers and their classification*	*Soil-water-plant relationship*
S-3	SLO-1	*Mean areal depth of precipitation, arithmetic average method*	*Specific yield and specific retention*	*Failure of hydraulic structures*	*Behaviour of rivers: straight reaches, bends and meanders*	*Hygroscopic water, capillary water and gravitational water*
	SLO-2	*Thiessen polygon method and isohyetal method*	*Aquifers and their types*	*Failure by piping and failure by direct uplift*	*Causes of meandering, cutoff*	*Field capacity, permanent wilting point, available moisture, readily available moisture*
S-4	SLO-1	*Tutorial*	*Tutorial*	*Tutorial*	*Tutorial*	*Tutorial*
	SLO-2	*Tutorial*	*Tutorial*	*Tutorial*	*Tutorial*	*Tutorial*
S-5	SLO-1	*Estimation of missing precipitation*	*Specific capacity and coefficient of storage*	*Bligh's creep theory*	*River training: objectives and classification*	*Depth of water stored in root zone*
	SLO-2	*Optimum raingauge network design*	*Infiltration wells and infiltration galleries*	*Lane's weighted creep theory*	*Types of training works*	*Limiting soil moisture conditions, depth and frequency of irrigation*
S-6	SLO-1	*Probable Maximum Precipitation*	*Open wells and tube wells*	*Khosla's theory*	*Levees, guide banks*	*Crop season, duty and delta*

	SLO-2	*Runoff process, components of stream flow*	*Types of tube wells*	*Khosla's method of independent variables for determination of pressures and exit gradient for seepage below a weir or a barrage*	*Artificial cutoff and pitched island*	*Factors affecting duty and method of improving duty*
S-7	SLO-1	*Factors affecting runoff*	*Yield of an open well, pumping test*	*Design of pucca floor and aprons*	*Groynes: types – normal, attracting and deflecting*	*Consumptive use: estimation by Blaney Criddle method and pan evaporation method*
	SLO-2	*Estimation of runoff, empirical formulae*	*Recuperation test*	*Design of pucca floor and aprons*	*Reservoir: types*	*Canal: types of alignment*
S-8	SLO-1	*Tutorial*	*Tutorial*	*Tutorial*	*Tutorial*	*Tutorial*
	SLO-2	*Tutorial*	*Tutorial*	*Tutorial*	*Tutorial*	*Tutorial*
S-9	SLO-1	*Infiltration method*	*Steady state flow in wells*	*Dams, function and uses, classification*	*Suitable site for a reservoir and storage zones*	*Distribution systems, channel losses*
	SLO-2	*SCS-CN method of estimating runoff volume*	*Dupuit's equilibrium equation for confined and unconfined aquifers*	*Factors governing the selection of a particular type of dam*	*Storage-discharge relation of a reservoir*	*Design of channels: rigid boundary channels and alluvial channels*
S-10	SLO-1	*Flow duration curve*	*Theim's equation for confined aquifer*	*Selection of dam site, problems in dam construction*	*Reservoir yield, safe yield, design yield, secondary yield and average yield*	*Kennedy's and Lacey's theories of regime channels*
	SLO-2	*Flow mass curve*	*Theim's equation for unconfined aquifer*	*Gravity dams: forces on gravity dams*	*Mass curve and demand curve*	*Water logging: causes, effects and remedial measures*
S-11	SLO-1	*Hydrograph, components of hydrograph*	*Spacing of wells*	*Modes of failure, construction of gravity dams*	*Designing reservoir capacity for a given yield and designing yield from a reservoir of a given capacity*	*Functions and uses of canal regulator and cross regulator*
	SLO-2	*Environmental flows*	*Artificial recharge methods*	*Galleries: functions and types. Earthen dam: types and causes of failure*	*Reservoir sedimentation: pre and post control measures, economic height of dam*	*Functions and uses of canal fall, canal escape and cross drainage works*
S -12	SLO-1	*Tutorial*	*Tutorial*	*Tutorial*	*Tutorial*	*Tutorial*
	SLO-2	*Tutorial*	*Tutorial*	*Tutorial*	*Tutorial*	*Tutorial*

Learning Resources	1. *Santosh Kumar Garg, Irrigation Engineering and Hydraulic Structures, Khanna Publication, New Delhi, 2000.* 2. *Subramanya, K., Engineering Hydrology, Tata Mc-Graw Hill* 3. *Asawa, G.L.., Irrigation Engineering, Wiley Eastern* 4. *Ven Te Chow, David R. Maidment and Larry W. Mays, Applied Hydrology, McGraw-Hill Book Company*	*5. Raghunath, H.M., Hydrology, New Age International Publishers, New Delhi, 2007.* *6. Sharma, R.K., Irrigation Engineering and Hydraulic Structures, Oxford and IBH Publishing Company, New Delhi* *7. Punmia, B.C., and Pande, B.B., Irrigation and Water Power Engineering, Laxmi Publications Pvt. Ltd., New Delhi, 2009* *8..NPTEL Course: Water Resources Engineering: https://nptel.ac.in/downloads/105105110/#,*

Learning Assessment

	Bloom's Level of Thinking	Continuous Learning Assessment (50% weightage)								Final Examination (50% weightage)	
		CLA – 1 (10%)		CLA – 2 (15%)		CLA – 3 (15%)		CLA – 4 (10%)#			
		Theory	Practice	Theory	Practice	Theory	Practice	Theory	Practice	Theory	Practice
Level 1	Remember Understand	40 %	-	30 %	-	30 %	-	30 %	-	30%	-
Level 2	Apply Analyze	40 %	-	40 %	-	40 %	-	40 %	-	40%	-
Level 3	Evaluate Create	20 %	-	30 %	-	30 %	-	30 %	-	30%	-
	Total	100 %		100 %		100 %		100 %		100 %	

CLA – 4 can be from any combination of these: Assignments, Seminars, Tech Talks, Mini-Projects, Case-Studies, Self-Study, MOOCs, Certifications, and Conf. Paper etc.

Course Designers		
Experts from Industry	Experts from Higher Technical Institutions	Internal Experts
1. Mr. Abdul Hakeem, National Remote Sensing Center, Hyderabad, abdulhakeem_k@nrsc.gov.in	1. Dr. Rehana Shaik, IIIT, Hyderabad, rehana.s@iiit.ac.in	1. Dr. R. Sathyanathan, SRMIST
2. Dr. Sat Kumar Tomer, Satyukt Analytics Pvt Ltd., Bengaluru, sat@satyukt.com	2. Dr. S. Saravanan, NIT Trichy, saravanans@nitt.edu	2. Dr. Deeptha Thattai, SRMIST

Course Code	18CEC302T	Course Name	GEOTECHNICAL ENGINEERING	Course Category	C	Professional Core	L	T	P	C
							2	1	0	3

Pre-requisite Courses	Nil	Co-requisite Courses	Nil	Progressive Courses	Nil
Course Offering Department	CIVIL ENGINEERING	Data Book / Codes/Standards	Nil		

Course Learning Rationale (CLR):	*The purpose of learning this course is to:*
CLR-1 :	*Create insights in to different properties of soil*
CLR-2 :	*Deal with the classification and identification of soil*
CLR-3 :	*Understand concept of permeability and seepage of soils*
CLR-4 :	*Analyse the consolidation and compaction effect on soil in lab and field*
CLR-5 :	*Analyse the principles of effective stress in saturated soils, various soil condition the shear strength of the soils*
CLR-6 :	*Utilize the concept of various soil condition and shear strength of the soils in real time applications*

Course Learning Outcomes (CLO):	*At the end of this course, learners will be able to:*	Learning 1	Learning 2	Learning 3	PLO 1	PLO 2	PLO 3	PLO 4	PLO 5	PLO 6	PLO 7	PLO 8	PLO 9	PLO 10	PLO 11	PLO 12	PLO 13	PLO 14	PLO 15
		Level of Thinking (Bloom)	Expected Proficiency (%)	Expected Attainment (%)	Engineering Knowledge	Problem Analysis	Design & Development	Analysis, Design, Research	Modern Tool Usage	Society & Culture	Environment & Sustainability	Ethics	Individual & Team Work	Communication	Project Mgt. & Finance	Life Long Learning	PSO - 1	PSO - 2	PSO – 3
CLO-1 :	*Identify the various properties of soil*	*2*	*85*	*80*	*H*	*H*	-	-	-	-	-	-	-	-	-	-	*H*	-	-
CLO-2 :	*Analyse the classification of soil*	*2*	*85*	*75*	*H*	*H*	-	*M*	-	-	-	-	-	-	-	-	*H*	-	-
CLO-3 :	*Identify permeability and seepage of soils*	*2*	*80*	*75*	*H*	*H*	-	-	-	-	-	-	-	-	-	-	*H*	-	-
CLO-4 :	*Identify the consolidation and compaction effect on soil in lab and field*	*2*	*85*	*80*	*H*	*H*	-	-	-	-	-	-	-	-	-	-	*H*	-	-
CLO-5 :	*Apply the principles of effective stress in saturated soils, various soil condition the shear strength of the soils*	*2*	*85*	*80*	*H*	*H*	-	*M*	-	-	-	-	-	-	-	-	*H*	-	-
CLO-6 :	*Analyse the concept of various soil condition and shear strength of the soils in real time applications*	*2*	*80*	*75*	*H*	*H*	-	*M*	-	-	-	-	-	-	-	-	*H*	-	-

Duration (hour)		09	09	09	09	09
S-1	SLO-1	*Introduction-Definitions: soils*	*Particle size distribution*	*Permeability of Soil-importance*	*Compaction of Soil*	*Introduction- Stresses in soils*
	SLO-2	*Soil mechanics*	*Sieve analysis - problem*	*Introduction to hydraulic head*	*Introduction, theory of compaction,*	*Geostatic stress*
S-2	SLO-1	*Scope of Geotechnical engineering,*	*Plasticity Characteristics of soil*	*Darcy's law - Assumptions.*	*Laboratory determination of optimum moisture content and maximum dry density*	*Total - Effective and Neutral stress,*
	SLO-2	*Basic Definitions and Relationships-*	*Introduction to definitions of: plasticity of soil*	*Determination of coefficient of permeability*	*Standard Proctor test and Modified Proctor test – Problems in compaction*	*Fluctuations of effective stress*
S-3	SLO-1	*Two and three phase system of soil*	*Consistency limits-liquid limit, plastic limit*	*Laboratory method: Constant head method problems*	*Compactive energy –Factors affecting compaction*	*Effective stress in soils saturated by capillary action,*
	SLO-2	*Relationships in terms of weightand volume in phase system – moisture content*	*Shrinkage limit, Determination of: liquid limit*	*Coefficient of permeability*	*CBR of soil – procedure - problem*	*Problems in Geostatic stress – soil condition*
S-4	SLO-1	*Definitions: degree of saturation, void ratio, porosity*	*Determination of plastic limit and shrinkage limit.*	*Falling head method - problems*	*Field compaction methods*	*Problems in Geostatic stress – water table effect*
	SLO-2	*specific gravity, unit weights*	*Indices: Plasticity, liquidity and consistency, flow and toughness*	*Field method: types*	*Factors affecting field compaction*	*Shear Strength- Lab and filed methods*
S-5	SLO-1	*Relationship between bulk and dry density , void ratio- porosity, void ratio*	*Definition: Activity and sensitivity.*	*Pumping-out test – Confined aquifer*	*Consolidation of Soil*	*Shear test: direct shear test*
	SLO-2	*Water content- specific gravity-degree of saturation*	*Classification of Soils*	*Field method - Unconfined aquifer*	*Introduction, comparison between compaction and consolidation,*	*Shear test: merits and demerits - problem*
S6	SLO-1	*Unit weights - specific gravity - void ratio – degree of saturation –*	*Introduction of soil classification system*	*problems in field methods*	*Initial, primary consolidation*	*Unconfined compression test - problem*
	SLO-2	*Moisture content determination – Methods, Determination by oven dry method*	*methods:- particle size classification*	*Permeability in stratified soils*	*Secondary consolidation*	*Triaxial compression tests.*

S-7	SLO-1	*Problems in two phase system.*	*Indian standard soil classification system*	*Flow parallel and perpendicular to bedding plane - problems*	*Spring analogy for primary consolidation,*	*Drainage conditions*
	SLO-2	*Problems in three phase system.*	*Indian Soil classification system cohesive soil, cohesionless soil.*	*Factors affecting permeability of soil*	*Terzaghi's theory of one dimensional consolidation*	*Merits and demerits*
S-8	SLO-1	*Specific gravity – methods,*	*Indian Soil classification system –- Problems*	*Quick sand condition - Seepage Analysis*	*Partial differential equations (no analytical)*	*Drainage conditions- problem*
	SLO-2	*Determination by density bottle method and pycnometer method*	*Problems in BIS system*	*Introduction- seepage pressure.*	*Laboratory tests-*	*Relation between major and minor principal stresses*
S-9	SLO-1	*Field density methods – Determination by core cutter method*	*Soil identification*	*Characteristics of flow nets*	*Determination of coefficient of consolidation*	*Vane shear test. – problem*
	SLO-2	*Sand replacement method.*	*Field identification of soils.*	*Uses and application of flow nets.*	*$\sqrt{t}$ andLog t methods.*	*Factors affecting shear strength*

Learning Resources	1. *Raju .K.V.B .and Ravichandran .P.T, "Mechanics of Soils", Ayyappaa Publications, 2000.* 2. *Punmia B.C., Soil Mechanics and Foundations, Laxmi Publications Pvt. Ltd., 2000* 3. *Arora .K.R, "Soil Mechanics and Foundation Engineering", Standard Publication Distributors, 2011.* 4. *Gopal Ranjan, Rao.A.S.R., Basic and Applied Soil Mechanics, Wiley Eastern Ltd., 2000*	5. *Terzaghi K., Peck R.B., Soil Mechanics in Engineering Practice, John Wiley Ltd., 1967* 6. *Lambe T.W., Whitman, Soil Mechanics, John Wiley Ltd., 1979.* 7. *NPTEL Course - Soil Mechanics / Geotechnical Engineering1 : https://nptel.ac.in/courses/105105168/* 8. *NPTEL Course - Concepts in Geotechnical and Foundation Engineering : https://nptel.ac.in/courses/105106142/*

Learning Assessment

	Bloom's Level of Thinking	Continuous Learning Assessment (50% weightage)								Final Examination (50% weightage)	
		CLA – 1 (10%)		CLA – 2 (15%)		CLA – 3 (15%)		CLA – 4 (10%)#			
		Theory	Practice	Theory	Practice	Theory	Practice	Theory	Practice	Theory	Practice
Level 1	Remember Understand	*40%*	-	*30%*	-	*30%*	-	*30%*	-	*30%*	-
Level 2	Apply Analyze	*30%*	-	*40%*	-	*40%*	-	*40%*	-	*40%*	-
Level 3	Evaluate Create	*30%*	-	*30%*	-	*30%*	-	*30%*	-	*30%*	-
	Total	100 %		100 %		100 %		100 %		100 %	

CLA – 4 : Assignments and / or Multiple choice Quizzes

Course Designers

Experts from Industry	Experts from Higher Technical Institutions	Internal Experts
Dr. P.Selvanambi, Divisional Engineer (Highways), sundariselvam@yahoo.com	*Dr.M.Muttharam, Anna University, muttharam@annauniv.edu*	*Dr. P.T. Ravichandran, SRMIST*
Mr.Lenin K.R., Head –GEOTECH, SECON Private Limited, Bangalore, lenin.kr@secon.in	*Dr.V.Murugaiyan, Pondichery Engineering College, vmurugaiyan@pec.edu*	*Ms.Divya Krishnan K, SRMIST*

Course Code	18CEC302L	Course Name	GEOTECHNICAL ENGINEERING LABORATORY	Course Category	C	Professional Core	L	T	P	C
							0	0	2	1

Pre-requisite Courses	Nil	Co-requisite Courses	Nil	Progressive Courses	Nil
Course Offering Department	Civil Engineering	Data Book / Codes/Standards	Nil		

Course Learning Rationale (CLR):	*The purpose of learning this course is to:*
CLR-1 :	*Determine the engineering and index properties of soils*
CLR-2 :	*Determine the compaction and CBR value of soil*
CLR-3 :	*Impart knowledge on permeability characteristics of soil*
CLR-4 :	*Determine the filed density of soil*
CLR-5 :	*Determine the shear strength of soil*
CLR-6 :	*Study the working principle and function of triaxial shear test*

		Learning			Program Learning Outcomes (PLO)														
		1	2	3	1	2	3	4	5	6	7	8	9	10	11	12	13	14	15
Course Learning Outcomes (CLO):	*At the end of this course, learners will be able to:*	Level of Thinking (Bloom)	Expected Proficiency (%)	Expected Attainment (%)	Engineering Knowledge	Problem Analysis	Design & Development	Analysis, Design, Research	Modern Tool Usage	Society & Culture	Environment & Sustainability	Ethics	Individual & Team Work	Communication	Project Mgt. & Finance	Life Long Learning	PSO - 1	PSO - 2	PSO – 3
CLO-1 :	*Identify the use of sieve, Atterberg's apparatus in determination of soil properties.*	*2*	*90*	*85*	*H*	*H*	-	-	-	-	-	-	*H*	-	-	-	*M*	-	*H*
CLO-2 :	*Estimate the OMC and Density to compact and CBR value of soil*	*2*	*85*	*80*	*H*	*H*	-	-	-	-	-	-	*H*	-	-	-	*M*	-	*H*
CLO-3 :	*Analyse the permeability characteristics of various soil.*	*2*	*90*	*85*	*H*	*H*	-	-	-	-	-	-	*H*	-	-	-	*M*	-	*H*
CLO-4 :	*Measure the density of soil in-situ*	*2*	*85*	*80*	*H*	*H*	-	-	-	-	-	-	*H*	-	-	-	*M*	-	*H*
CLO-5 :	*Evalute the shear strength of soil*	*2*	*85*	*80*	*H*	*H*	-	-	-	-	-	-	*H*	-	-	-	*M*	-	*H*
CLO-6 :	*Understand the working principle and use of triaxial shear test*	*2*	*85*	*80*	*H*	*H*	-	-	-	-	-	-	*H*	-	-	-	*M*	-	*H*

Duration (hour)		6	6	6	6	6
S 1-2	SLO-1 SLO-2	*Moisture content using oven drying method*	*Consistency limits - Liquid limit, Plastic limit and Shrinkage limit.*	*Compaction test - Standard Proctor method*	*California Bearing Ratio of soil*	*Direct shear test*
S 3-4	SLO-1 SLO-2	*Specific gravity of soil grains*	*Permeability - Constant head method.*	*Field density - Core cutter method and Sand replacement method*	*Unconfined compression strength test*	*Triaxial shear test*
S 5-6	SLO-1 SLO-2	*Grain size distribution by sieve analysis*	*Permeability - Falling head method*	*Relative density of cohesion less soil*	*Free swell index test*	*Vane shear test*

Learning Resources	
	5. Raju .K.V.B .and Ravichandran .P.T, "Mechanics of Soils", Ayyappaa Publications, 2000. *6. Punmia B.C., Soil Mechanics and Foundations, Laxmi Publications Pvt. Ltd., 2000* *7. Laboratory Manual for Soil Mechanics Laboratory, SRMIST* *8. Terzaghi K., Peck R.B., Soil Mechanics in Engineering Practice, John Wiley Ltd., 1967* *5. NPTEL course – Geotechnical Engineering Laboratory : https://nptel.ac.in/courses/105101160/*

Learning Assessment

	Bloom's Level of Thinking	Continuous Learning Assessment (50% weightage)								Final Examination (50% weightage)	
		CLA – 1 (10%)		CLA – 2 (15%)		CLA – 3 (15%)		CLA – 4 (10%)#			
		Theory	Practice	Theory	Practice	Theory	Practice	Theory	Practice	Theory	Practice
Level 1	Remember / Understand	-	*40%*	-	*30%*	-	*30%*	-	*30%*	-	*30%*
Level 2	Apply / Analyze	-	*40%*	-	*40%*	-	*40%*	-	*40%*	-	*40%*
Level 3	Evaluate / Create	-	*20%*	-	*30%*	-	*30%*	-	*30%*	-	*30%*
	Total	100 %		100 %		100 %		100 %		100 %	

CLA – 4 can be from Record and Model Examination.

Course Designers

Experts from Industry	Experts from Higher Technical Institutions	Internal Experts
Dr. P.Selvanambi, Divisional Engineer (Highways), sundariselvam@yahoo.com	*Dr.M.Muttharam, Anna University, muttharam@annauniv.edu*	*Ms.S. Mary Rebekah Sharmila, SRMIST.*
Mr.Lenin K.R., Head –GEOTECH, SECON Private Limited, Bangalore, lenin.kr@secon.in	*Dr.V.Murugaiyan, Pondichery Engineering College, vmurugaiyan@pec.edu*	*Ms.Divya Krishnan K, SRMIST*

Course Code	18CEC303T	Course Name	HIGHWAY ENGINEERING AND DESIGN	Course Category	C	Professional Core Course	L	T	P	C
							2	1	0	3

Pre-requisite Courses	Nil	Co-requisite Courses	Nil	Progressive Courses	Nil
Course Offering Department	CIVIL ENGINEERING	Data Book / Codes/Standards	Nil		

Course Learning Rationale (CLR):	*The purpose of learning this course is to:*
CLR-1 :	*Understand the concepts in the geometric design of highway*
CLR-2 :	*Learn the needs and concepts in horizontal and vertical alignment of highway*
CLR-3 :	*Learn various traffic studies required for traffic management*
CLR-4 :	*Learn the design of various infrastructure facilities required for the traffic*
CLR-5 :	*Understand the material requirement of flexible pavement and design the pavement*
CLR-6 :	*Understand the components of rigid pavement and its design*

Course Learning Outcomes (CLO):	At the end of this course, learners will be able to:	Learning 1: Level of Thinking (Bloom)	2: Expected Proficiency (%)	3: Expected Attainment (%)	PLO 1: Engineering Knowledge	2: Problem Analysis	3: Design & Development	4: Analysis, Design, Research	5: Modern Tool Usage	6: Society & Culture	7: Environment & Sustainability	8: Ethics	9: Individual & Team Work	10: Communication	11: Project Mgt. & Finance	12: Life Long Learning	13: PSO - 1	14: PSO - 2	15: PSO – 3
CLO-1 :	*Design the geometric cross-section of highway*	2	85	80	H	H	M	H	-	-	M	-	-	-	-	-	M	-	-
CLO-2 :	*Design the horizontal and vertical alignment of highway*	2	85	75	H	H	H	H	-	-	M	-	-	-	-	-	M	-	-
CLO-3 :	*Conduct various traffic studies and analysis the volume and speed data*	2	80	75	M	H	L	L	-	-	M	-	-	-	-	-	M	-	-
CLO-4 :	*Plan and design the various infrastructure facilities required for the traffic*	2	85	75	H	H	H	H	-	-	H	-	-	-	-	-	M	-	-
CLO-5 :	*Execute the material and the structural design of flexible pavement*	2	85	80	H	H	M	H	-	-	M	-	-	-	-	-	M	-	-
CLO-6 :	*Execute the material and the structural design of flexible pavement*	2	80	75	H	H	M	H	-	-	M	-	-	-	-	-	M	-	-

Duration (hour)		9	9	9	9	9
S-1	SLO-1	*Highway Geometric Design Elements of transportation Engineering*	*Extra widening and numerical examples*	*Traffic Facilities Design Traffic signs and*	*Flexible Pavement Component of Flexible pavement*	*Rigid Pavement Components of Rigid pavement*
	SLO-2	*Overviewof the course*	*Method of attaining superelevation in curves*	*Road markings*	*Functions of each component*	*Components of Rigid pavement – Details of joints*
S-2	SLO-1	*Highway planning and Alignment*	*Set back distance and shift in curves with numerical examples*	*Channelization of traffic*	*Materials - Basic properties of bitumen*	*Stresses in Rigid pavement – Temperature stress*
	SLO-2	*Classification of rural and urban roads*	*Reverse curve and compound curve*	*Channelization layouts*	*Binder grade and classification*	*Stresses in Rigid pavement – Temperature stress – numerical examples*
S-3	SLO-1	*Cross sectional elements of roads*	*Design of vertical alignment – summit curve*	*Traffic rotary - design elements capacity of rotary*	*Materials – Soil and aggregate properties*	*Stresses in Rigid pavement – Wheel load stress*
	SLO-2	*Terrain classification and speed and geometric standards for different terrain*	*Design of vertical alignment – summit curve – numerical example*	*Capacity ofrotary*	*Resilient modulus of aggregate and soil*	*Stresses in Rigid pavement – Wheel load stress – Numerical examples*
S-4	SLO-1	*Sight Distance – Stopping sight distance – Concept and derivations*	*Design of vertical alignment – valley curve*	*Rotary design - Numerical Example*	*Materials – Bituminous concrete mix properties*	*Stress combinations and critical stress*
	SLO-2	*Stopping sight distance – Numerical examples*	*Design of vertical alignment – valley curve – Numerical example*	*Rotary design - Numerical Example*	*Materials – Types of bituminous concrete mix*	*Thickness of Rigid pavement*
S-5	SLO-1	*Overtaking sight distance – assumptions and derivations*	*Traffic studies Fundamental traffic parameters - speed, density, volume, travel time*	*Grade separated intersection – Warrants and types*	*Bituminous concrete mix design*	*Design of Joint spacing*
	SLO-2	*Overtaking sight distance – Numerical examples*	*Headway, and spacing -time mean speed, space mean speed – spot speed*	*Layout of grade separated intersection*	*Bituminous concrete mix design*	*Design of Joint spacing – Numerical examples*

S-6	SLO-1	*Overtaking sight distance – Numerical examples*	*Traffic volume study – need and procedure*	*Elementsof traffic signal - headway, saturation flow*	*Flexible pavement design factor – Traffic factor*	*Dowel bar design*
	SLO-2	*Intersection sightdistance*	*Traffic volume calculation and analysis*	*Design principles of a traffic signal – Phase design, cycle time determination, green splitting*	*Traffic– equivalent single wheel load and standard axle load*	*Design of dowel bars – Numerical examples*
S-7	SLO-1	*Horizontal curve – circular curve radius*	*Spotspeed study – need and procedure*	*Two phase signal design – Numerical example*	*Traffic factor - truck factor, vehicle damage factor,number of repetition of standard axle load*	*Check for the adequacy of dowel bars – Numerical example*
	SLO-2	*Super elevation and minimum ruling radius*	*Traffic speed analysis*	*Two phase signal design – Numerical example*	*Number of repetition of standard axle load – Numerical examples*	*Check for the adequacy of dowel bars – Numerical example*
S-8	SLO-1	*Determination of radius and super elevation – numerical example*	*Speed study – Moving observer method*	*Three phase signal design- with exclusive pedestrian phase – Numerical example -*	*Design of flexible pavement – determination of pavement thickness (with unbounded layers)*	*Design of tie bars*
	SLO-2	*Determination of radius and super elevation – numerical example*	*Moving observer method – numerical calculation*	*Three phase signal design- with exclusive pedestrian phase – Numerical example -*	*Design of flexible pavement – determination of pavement thickness (with unbounded layers)*	*Design of tie bars – numericalexamples*
S-9	SLO-1	*Transition curve – length – assumptions and derivations*	*Parking study and demand analysis*	*Signal co-ordination*	*Design of flexible pavement – determination of pavement thickness (with bonded layers)*	*Codal provisions and issues in current design methods*
	SLO-2	*Transition curve – length – Numerical examples*	*Data to be studied in accident spots*	*Signal co-ordination – determination of bandwidth*	*Design of flexible pavement – determination of pavement thickness (with bonded layers)*	*Codal provisions and issues in current design methods*

Learning Resources	1. *Chakroborthy and A. Das, "Principles of Transportation Engineering", Prentice-Hall of India, 2003* 2. *S. K. Khanna, C.E.G. Justo and A. Veeraragavan, "Highway Engineering", Revised 10th edition, Nem Chand &Bros., Roorkee, 2014.* 3. *Roess, R. P. McShane, W. R. & Prassas, E. S. (1998), Traffic Engineering, Prentice – Hall.*	4. *Papacostas, C. S. and Prevedouros, P.D. (2001) "Transportation Engineering and Planning", Prentice Hall of India Pvt. Ltd.* 5. *Kadiyali, L. R. (1987), "Traffic Engineering and Transportation Planning", Khanna Publishers, India.* 6. *Yang Huang, Pavement Analysis and Design, Pearson, 2004* 7. *NPTEL – Introduction to Transportation Engineering - https://nptel.ac.in/courses/105105107/ (as on 05.07.2019)*

Learning Assessment											
	Bloom's Level of Thinking	Continuous Learning Assessment (50% weightage)								Final Examination (50% weightage)	
		CLA – 1 (10%)		CLA – 2 (15%)		CLA – 3 (15%)		CLA – 4 (10%)			
		Theory	Practice	Theory	Practice	Theory	Practice	Theory	Practice	Theory	Practice
Level 1	Remember Understand	*30%*	-	*30%*	-	*30%*	-	*30%*	-	*30%*	-
Level 2	Apply Analyze	*40%*	-	*40%*	-	*40%*	-	*40%*	-	*40%*	-
Level 3	Evaluate Create	*30%*	-	*30%*	-	*30%*	-	*30%*	-	*30%*	-
	Total	100 %		100 %		100 %		100 %		100 %	

CLA – 4 can be from any combination of Assignments, Seminars, Tech Talks, Mini Projects, Case Studies, Self Study, MOOCs, Certifications, Conference Paper

Course Designers		
Experts from Industry	Experts from Higher Technical Institutions	Internal Experts
Dr. Asif Ahmed, Business manager, Ingevity, ahmed.asif@ingevity.com	*Dr. Venkaiah Chowdary, Associate Professor, NITW, vc@nitw.ac.in*	*Dr.A.Padma Rekha, SRM IST*
Mr. Ankit Pachouri, Transport Planner, IUT, New Delhi, ankit.pachouri@iutundia.org	*Dr. V Sunitha, Assistant Professor, NITT, sunitha@nitt.edu*	*Mr.G.Sivaprakash, SRM IST*

Course Code	18CEC303L	Course Name	HIGHWAY ENGINEERING LABORATORY	Course Category	C	Professional Core Course	L	T	P	C
							0	0	2	1

Pre-requisite Courses	Nil	Co-requisite Courses	Nil	Progressive Courses	Nil
Course Offering Department	Civil Engineering	Data Book / Codes/Standards	Nil		

Course Learning Rationale (CLR):	*The purpose of learning this course is to:*
CLR-1 :	*Learn to measure traffic volume count and categorize different mode of traffic at straight road and intersection*
CLR-2 :	*Analyze the travel time and speed characteristics*
CLR-3 :	*Study the parking characteristics*
CLR-4 :	*Measure the properties of bitumen and aggregates*
CLR-5 :	*Learn the proportioning of aggregate*
CLR-6 :	*Measure the volumetric and strength of bituminous mixture*

Course Learning Outcomes (CLO):	At the end of this course, learners will be able to:	Learning 1: Level of Thinking (Bloom)	Learning 2: Expected Proficiency (%)	Learning 3: Expected Attainment (%)	PLO 1: Engineering Knowledge	PLO 2: Problem Analysis	PLO 3: Design & Development	PLO 4: Analysis, Design, Research	PLO 5: Modern Tool Usage	PLO 6: Society & Culture	PLO 7: Environment & Sustainability	PLO 8: Ethics	PLO 9: Individual & Team Work	PLO 10: Communication	PLO 11: Project Mgt. & Finance	PLO 12: Life Long Learning	PLO 13: PSO - 1	PLO 14: PSO - 2	PLO 15: PSO – 3
CLO-1 :	*Evaluate the vehicular composition in the straight road and intersection*	*3*	*90*	*85*	*H*	*M*		-	-	-	-	-	*H*	-	-	-	*H*	-	*H*
CLO-2 :	*Understand the travel time, delay and speed characteristics*	*3*	*85*	*80*	*H*	*M*	-	-	-	-	-	-	*H*	-	-	-	*H*	-	*H*
CLO-3 :	*Apply the effective parking systems*	*3*	*90*	*85*	*H*	*M*	-	-	-	-	-	-	*H*	-	-	-	*H*	-	*H*
CLO-4 :	*Grade the bitumen and select the aggregate for the preparation of bituminous mixture*	*3*	*85*	*80*	*H*	*M*	-	-	-	-	-	-	*H*	-	-	-	*H*	-	*H*
CLO-5 :	*Design the aggregate gradation for bituminous mixture*	*3*	*85*	*80*	*H*	*M*	-	-	-	-	-	-	*H*	-	-	-	*H*	-	*H*
CLO-6 :	*Design the bituminous mixture mix proportion*	*3*	*85*	*80*	*H*	*M*	-	-	-	-	-	-	*H*	-	-	-	*H*	-	*H*

Duration (hour)		6	6	6	6	6
S 1-2	SLO-1 SLO-2	*Determination of Vehicular composition in Straight moving traffic stream*	*Determination of traffic stream parameters by Moving Observer method*	*Determination of the penetration value of bitumen*	*Determination of ductility of bitumen*	*Batching of aggregates*
S 3-4	SLO-1 SLO-2	*Determination of Vehicular turning movement at any intersection*	*Evaluation of on street parking characteristics*	*Determination of softening point of bitumen*	*Determination of specific gravity of bitumen and aggregates*	*Preparation of bituminous mix and measure of mixture volumetric properties*
S 5-6	SLO-1 SLO-2	*Determination of instantaneous spot speed of vehicles*	*Evaluation of off street parking characteristics*	*Determination of viscosity of bitumen*	*Performance grading of bitumen - demo*	*Marshall stability test and design of bituminous mix*

Learning Resources	
	1. S. K Khanna, C E G Justo, A Veeraraghavan, Highway Engineering,Nem Chand and Bros 2. IS 73 : 2013, Paving Bitumen - Specification, 4th Revision, BIS, New Delhi
	3. IS 15462:2004, Polymer and Rubber Modified Bitumen - Specification, BIS, New Delhi 4. MoRTH. Specification for roads and bridge work. Indian Roads Congress, New Delhi, India.

Learning Assessment

	Bloom's Level of Thinking	Continuous Learning Assessment (50% weightage)								Final Examination (50% weightage)	
		CLA – 1 (10%)		CLA – 2 (15%)		CLA – 3 (15%)		CLA – 4 (10%)			
		Theory	Practice	Theory	Practice	Theory	Practice	Theory	Practice	Theory	Practice
Level 1	Remember Understand	-	40 %	-	30 %	-	30 %	-	30 %	-	30%
Level 2	Apply Analyze	-	40 %	-	40 %	-	40 %	-	40 %	-	40%
Level 3	Evaluate Create	-	20 %	-	30 %	-	30 %	-	30 %	-	30%
	Total	100 %		100 %		100 %		100 %		100 %	

CLA – 4 can be from Record and Model Examination.

Course Designers		
Experts from Industry	Experts from Higher Technical Institutions	Internal Experts
Dr. Asif Ahmed, Business manager, Ingevity, ahmed.asif@ingevity.com	*Dr. VenkaiahChowdary, Associate Professor, NITW, vc@nitw.ac.in*	*Dr. A. Padma Rekha, SRM IST*
Mr. Ankit Pachouri, Transport Planner, IUT, New Delhi, ankit.pachouri@iutundia.org	*Dr. V Sunitha, Assistant Professor, NITT, sunitha@nitt.edu*	*Mr. G. Sivaprakash and Ms. R Dhanya, SRM IST*

Course Code	18CEC304T	Course Name	CONSTRUCTION ENGINEERING AND MANAGEMENT	Course Category	C	Professional Core Course	L	T	P	C
							2	1	0	3

Pre-requisite Courses	Nil	Co-requisite Courses	Nil	Progressive Courses	Nil
Course Offering Department	Civil Engineering	Data Book / Codes/Standards	Nil		

Course Learning Rationale (CLR):	*The purpose of learning this course is to:*
CLR-1 :	*Identify the characteristics of project and planning aspects*
CLR-2 :	*Solve the CPM and PERT problems and apply the concept of project planning*
CLR-3 :	*Identify the techniques of project controlling and monitoring*
CLR-4 :	*Analyse the project performance based on S-Curve and Earned Value*
CLR-5 :	*Analyze the basic concepts of various resources and its importance*
CLR-6 :	*Analyse the project performance based on Quality and Safety*

Course Learning Outcomes (CLO):	*At the end of this course, learners will be able to:*	Learning 1: Level of Thinking (Bloom)	2: Expected Proficiency (%)	3: Expected Attainment (%)	PLO 1: Engineering Knowledge	2: Problem Analysis	3: Design & Development	4: Analysis, Design, Research	5: Modern Tool Usage	6: Society & Culture	7: Environment & Sustainability	8: Ethics	9: Individual & Team Work	10: Communication	11: Project Mgt. & Finance	12: Life Long Learning	13: PSO - 1	14: PSO - 2	15: PSO – 3
CLO-1 :	*Accrue the knowledge the characteristics of project and planning aspects*	2	85	75	H	L	M	-	L	-	-	-	H	H	H	M	H	-	-
CLO-2 :	*Analyze the CPM and PERT problems and apply the concept of project planning*	3	85	75	H	H	M	M	-	-	-	-	H	-	H	M	H	-	-
CLO-3 :	*Accrue the knowledge project controlling and monitoring*	2	85	75	L	H	M	H	M	-	-	-	M	-	H	M	H	-	-
CLO-4 :	*Apply the mathematical techniques of S-Curve and Earned Value*	3	85	75	H	H	M	H	-	-	-	-	L	M	H	M	H	-	-
CLO-5 :	*Accrue the knowledge about Types of resourcesand its importance*	2	85	75	H	L	L	L	-	M	H	L	-	-	H	M	H	-	-
CLO-6 :	*Accrue comprehensive knowledge in Quality and safety*	2	85	75	H	H	L	L	-	H	-	H	L	-	H	M	H	-	-

Duration (hour)		9	9	9	9	9
S-1	SLO-1	*Basics of Construction- Unique features of construction*	*Work break-down structure*	*Planning and organizing construction site and resources*	*Resource Planning- Procurement, Identification*	*Quality control: concept of quality, quality assurance*
	SLO-2	*Construction projects types and features, Phases of a project*	*Activity lists*	*Site layout including enabling structures,*	*Types of resources, manpower, Equipment Material, Money, Time*	*Quality gurus*
S-2	SLO-1	*Project Life cycle*	*Estimating durations*	*developing site organization, Documentation at site*	*Systems approach In resource management, Characteristics of resources*	*TQM*
	SLO-2	*Construction project planning and competency skills*	*Sequence of activities, Activity utility data*	*Manpower: planning,*	*Resources Utilization, measurement of actual resources required-Tools for measurement of resources*	*use of manuals and checklists for quality control, role of inspection*
S-3	SLO-1	*Stages of project planning: pre-tender planning*	*Techniques of planning- Bar charts, Gantt Charts.*	*organizing, staffing, motivation*	*Material: Functions of Material Management*	*Basics of statistical quality control*
	SLO-2	*Pre-construction planning,*	*Networks: Basic terminology,*	*Histograms and S-Curves*	*Inventory cost, ABC analysis*	*Cost Of Quality(COQ) y, Quality audits*
S 4-5	SLO-1	*Detailed construction planning*	*AOA, AON*	*Earned Value*	*EOQ Model*	*Failure Mode & Effects Analysis (FMEA)*
	SLO-2	*Agencies involved and their methods of execution*	*Types of precedence relationships, Preparation of CPM networks*	*Supervision, Record keeping,*	*Equipment: Classification of Construction Equipment*	*Risk, Risk Management process*
S-6	SLO-1	*Process of development of plans and schedules*	*Activity on link and activity on node representation,*	*Periodic progress reports, periodical progress meetings*	*Factors Behind the selection of Construction of equipment*	*Risk Identification Process*
	SLO-2	*Role of client and contractor*	*critical and semi Critical paths*	*Updating of plans: purpose*	*Depreciation, Methods of Calculating Depreciation*	*Safety, Health and Environment on project sites*
S-7	SLO-1	*Feasibility study - preliminary analysis - market, technical, financial,*	*Computation of float values*	*Frequency and methods of updating*	*Classes of Labor, Labor Productivity*	*accident Causation Theories*
	SLO-2	*economic and ecological - detailed market and demand analysis- detailed technical analysis*	*Crashing Technique*	*Classification of costs, timecost trade-off in construction projects*	*Cost of Labour, Labour schedule, optimum use Labour*	*accidents; their cause Effects and preventive measures*

S-8	SLO-1	*Time value of money, NPV*	*PERT- Assumptions underlying PERT analysis,*	*Common causes of time and cost overruns*	*Resource Scheduling- Bar chart, line of balance technique*	*Cost of Accidents*
	SLO-2	*Contracts and Types*	*determining three time estimates, analysis,*	*Corrective measures*	*Resource constraints and conflicts*	*Occupational health problems in construction*
S-9	SLO-1	*Important Terminologies: Delays, penalties and liquidated damages; Force Majeure, Suspension and Termination*	*Slack computations*	*Common Good Practices in Construction*	*Resource aggregation, allocation, smoothening and leveling*	*Organizing for safety and health.*
	SLO-2	*Bidding Process*	*Calculation of probability of completion.*	*Basics of Modern Project management systems*	*Resource smoothening problems*	*Safety inspection, Safety Audit*

Learning Resources	1. *Kumar Neeraj Jha, "Construction project management", Dorling Kindersley, New Delhi.2013* 2. *Sengupta .B, Guha .H, "Construction management and planning", Tata Mcgraw Hill, New Delhi,2001* 3. *Sharma .S.C, "Construction engineering and management",KhannaPublishers,Delhi,2008*	4. *Prasanna Chandra, "Planning, Analysis, Selection, Financing, Implementation, and Review", 7 th Edition, Tata Mcgraw Hill, New Delhi,2001.* 5. *Principles of Construction Management https://nptel.ac.in/courses/105104161/* 6. *Project Planning & Control https://nptel.ac.in/courses/105106149/*

Learning Assessment											
	Bloom's Level of Thinking	Continuous Learning Assessment (50% weightage)								Final Examination (50% weightage)	
		CLA – 1 (10%)		CLA – 2 (15%)		CLA – 3 (15%)		CLA – 4 (10%)#			
		Theory	Practice	Theory	Practice	Theory	Practice	Theory	Practice	Theory	Practice
Level 1	Remember Understand	*40%*		*40%*		*40%*		*40%*		*40%*	
Level 2	Apply Analyze	*40%*		*40%*		*40%*		*40%*		*40%*	
Level 3	Evaluate Create	*20%*		*20%*		*20%*		*20%*		*20%*	
	Total	100 %		100 %		100 %		100 %		100 %-	

CLA – 4 can be from any combination of these: Assignments, Seminars, Tech Talks, Mini-Projects, Case-Studies, Self-Study, MOOCs, Certifications, Conf. Paper etc.,

Course Designers		
Experts from Industry	Experts from Higher Technical Institutions	Internal Experts
Mr.Jayasankar k, Zonal Head (Technical Services) at UltraTech Cement Limited, jayasankar2411@gmail.com	*Dr. Radhakrishna, R.V. College of Engineering (RVCE), radhakrishna@rvce.edu.in*	*Dr. L. Krishnaraj, SRM IST*
Mr. V. Krishnaraju, Modec Offshore Production Systems Pvt. Ltd, krishnaraju.vaithiyanathan@modec.com	*Dr. K.Yogeswari,, B.S. Abdur Rahman Crescent Institute of Science and technology, yogeswari@crescent.education*	*Mr. N. Ganapathy Ramasamy, SRM IST*

Course Code	18CEC304L	Course Name	CONSTRUCTION ENGINEERING & MANAGEMENT LABORATORY	Course Category	C	Professional Core	L	T	P	C
							0	0	2	1

Pre-requisite Courses	Nil	Co-requisite Courses	Nil	Progressive Courses	Nil
Course Offering Department	Civil Engineering	Data Book / Codes/Standards	Nil		

Course Learning Rationale (CLR):	*The purpose of learning this course is to:*
CLR-1 :	*Understand the basic skills in network framing*
CLR-2 :	*Identifying the Activity involved in construction projects*
CLR-3 :	*Understand the concept of Scheduling*
CLR-4 :	*Apply the concept of Planning and scheduling*
CLR-5 :	*Identify the resource requirement*
CLR-6 :	Identify resource allocation

Course Learning Outcomes (CLO):	*At the end of this course, learners will be able to:*	Learning 1: Level of Thinking (Bloom)	2: Expected Proficiency (%)	3: Expected Attainment (%)	PLO 1: Engineering Knowledge	2: Problem Analysis	3: Design & Development	4: Analysis, Design, Research	5: Modern Tool Usage	6: Society & Culture	7: Environment & Sustainability	8: Ethics	9: Individual & Team Work	10: Communication	11: Project Mgt. & Finance	12: Life Long Learning	13: PSO - 1	14: PSO - 2	15: PSO – 3
CLO-1 :	*Accrue the knowledge in Project network diagrams*	*3*	*85*	*75*	*H*	*H*	-	-	-	*H*	-	-	-	-	-	-	*H*	-	-
CLO-2 :	*Analyze the construction activities and activity sequence*	*2*	*85*	*75*	*H*	*H*	-	-	-	*H*	-	-	-	-	-	-	*H*	-	-
CLO-3 :	*Accrue the knowledge in different scheduling charts*	*2*	*85*	*75*	*H*	*H*	-	-	-	-	-	-	-	-	*H*	-	*H*	-	-
CLO-4 :	*Accrue the knowledge in planning of activities in order*	*2*	*85*	*75*	*H*	*H*	-	*M*	-	-	-	-	-	-	-	-	*H*	-	-
CLO-5 :	*Develop the schedule with resources*	*3*	*85*	*75*	*H*	*H*	-	*M*	-	-	-	-	*H*	-	-	-	*H*	-	-
CLO-6 :	*Analyze over allocation and under allocation of resources*	*3*	*85*	*75*	*H*	*H*	-	*M*	-	-	-	-	*H*	-	-	-	*H*	-	-

Duration (hour)		6	6	6	6	6
S-1	SLO-1	*MSP- Basic Network diagrammes*	*Resource list*	*Complete schedule for Institutional projects*	*Activity Entry*	*Complete schedule for Residential projects*
	SLO-2	*Terms involved*	*Resource assigning*		*Activity Entry*	
S-2	SLO-1	*Activity in projects*	*Resource analysis*	*Complete schedule for Infra structure projects*	*Activity Entry*	*Complete schedule for Residential projects*
	SLO-2	*Activity sequence*	*Resource usage*		*Activity Entry*	
S-3	SLO-1	*Main activities and Sub activities*	*Cost analysis*	*Complete schedule for Infra structure projects*	*Resource list*	*Complete schedule for Institutional projects*
	SLO-2	*Relationship line and precedence relationship*	*Tracking*		*Resource assigning*	
S-4	SLO-1	*Calendar design and assign*	*Complete schedule for Residential projects*	*Primavera Basics*	*Resource analysis*	*Complete schedule for Institutional projects*
	SLO-2	*Gantt chart and PERT diagram*		*EPS*	*Resource usage*	
S-5	SLO-1	*Activity resource estimation*	*Complete schedule for Residential projects*	*OBS and WBS*	*Cost analysis*	*Complete schedule for Infra structure projects*
	SLO-2	*Activity duration estimation*		*Types of calendar*	*Tracking*	
S-6	SLO-1	*Activity entry*	*Complete schedule for Institutional projects*	*Relationship lines and Constraints*	*Linking WBS, OBS and EPS*	*Complete schedule for Infra structure projects*
	SLO-2	Activity entry		New project Creation	Multiple project entry	

Learning Resources		
Learning Resources	*1. Laboratory Manual* *2. Feigenbaum.L, "Construction Scheduling with Primavera Project Planner", Prentice Hall Inc., 1999.* *3. "Project planning and management: Primavera Reference guide", CADD Centre training services* *4. Paul F. Aubin, "Mastering Autodesk Revit Building", Cengage Learning, March 2006.*	*5. Robert M. Thomas, "Advanced AutoCAD Release" 12, ED 3, Wiley, John & Sons, Incorporated, 1993.* *6. "Project planning and management: MS Project specially for Civil professional", CADD Centre training services* *7. Geprge Omura," Introducing AutoCAD 2010 and AutoCAD LT 2010", Willey India Pvt. Ltd., 2010.*

Learning Assessment											
	Bloom's Level of Thinking	Continuous Learning Assessment (50% weightage)								Final Examination (50% weightage)	
		CLA – 1 (10%)		CLA – 2 (15%)		CLA – 3 (15%)		CLA – 4 (10%)#			
		Theory	Practice	Theory	Practice	Theory	Practice	Theory	Practice	Theory	Practice
Level 1	Remember Understand	-	*40%*	-	*30%*	-	*30%*	-	*30%*	-	*30%*
Level 2	Apply Analyze	-	*40%*	-	*40%*	-	*40%*	-	*40%*	-	*40%*
Level 3	Evaluate Create	-	*20%*	-	*30%*	-	*30%*	-	*30%*	-	*30%*
	Total	100 %		100 %		100 %		100 %		100 %	

CLA – 4 can be from Record and Model Examination.

Course Designers		
Experts from Industry	Experts from Higher Technical Institutions	Internal Experts
Mr. Jayasankar K, Zonal Head (Technical Services) at ultraTech cement Limited, jayasankar2411@gmail.com	*Dr. Radhakrishna, R.V. College of Engineering (RVCE), radhakrishna@rvce.edu.in*	*Dr. L. Krishnaraj, SRMIST*
Mr. V. Krishnaraju,, Modec Offshore Production Systems, pvt,ltd, krishnaraju.vaithiyanathan@modec.com	*Dr. K.Yogeswari, B.S. Abdur Rahman Crescent Institute of Science and technology, yogeswari@crescent.education*	*Dr. M. Balasubramanian, SRMIST*

Course Code	18CEC350T	Course Name	COMPREHENSION	Course Category	C	Professional Core	L	T	P	C
							0	1	0	1

Pre-requisite Courses	Nil	Co-requisite Courses	Nil	Progressive Courses	Nil
Course Offering Department	Civil Engineering	Data Book / Codes/Standards	As Applicable		

Course Learning Rationale (CLR):	*The purpose of learning this course is to:*
CLR-1 :	*Acquire skills to solve real world problems in Engineering Geology and Engineering Surveying*
CLR-2 :	*Acquire skills to solve real world problems in Mechanics of Structures, Design of RCC & Steel and Structural Analysis*
CLR-3 :	*Acquire skills to solve real world problems in Fluid Mechanics, Hydraulic Engineering Design and Hydrology*
CLR-4 :	*Acquire skills to solve real world problems in Geotechnical Engineering*
CLR-5 :	*Acquire skills to solve real world problems in Environmental Engineering*
CLR-6 :	*Acquire skills to solve real world problems in Transportation Engineering*

		Learning			Program Learning Outcomes (PLO)														
		1	2	3	1	2	3	4	5	6	7	8	9	10	11	12	13	14	15
Course Learning Outcomes (CLO):	*At the end of this course, learners will be able to:*	Level of Thinking (Bloom)	Expected Proficiency (%)	Expected Attainment (%)	Engineering Knowledge	Problem Analysis	Design & Development	Analysis, Design, Research	Modern Tool Usage	Society & Culture	Environment & Sustainability	Ethics	Individual & Team Work	Communication	Project Mgt. & Finance	Life Long Learning	PSO - 1	PSO - 2	PSO - 3
CLO-1 :	*Practice and gain confidence to solve problems in Engineering Geology and Engineering Surveying*	*3*	*85*	*80*	*H*	*H*	*M*	*L*	*L*	*L*	*L*	*L*	*L*	*L*	*L*	*L*	*H*	*M*	*H*
CLO-2 :	*Practice and gain confidence to solve problems in Mechanics of Structures, Design of RCC & Steel and Structural Analysis*	*3*	*85*	*80*	*H*	*H*	*H*	*L*	*L*	*L*	*L*	*L*	*L*	*L*	*L*	*L*	*H*	*M*	*H*
CLO-3 :	*Practice and gain confidence to solve problems in Fluid Mechanics, Hydraulic Engineering Design and Hydrology*	*3*	*85*	*80*	*H*	*H*	*M*	*L*	*L*	*L*	*L*	*L*	*L*	*L*	*L*	*L*	*H*	*L*	*H*
CLO-4 :	*Practice and gain confidence to solve problems in Geotechnical Engineering*	*3*	*85*	*80*	*H*	*H*	*M*	*L*	*L*	*L*	*L*	*L*	*L*	*L*	*L*	*L*	*H*	*L*	*H*
CLO-5 :	*Practice and gain confidence to solve problems in Environmental Engineering*	*3*	*85*	*80*	*H*	*H*	*M*	*L*	*L*	*L*	*L*	*L*	*L*	*L*	*L*	*L*	*H*	*L*	*H*
CLO-6 :	*Practice and gain confidence to solve problems in Transportation Engineering*	*3*	*85*	*80*	*H*	*H*	*H*	*L*	*L*	*L*	*L*	*L*	*L*	*L*	*L*	*L*	*H*	*L*	*H*

Duration (hour)		3	3	3	3	3
S-1	SLO-1 SLO-2	*Tutorial on Engineering Geology and Engineering Surveying*	*Tutorial on Mechanics of Structures*	*Tutorial on Structural Analysis*	*Tutorial on Geotechnical Engineering*	*Tutorial on Environmental Engineering*
S-2	SLO-1 SLO-2	*Tutorial on Engineering Geology and Engineering Surveying*	*Tutorial on Design of RCC and Steel Structures*	*Tutorial on Fluid Mechanics and Hydraulic Engineering Design and Hydrology*	*Tutorial on Geotechnical Engineering*	*Tutorial on Transportation Engineering*
S-3	SLO-1 SLO-2	*Tutorial on Mechanics of Structures*	*Tutorial on Design of RCC and Steel Structures*	*Tutorial on Fluid Mechanics and Hydraulic Engineering Design and Hydrology*	*Tutorial on Environmental Engineering*	*Tutorial on Transportation Engineering*

Learning Resources		
	1. *Handa, S., and Rangaswamy, Civil Engineering Objective Type, Satya Prakashan, 2017* 2. *Agor, R., Objective Type and Conventional Questions and Answers on Civil Engineering for All Types of Examinations & Interviews, Khanna Publishers, 2019*	3. *Venkatramaiah, C., and Krishna Sharma, A., A Compendium of Objective Questions in Civil Engineering, Universities Press, 2014*

Learning Assessment

	Bloom's Level of Thinking	Continuous Learning Assessment (100% weightage)								Final Examination	
		CLA – 1 (20%)		CLA – 2 (30%)		CLA – 3 (30%)		CLA – 4 (20%)#			
		Theory	Practice	Theory	Practice	Theory	Practice	Theory	Practice	Theory	Practice
Level 1	Remember Understand	-	*40%*	-	*30%*	-	*30%*	-	*30%*	-	-
Level 2	Apply Analyze	-	*40%*	-	*40%*	-	*40%*	-	*40%*	-	-
Level 3	Evaluate Create	-	*20%*	-	*30%*	-	*30%*	-	*30%*	-	-
	Total	100 %		100 %		100 %		100 %		-	

CLA – 4 can be from any combination of these: Assignments, Seminars, Tech Talks, Mini-Projects, Case-Studies, Self-Study, MOOCs, Certifications, Conf. Paper etc.,

Course Designers

Experts from Industry	Experts from Higher Technical Institutions	Internal Experts
1. Er. G.Hariharanath, GA Consultants, Chennai, gac1996@hotmail.com	*1. Dr. G. Appa Rao, Professor, IIT Madras, garao@iitm.ac.in*	*1. Dr. K. S. Satyanarayanan, SRMIST*
2. Er. AGV. Desigan, Design Group Engineering Consultancy Pvt Ltd. Chennai, desigan.agv@gmail.com	*2. Dr. C. Uma Rani, Professor, Anna University, umarani@annauniv.edu*	*2. Prof. G. Augustine Maniraj Pandian, SRMIST*

ACADEMIC CURRICULA

Professional Core Courses

COMPUTER SCIENCE AND ENGINEERING

Regulations - 2018

SRM INSTITUTE OF SCIENCE AND TECHNOLOGY

(Deemed to be University u/s 3 of UGC Act, 1956)

Kattankulathur, Kancheepuram, Tamil Nadu, India

Course Code	18CSC301T	Course Name	FORMAL LANGUAGE AND AUTOMATA	Course Category	C	Professional Core	L	T	P	C
							3	0	0	3

Pre-requisite Courses	Nil	Co-requisite Courses	Nil	Progressive Courses	Nil
Course Offering Department	Computer Science and Engineering	Data Book / Codes/Standards	Nil		

Course Learning Rationale (CLR):	*The purpose of learning this course is to:*
CLR-1 :	*Utilize the mathematics and engineering principles for the basics of Formal Language*
CLR-2 :	*Acquire knowledge of Automata and minimize with Regular language's*
CLR-3 :	*Acquire knowledge of Context free Grammar and simplify using normal forms*
CLR-4 :	*Gain knowledge to push down automata and apply it with CFL*
CLR-5 :	*Analyze the methods of turning machine*
CLR-6 :	*Analyze and Design the methods of computational complexity*

Course Learning Outcomes (CLO):	*At the end of this course, learners will be able to:*	Learning 1: Level of Thinking (Bloom)	Learning 2: Expected Proficiency (%)	Learning 3: Expected Attainment (%)	PLO 1: Engineering Knowledge	PLO 2: Problem Analysis	PLO 3: Design & Development	PLO 4: Analysis, Design, Research	PLO 5: Modern Tool Usage	PLO 6: Society & Culture	PLO 7: Environment & Sustainability	PLO 8: Ethics	PLO 9: Individual & Team Work	PLO 10: Communication	PLO 11: Project Mgt. & Finance	PLO 12: Life Long Learning	PLO 13: PSO - 1	PLO 14: PSO - 2	PLO 15: PSO – 3
CLO-1 :	*Acquire the knowledge of mathematics and engineering principles for the basics of Formal Language*	3	80	70	M	H	-	H	L	-	-	-	L	L	-	H	-	-	-
CLO-2 :	*Acquire the ability to identify specification of a Regular language's with Automata*	3	85	75	M	H	L	M	L	-	-	-	M	L	-	H	-	-	-
CLO-3 :	*Acquire knowledge of Context free Grammar and simplify using normal forms*	3	75	70	M	H	M	H	L	-	-	-	M	L	-	H	-	-	-
CLO-4 :	*Understand the concepts of push down automata and CFL .*	3	85	80	M	H	M	H	L	-	-	-	M	L	-	H	-	-	-
CLO-5 :	*Apply the knowledge to turning machine and its methods*	3	85	75	H	H	M	H	L	-	-	-	M	L	-	H	-	-	-
CLO-6 :	*Design the computational and acceptor machines using FA, PDA and Turing machines*	3	80	70	L	H	-	H	L	-	-	-	L	L	-	H	-	-	-

Duration (hour)		11	9	9	9	7
S-1	SLO-1	*Introduction to Automaton*	*Grammars: Introduction: Types of Grammar*	*Pushdown Automata: Definitions Moves*	*Turing Machines: Introduction*	*Undecidability :Basic definitions*
	SLO-2	*Mathematical concepts*	*Context Free Grammars and Languages*	*Instantaneous descriptions*	*Formal definition of Turing machines, Instantaneous descriptions*	*Decidable problems,*
S-2	SLO-1	*Formal Languages: Strings, Languages, Properties*	*Derivations*	*Deterministic pushdown automata*	*Turing Machine as Acceptors*	*Examples of undecidable problems and Problems*
	SLO-2	*Finite Representation : Regular Expressions*	*Ambiguity*	*Problems related to DPDA*	*Problems related to turning machine as Acceptors*	*Rice's Theorem*
S-3	SLO-1	*Problems related to regular expressions*	*Relationship between derivation and derivation trees*	*Non - Deterministic pushdown automata*	*Problems related to turning machine as Acceptors*	*Undecidable problems about Turing Machine- Post's Correspondence Problem*
	SLO-2	*Finite Automata :Deterministic Finite Automata*	*Problems related to Context free Grammar*	*Problems related to NDPDA*		*Problems related to Post's Correspondence Problem*
S-4	SLO-1	*Nondeterministic Finite Automata*	*Simplification of CFG : Elimination of Useless Symbols*	*Problems related to DPDA and NDPDA*	*Turing Machine as a Computing Device*	*Properties of Recursive and Recursively enumerable languages*
	SLO-2	*Finite Automaton with €- moves*			*Problems related to turning Turing Machine as a Computing Device*	
S-5	SLO-1	*Problems related to Deterministic and Nondeterministic Finite Automata*	*Simplification of CFG : Unit productions*	*Pushdown automata to CFL Equivalence*	*Problems related to turning Turing Machine as a Computing Device*	*Introduction to Computational Complexity: Definitions*
	SLO-2	*Problems related to Finite Automaton with €- moves*	*Simplification of CFG : Null productions*	*Problems related to Equivalence of PDA to CFG*		*Time and Space complexity of TMs*
S-6	SLO-1	*Equivalence of NFA and DFA*	*Problems related to Simplification of CFG*	*Problems related to Equivalence of PDA to CFG*	*Techniques for Turing Machine Construction*	*Complexity classes: Class P, Class NP*
	SLO-2	*Heuristics to Convert NFA to DFA*				
S-7	SLO-1	*Equivalence of NDFA's with and without €-moves*	*Chomsky normal form*	*CFL to Pushdown automata Equivalence*	*Considering the state as a tuple Considering the tape symbol as a tuple*	*Complexity classes: Introduction to NP-Hardness*

	SLO-2	*Problems related Equivalence of NDFA's with and without €-moves*	*Problems related to CNF*	*Problems related to Equivalence of CFG to PDA*	*Checking off symbols*	*NP Completeness*
S-8	SLO-1	*Minimization of DFA*	*Greiback Normal form*	*Pumping lemma for CFL*	*Modifications of Turing Machine*	
	SLO-2	*Problems related to Minimization of DFA*			*Multi-tape Turing Machine*	
S-9	SLO-1	*Regular Languages : Equivalence of Finite Automata and Regular Languages*	*Problems related to GNF*	*Problems based on pumping Lemma*	*Non-Deterministic Turing Machine*	
	SLO-2	*Equivalence of Finite Automata and Regular Grammars*			*Semi-Infinite Tape Turing Machine*	
S-10	SLO-1	*Problems related to Equivalence of Finite Automata and Regular Languages and Regular Grammars*				
	SLO-2	*Variants of Finite Automata :Two-way Finite Automaton Mealy Machines*				
S-11	SLO-1	*Properties of Regular Languages: Closure Properties*				
	SLO-2	*Set Theoretic Properties & Other Properties*				
	SLO-3	*Pumping Lemma*				

Learning Resources	*1.Hopcroft J.E., Motwani R. and Ullman J.D, "Introduction to Automata Theory, Languages and Computations", Second Edition, Pearson Education, 2008.* *2. Michael Sipser, "Introduction to the Theory of Computation" Cengage Learning, 2012.*	*4..John.C.Martin, "Introduction to Languages and the Theory of Computation" McGraw-Hill Education, 01- May-2010.* *5. Kamala Krithivasan, Rama.R," Introduction to Formal Languages, Automata Theory and Computation", Pearson Education India, 01-Sep-2009.* *6. Peter Linz , "An introduction to formal languages and automata", Jones & Bartlett Learning, 2001.*

Learning Assessment

	Bloom's Level of Thinking	Continuous Learning Assessment (50% weightage)								Final Examination (50% weightage)	
		CLA – 1 (10%)		CLA – 2 (15%)		CLA – 3 (15%)		CLA – 4 (10%)#			
		Theory	Practice	Theory	Practice	Theory	Practice	Theory	Practice	Theory	Practice
Level 1	Remember Understand	40 %	-	30 %	-	30 %	-	30 %	-	30%	-
Level 2	Apply Analyze	40 %	-	40 %	-	40 %	-	40 %	-	40%	-
Level 3	Evaluate Create	20 %	-	30 %	-	30 %	-	30 %	-	30%	-
	Total	100 %		100 %		100 %		100 %		100 %	

CLA – 4 can be from any combination of these: Assignments, Seminars, Tech Talks, Mini-Projects, Case-Studies, Self-Study, MOOCs, Certifications, Conf. Paper etc.,

Course Designers		
Experts from Industry	Experts from Higher Technical Institutions	Internal Experts
		Dr.R.AnnieUthra
		Dr.Jeyasudha

Course Code	18CSC302J	Course Name	COMPUTER NETWORKS	Course Category	C	Professional Core	L	T	P	C
							3	0	2	4

Pre-requisite Courses	Nil	Co-requisite Courses	Nil	Progressive Courses	Nil
Course Offering Department	Computer Science and Engineering	Data Book / Codes/Standards	Nil		

Course Learning Rationale (CLR):	*The purpose of learning this course is to:*
CLR-1 :	*Understand the evolution of computer networks using the layered network architecture*
CLR-2 :	*Understand the addressing concepts and learn networks devices*
CLR-3 :	*Design computer networks using subnetting and routing concepts*
CLR-4 :	*Understand the error types , framing, flow control*
CLR-5 :	*Understand the various Medium Access Control techniques and also the characteristics of physical layer functionalities*
CLR-6 :	*Understand basic network administration*

Course Learning Outcomes (CLO):	*At the end of this course, learners will be able to:*	Learning 1 Level of Thinking (Bloom)	2 Expected Proficiency (%)	3 Expected Attainment (%)	PLO 1 Engineering Knowledge	2 Problem Analysis	3 Design & Development	4 Analysis, Design, Research	5 Modern Tool Usage	6 Society & Culture	7 Environment & Sustainability	8 Ethics	9 Individual & Team Work	10 Communication	11 Project Mgt. & Finance	12 Life Long Learning	13 PSO - 1	14 PSO - 2	15 PSO – 3
CLO-1 :	*Acquire the basics of computer network and its architecture*	3	80	70	L	H	-	H	L	-	-	-	L	L	-	H	-	-	-
CLO-2 :	*Acquire the knowledge of various networks devices and addressing methods*	3	85	75	M	H	L	M	L	-	-	-	M	L	-	H	-	-	-
CLO-3 :	*Abilty to design the network routing methods*	3	75	70	M	H	M	H	L	-	-	-	M	L	-	H	-	-	-
CLO-4 :	*Acquire the various error codes and framing concepts*	3	85	80	M	H	M	H	L	-	-	-	M	L	-	H	-	-	-
CLO-5 :	*Ability to understand the physical layer functions and components*	3	85	75	H	H	M	H	L	-	-	-	M	L	-	H	-	-	-
CLO-6 :	*Ability to design a computer network using a switch and router*	3	80	70	L	H	-	H	L	-	-	-	L	L	-	H	-	-	-

Duration (hour)		15	15	15	15	15
S-1	SLO-1	*Evolution of Computer Networks*	*Addressing types*	*Network layer functionalities*	*Introduction- error types*	*Physical layer overview*
	SLO-2	*The Internet today*	*Physical, logical, port, specific addresses*	*Delivery vs Forwarding*	*Detection vs Correction*	*Functionalities*
S-2	SLO-1	*Data communications*	*IPv4 addresses*	*Unicast routing protocols*	*Error detection*	*Analog and digital*
	SLO-2	*Components*	*Notations*	*Intra , inter domain routing*	*Parity*	*Data, signals*
S-3	SLO-1	*Networks*	*Classful addressing*	*Multicast routing protocols*	*CRC*	*Transmission impairment*
	SLO-2	*Physical structures*	*Categories*	*Applications*	*Checksum*	*Attenuation, Distortion, Noise*
S 4-5	SLO-1 SLO-2	*Lab 1: Introduction to Packet racer*	*Lab 4 :IP Addressing and subnetting (VLSM).*	*Lab 7 : Implementation of Static Routing*	*Lab 10: Implementation of EIGRP Configuration*	*Lab 13: Implementation of Single-Area OSPF Link Costs and Interface*
S-6	SLO-1	*Network models*	*Classless addressing*	*Distance vector routing*	*Error correction*	*Performance metrics*
	SLO-2	*Categories of network*	*Prefix usage*	*Node instability issues*	*Hamming code*	*Bandwidth, delay, throughput, jitter*
S-7	SLO-1	*Protocols and standards*	*Network Address Translation(NAT)*	*RIPv1*	*Framing*	*Wireless 802.11*
	SLO-2	*Standards organizations*	*Translation table*	*RIPv2*	*Flow control*	*Addressing mechanism*

S-8	SLO-1	*Layered tasks*	*IPv6 addresses*	*Link state routing*	*Error control*	*Transmission Media*
	SLO-2	*Hierarchy*	*Types, Notation*	*Dijkstra's Algorithm*	*ARQ types*	*Twisted pair, Coaxial, Fibre*
S 9-10	SLO-1 SLO-2	*Lab 2: Implementation of various Topology creation*	*Lab 5: Configuring Interfaces*	*Lab 8: Implementation of Default Routing*	*Lab 11: Implementation of EIGRP Bandwidth and Adjacencies*	*Lab 14 :Implementation of Multi-Area OSPF with Stub Areas and Authentication*
S-11	SLO-1	*OSI model*	*VLSM*	*OSPF*	*Random access*	*IEEE 802.15*
	SLO-2	*Layered approach, Peer-peer approach*	*Masking*	*EIGRP*	*ALOHA*	*Architecture*
S-12	SLO-1	*Layers in the OSI model*	*CIDR*	*Path vector routing*	*CSMA/CD*	*IEEE 802.15.4*
	SLO-2	*Comparison of layers*	*Address aggregation*	*Stabilized routing table creation for AS*	*CSMA/CA*	*Architecture*
S-13	SLO-1	*TCP/IP protocol suite*	*Networking devices*	*BGP*	*Controlled access*	*IEEE 802.16*
	SLO-2	*Comparison with OSI moldel*	*Router, Switch, hub, Bridges*	*BGP Sessions*	*Channelization*	*Architecture*
S 14-15	SLO-1 SLO-2	*Lab 3: Implement the categories of network(LAN,MAN,WAN)*	*Lab 6: Basic Router Configuration, Creating Passwords*	*Lab 9: Implementation of RIPv1, v2*	*Lab 12:Implementation of EIGRP Authentication and Timers*	*Lab 15 : Redistribution Between EIGRP and OSPF*

Learning Resources	1. Behrouz A.Forouzan,"Data Communications and Networking"5th edition,July1,2010,ISBN: 9780073376226. 2. Todd Lammle,"CCNA Study Guide",Edition7,2011, ISBN:13:9780470901076. William Stallings,"Data and Computer Communications",Edition9,2010.

Learning Assessment

	Bloom's Level of Thinking	Continuous Learning Assessment (50% weightage)								Final Examination (50% weightage)	
		CLA – 1 (10%)		CLA – 2 (15%)		CLA – 3 (15%)		CLA – 4 (10%)#			
		Theory	Practice	Theory	Practice	Theory	Practice	Theory	Practice	Theory	Practice
Level 1	Remember Understand	*20%*	*20%*	*15%*	*15%*	*15%*	*15%*	*15%*	*15%*	*15%*	*15%*
Level 2	Apply Analyze	*20%*	*20%*	*20%*	*20%*	*20%*	*20%*	*20%*	*20%*	*20%*	*20%*
Level 3	Evaluate Create	*10%*	*10%*	*15%*	*15%*	*15%*	*15%*	*15%*	*15%*	*15%*	*15%*
	Total	100 %		100 %		100 %		100 %		-	

CLA – 4 can be from any combination of these: Assignments, Seminars, Tech Talks, Mini-Projects, Case-Studies, Self-Study, MOOCs, Certifications, Conf. Paper etc.,

Course Designers

Experts from Industry	Experts from Higher Technical Institutions	Internal Experts
1. . Dr. Sricharan, Wipro Technologies, Chennai	*1. Dr.Noor Mahammad, IIITDM, Kancheepuram, noor@iiitdm.ac.in*	*1. Mr. K. Venkatesh, SRMIST*
2.	*2.*	*2. Ms.D. Anitha, SRMIST*
	3.	*3. Ms. Ferni Ukrit, SRMIST*

Course Code	18CSC303J	Course Name	DATABASE MANAGEMENT SYSTEMS	Course Category	C	Professional Core	L	T	P	C
							3	0	2	4

Pre-requisite Courses	Nil	Co-requisite Courses	Nil	Progressive Courses	Nil
Course Offering Department	Computer Science and Engineering	Data Book / Codes/Standards	Nil		

Course Learning Rationale (CLR):	*The purpose of learning this course is to:*
CLR-1 :	*Understand the fundamentals of Database Management Systems, Architecture and Languages*
CLR-2 :	*Conceive the database design process through ER Model and Relational Model*
CLR-3 :	*Design Logical Database Schema and mapping it to implementation level schema through Database Language*
CLR-4 :	*Familiarize queries using Structure Query Language (SQL) and PL/SQL*
CLR-5 :	*Familiarize the Improvement of the database design using normalization criteria and optimize queries*
CLR-6 :	*Understand the practical problems of concurrency control and gain knowledge about failures and recovery*

Course Learning Outcomes (CLO):	*At the end of this course, learners will be able to:*	Learning 1	2	3	Program Learning Outcomes (PLO) 1	2	3	4	5	6	7	8	9	100	11	12	13	14	15
		Level of Thinking (Bloom)	Expected Proficiency (%)	Expected Attainment (%)	Engineering Knowledge	Problem Analysis	Design & Development	Analysis, Design, Research	Modern Tool Usage	Society & Culture	Environment & Sustainability	Ethics	Individual & Team Work	Communication	Project Mgt. & Finance	Life Long Learning	PSO - 1	PSO - 2	PSO – 3
CLO-1 :	*Acquire the knowledge on DBMS Architecture and Languages*	3	80	70	H	M	L	L	-	-	-	-	L	L	L	H	-	-	-
CLO-2 :	*Apply the fundamentals of data models to model an application's data requirements using conceptual modeling tools like ER diagrams*	3	85	75	H	H	H	H	H	-	-	-	H	H	H	H	-	-	-
CLO-3 :	*Apply the method to convert the ER model to a database schemas based on the conceptual relational model*	3	75	70	H	H	H	H	H	-	-	-	H	H	H	H	-	-	-
CLO-4 :	*Apply the knowledge to create, store and retrieve data using Structure Query Language (SQL) and PL/SQL*	3	85	80	H	H	H	H	H	-	-	-	H	H	H	H	-	-	-
CLO-5 :	*Apply the knowledge to improve database design using various normalization criteria and optimize queries*	3	85	75	H	H	L	M	L	-	-	-	M	M	M	L	-	-	-
CLO-6 :	*Appreciate the fundamental concepts of transaction processing- concurrency control techniques and recovery procedures.*	3	85	75	H	L	L	L	L	-	-	-	H	L	L	L			

Duration (hour)		15	15	15	15	15
S-1	SLO-1	*What is Database Management System*	*Database Design*	*Basics of SQL-DDL,DML,DCL,TCL*	*Relational Algebra – Fundamental Operators and syntax, relational algebra queries, Tuple relational calculus*	*Transaction concepts, properties of transactions,*
	SLO-2	*Advantage of DBMS over File Processing System*	*Design process*	*Structure Creation, alternation*		
S-2	SLO-1	*Introduction and applications of DBMS*	*Entity Relation Model*	*Defining Constraints-Primary Key, Foreign Key, Unique, not null, check, IN operator*		*Serial izability of transactions,*
	SLO-2	*Purpose of database system*				*testing for serial inability, System recovery,*
S-3	SLO-1	*Views of data*	*ER diagram*	*Functions-aggregation functions*	*Pitfalls in Relational database, Decomposing bad schema*	*Concurrency Control*
	SLO-2			*Built-in Functions-numeric, date, string functions, string functions, Set operations,*	*Functional Dependency – definition, trivial and non-trivial FD*	
S 4-5	SLO-1	*Lab 1: SQL Data Definition Language Commands on sample exercise* ** The abstract of the project to construct database must be framed*	*Lab4 Inbuilt functions in SQL on sample Exercise.*	*Lab 7 : Join Queries on sample exercise.* ** Frame and execute the appropriate DDL,DML,DCL,TCL for the project*	*Lab10: PL/SQL Procedures on sample exercise.* ** Frame and execute the appropriate Join Queries for the project*	*Lab 13: PL/SQL Exception Handling* ** Frame and execute the appropriate PL/SQL Procedures and Functions for the project*
	SLO-2					
S-6	SLO-1	*Database system Architecture*	*Keys , Attributes and Constraints*	*Sub Queries, correlated sub queries*	*closure of FD set , closure of attributes*	*Two- Phase Commit protocol, Recovery and Atomicity*
	SLO-2				*irreducible set of FD*	
S-7	SLO-1	*Data Independence*	*Mapping Cardinality*	*Nested Queries, Views and its Types*	*Normalization – 1Nf, 2NF, 3NF,*	*Log-based recovery*
	SLO-2					
S-8	SLO-1	*The evolution of Data Models*	*Extended ER - Generalization,*	*Transaction Control Commands*	*Decomposition using FD- dependency*	*concurrent executions of transactions and*
	SLO-2		*Specialization and Aggregation*	*Commit, Rollback, Save point*	*preservation,*	*related problems*
S 9-10	SLO-1	*Lab 2: SQL Data Manipulation*	*Lab 5: Construct a ER Model for the*	*Lab 8: Set Operators & Views.*	*Lab 11: PL/SQL Functions*	*Lab 14: PL/SQL Trigger*

	SLO-2	Language Commands * Identification of project Modules and functionality	application to be constructed to a Database	* Frame and execute the appropriate In- Built functions for the project	* Frame and execute the appropriate Set Operators & Views for the project	* Frame and execute the appropriate PL/SQL Cursors and Exceptional Handling for the project
S-11	SLO-1	Degrees of Data Abstraction	ER Diagram Issues	PL/SQL Concepts- Cursors	BCNF	Locking mechanism, solution to concurrency related problems
	SLO-2		Weak Entity			
S-12	SLO-1	Database Users and DBA	Relational Model	Stored Procedure, Functions Triggers and Exceptional Handling	Multi- valued dependency,	Deadlock
	SLO-2				4NF	
S-13	SLO-1	Database Languages	Conversion of ER to Relational Table	Query Processing	Join dependency and 5NF	two-phase locking protocol, Isolation, Intent locking
	SLO-2					
S 14-15	SLO-1 SLO-2	Lab 3: SQL Data Control Language Commands and Transaction control commands to the sample exercises * Identify the issues that can arise in a business perspective for the application	Lab 6: Nested Queries on sample exercise * Construction of Relational Table from the ER Diagram	Lab9: PL/SQL Conditional and Iterative Statements * Frame and execute the appropriate Nested Queries for the project	Lab 12: PL/SQL Cursors * Frame and execute the appropriate PL/SQL Conditional and Iterative Statements for the project	Lab 15 : * Frame and execute the appropriate PL/SQL Cursors and Exceptional Handling for the project * Demo of the project

Learning Resources	1. Abraham Silberschatz, Henry F. Korth, S. Sudharshan, Database System Conceptsǁ, Sixth Edition, Tata McGraw Hill,2011. 2. Ramez Elmasri, Shamkant B. Navathe, Fundamentals of Database Systemsǁ, Sixth Edition, Pearson Education,2011. 3. CJ Date,A Kannan,S Swamynathan, An Introduction to Database Systems, Eight Edition, Pearson Education,2006. 4. Rajesh Narang, Database Management Systems, 2nd ed., PHI Learning Private Limited,2011.	4. Martin Gruber, Understanding SQL, Sybex,1990 5. Sharad Maheshwari,Introduction to SQLandPL/SQL,2ded.,LaxmiPublications,2016. 6. RaghuramaKrishnan,Johannes Gehrke,Database Management Systems,3rdEdition,McGrawHill Education,2003.

Learning Assessment

	Bloom's Level of Thinking	Continuous Learning Assessment (50%weightage)								Final Examination (50% weightage)	
		CLA – 1 (10%)		CLA – 2 (15%)		CLA – 3 (15%)		CLA – 4 (10%)#			
		Theory	Practice	Theory	Practice	Theory	Practice	Theory	Practice	Theory	Practice
Level 1	Remember Understand	20%	20%	15%	15%	15%	15%	15%	15%	15%	15%
Level 2	Apply Analyze	20%	20%	20%	20%	20%	20%	20%	20%	20%	20%
Level 3	Evaluate Create	10%	10%	15%	15%	15%	15%	15%	15%	15%	15%
	Total	100 %		100 %		100 %		100 %		-	

CLA – 4 can be from any combination of these: Assignments, Seminars, Tech Talks, Mini-Projects, Case-Studies, Self-Study, Conf. Paper etc.,

Course Designers

Experts from Industry	Experts from Higher Technical Institutions	Internal Experts
1. Dr.Mariappan Vaithilingam, Engineering Leader Amazon, dr.v.m@ieee.org		1. Ms. Sasi Rekha Sankar SRMIST
2. Mr. Badinath, SDET, Amzon, sbadhrinath@gmail.com		2. Mr.Elizer, SRMIST
		3. Mrs. Hemavathy, SRMIST

Course Code	18CSC304J	Course Name	COMPILER DESIGN	Course Category	C	Professional Core	L	T	P	C
							3	0	2	4

Pre-requisite Courses	18CSC301T	Co-requisite Courses	Nil	Progressive Courses	
Course Offering Department	Computer Science and Engineering	Data Book / Codes/Standards	Nil		

Course Learning Rationale (CLR):	*The purpose of learning this course is to:*
CLR-1 :	*Utilize the mathematics and engineering principles for the Design of Compilers*
CLR-2 :	*Acquire knowledge of Lexical Analyzer from a specification of a language's lexical rules*
CLR-3 :	*Acquire knowledge of Syntax Analyzer for parsing the sentences in a compiler grammar*
CLR-4 :	*Gain knowledge to translate a system into various intermediate codes*
CLR-5 :	*Analyze the methods of implementing a Code Generator for compilers*
CLR-6 :	*Analyze and Design the methods of developing a Code Optimizer*

Course Learning Outcomes (CLO):	*At the end of this course, learners will be able to:*	Learning 1: Level of Thinking (Bloom)	Learning 2: Expected Proficiency (%)	Learning 3: Expected Attainment (%)	PLO 1: Engineering Knowledge	PLO 2: Problem Analysis	PLO 3: Design & Development	PLO 4: Analysis, Design, Research	PLO 5: Modern Tool Usage	PLO 6: Society & Culture	PLO 7: Environment & Sustainability	PLO 8: Ethics	PLO 9: Individual & Team Work	PLO 10: Communication	PLO 11: Project Mgt. & Finance	PLO 12: Life Long Learning	PLO 13: PSO - 1	PLO 14: PSO - 2	PLO 15: PSO – 3
CLR-1 :	*Utilize the mathematics and engineering principles for the Design of Compilers*	3	80	70	H	H	H	H	M	L	L	L	M	M	L	H	H	H	H
CLR-2 :	*Acquire knowledge of Lexical Analyzer from a specification of a language's lexical rules*	3	85	75	H	H	H	H	M	L	L	L	M	M	L	H	H	H	H
CLR-3 :	*Acquire knowledge of Syntax Analyzer for parsing the sentences in a compiler grammar*	3	75	70	H	H	H	H	M	L	L	L	M	M	L	H	H	H	H
CLR-4 :	*Gain knowledge to translate a system into various intermediate codes*	3	85	80	H	H	H	H	M	L	L	L	M	M	L	H	H	H	H
CLR-5 :	*Analyze the methods of implementing a Code Generator for compilers*	3	85	75	H	H	H	H	M	L	L	L	M	M	L	H	H	H	H
CLR-6 :	*Analyze and Design the methods of developing a Code Optimizer*	3	80	70	H	H	H	H	M	L	L	L	M	M	L	H	H	H	H

Duration (hour)		15	15	15	15	15
S-1	SLO-1	*Compilers – Analysis of the source program*	*Syntax Analysis Definition - Role of parser*	*Bottom Up Parsing*	*Intermediate Code Generation*	*Code optimization*
	SLO-2	*Phases of a compiler – Cousins of the Compiler*	*Lexical versus Syntactic Analysis*	*Reductions*	*Intermediate Languages - prefix - postfix*	*Introduction– Principal Sources of Optimization*
S-2	SLO-1	*Grouping of Phases – Compiler construction tools*	*Representative Grammars*	*Handle Pruning*	*Quadruple - triple - indirect triples Representation*	*Function Preserving Transformation*
	SLO-2	*Lexical Analysis – Role of Lexical Analyzer*	*Syntax Error Handling*	*Shift Reduce Parsing*	*Syntax tree- Evaluation of expression - three-address code*	*Loop Optimization*
S-3	SLO-1	*Input Buffering*	*Elimination of Ambiguity, Left Recursion*	*Problems related to Shift Reduce Parsing*	*Synthesized attributes – Inherited attributes*	*Optimization of basic Blocks*
	SLO-2	*Specification of Tokens*	*Left Factoring*	*Conflicts During Shift Reduce Parsing*	*Intermediate languages – Declarations*	*Building Expression of DAG*
S 4-5	SLO-1 SLO-2	*Lab 1 - Implementation of Lexical Analyzer*	*Lab 4Elimation of Ambiguity, Left Recursion and Left Factoring*	*Lab 7 - Shift Reduce Parsing*	*Lab 10-Intermediate code generation – Postfix, Prefix*	*Lab 13 Implementation of DAG*
S-6	SLO-1	*Finite automation - deterministic*	*Top down parsing*	*LR Parsers- Why LR Parsers*	*Assignment Statements*	*Peephole Optimization*
	SLO-2	*Finite automation - non deterministic*	*Recursive Descent Parsing, back tracking*	*Items and LR(0) Automaton, Closure of Item Sets,*	*Boolean Expressions, Case Statements*	*Basic Blocks, Flow Graphs*
S-7	SLO-1	*Transition Tables*	*Computation of FIRST*	*LR Parsing Algorithm*	*Back patching – Procedure calls*	*Next -Use Information*

	SLO-2	*Acceptance of Input Strings by Automata*	*Problems related to FIRST*	*Operator Precedence Parser Computation of LEADING*	*Code Generation*	*Introduction to Global Data Flow Analysis*
S-8	SLO-1	*State Diagrams and Regular Expressions*	*Computation of FOLLOW*	*Computation of TRAILING*	*Issues in the design of code generator*	*Computation of gen and kill*
	SLO-2	*Conversion of regular expression to NFA – Thompson's*	*Problems related to FOLLOW*	*Problems related to LEADING AND TRAILING*	*The target machine – Runtime Storage management*	*Computation of in and out*
S 9-10	SLO-1 SLO-2	*Lab 2 conversion from Regular Expression to NFA*	*Lab 5 -FIRST AND FOLLOW computation*	*Lab 8- Computation of LEADING AND TRAILING*	*Lab 11 Intermediate code generation – Quadruple, Triple, Indirect triple*	*Lab 14 : Implementation of Global Data Flow Analysis*
S-11	SLO-1	*Conversion of NFA to DFA*	*Construction of a predictive parsing table*	*SLR Grammars*	*A simple Code generator*	*Parameter Passing.*
	SLO-2	*Simulation of an NFA*	*Predictive Parsers LL(1) Grammars*	*SLR Parsing Tables*	*Code Generation Algorithm*	*Runtime Environments*
S-12	SLO-1	*Converting Regular expression directly to DFA*	*Transition Diagrams for Predictive Parsers*	*Problems related to SLR*	*Register and Address Descriptors*	*Source Language issues*
	SLO-2	*Minimization of DFA*	*Error Recovery in Predictive Parsing*	*Construction of Canonical LR(1) and LALR*	*Generating Code of Assignment Statements*	*Storage Organization*
S-13	SLO-1	*Minimization of NFA*	*Predictive Parsing Algorithm*	*Construction of LALR*	*Cross Compiler – T diagrams*	*Activation Records*
	SLO-2	*Design of lexical analysis (LEX)*	*Non Recursive Predictive Parser*	*Problems related to Canonical LR(1) and LALR Parsing Table*	*Issues in Cross compilers*	*Storage Allocation strategies*
S 14-15	SLO-1 SLO-2	*Lab 3 Conversion from NFA to DFA*	*Lab 6 Predictive Parsing Table*	*Lab9 Computation of LR(0) items*	*Lab 12 : A simple Code Generator*	*Lab 15: Implement any one storage allocation strategies(heap, stack, static)*

Learning Resources	1. *AlfredVAho,JefferyDUllman,RaviSethi,"Compilers,Principlestechniquesandtools",Pearson Education2011* 2. *S.GodfreyWinster,S.ArunaDevi,R.Sujatha,"CompilerDesign",YesdeePublishingPvt.Ltd,2016* 3. *WilliamM.WaiteandGerhardGoos.CompilerConstruction.Springer-Verlag,New York,2013.*	*4. K.Muneeswaran,,"CompilerDesign",OxfordHigherEducation,Fourthedition2015* *5. DavidGalles,"ModernCompilerDesign",PearsonEducation,Reprint2012.* *6. RaghavanV.,"PrinciplesofCompilerDesign",TataMcGrawHillEducationPvt.Ltd.,2010*

Learning Assessment

	Bloom's Level of Thinking	Continuous Learning Assessment (50%weightage)								Final Examination (50% weightage)	
		CLA – 1 (10%)		CLA – 2 (15%)		CLA – 3 (15%)		CLA – 4 (10%)#			
		Theory	Practice	Theory	Practice	Theory	Practice	Theory	Practice	Theory	Practice
Level 1	Remember Understand	*20%*	*20%*	*15%*	*15%*	*15%*	*15%*	*15%*	*15%*	*15%*	*15%*
Level 2	Apply Analyze	*20%*	*20%*	*20%*	*20%*	*20%*	*20%*	*20%*	*20%*	*20%*	*20%*
Level 3	Evaluate Create	*10%*	*10%*	*15%*	*15%*	*15%*	*15%*	*15%*	*15%*	*15%*	*15%*
	Total	100 %		100 %		100 %		100 %		-	

CLA – 4 can be from any combination of these: Assignments, Seminars, Tech Talks, Mini-Projects, Case-Studies, Self-Study, MOOCs, Certifications, Conf. Paper etc.,

Course Designers

Experts from Industry	Experts from Higher Technical Institutions	Internal Experts
		1. Ms.R.Jeya
		2. Mrs.J. Jeyasudha

Course Code	18CSC305J	Course Name	ARTIFICIAL INTELLIGENCE	Course Category	C	Professional Core	L	T	P	C
							3	0	2	4

Pre-requisite Courses	Nil	Co-requisite Courses	Nil	Progressive Courses	Nil
Course Offering Department	Computer Science and Engineering	Data Book / Codes/Standards	Nil		

Course Learning Rationale (CLR):	*The purpose of learning this course is to:*
CLR-1 :	*Provide a broad understanding of the basic techniques for building intelligent computer systems and an understanding of how AI is applied to problems.*
CLR-2 :	*Gain knowledge in problem formulation and building intelligent agents*
CLR-3 :	*Understand the search technique procedures applied to real world problems*
CLR-4 :	*Understand the types of logic and knowledge representation schemes*
CLR-5 :	*Acquire knowledge in planning and learning algorithms*
CLR-6 :	*Gain knowledge in AI Applications and advances in Artificial Intelligence*

Course Learning Outcomes (CLO):	*At the end of this course, learners will be able to:*	Learning 1	2	3	Program Learning Outcomes (PLO) 1	2	3	4	5	6	7	8	9	10	11	12	13	14	15
		Level of Thinking (Bloom)	Expected Proficiency (%)	Expected Attainment (%)	Engineering Knowledge	Problem Analysis	Design & Development	Analysis, Design, Research	Modern Tool Usage	Society & Culture	Environment & Sustainability	Ethics	Individual & Team Work	Communication	Project Mgt. & Finance	Life Long Learning	PSO - 1	PSO - 2	PSO – 3
CLO-1 :	*Formulate a problem and build intelligent agents*	*1*	*80*	*70*	*M*	*M*	*M*	*M*	*H*	-	-	-	*M*	*L*	-	*H*	*L*	*L*	*L*
CLO-2 :	*Apply appropriate searching techniques to solve a real world problem*	*2*	*85*	*75*	*M*	*H*	*H*	*H*	*H*	-	-	-	*M*	*L*	-	*H*	*M*	*L*	*M-*
CLO-3 :	*Analyze the problem and infer new knowledge using suitable knowledge representation schemes*	*2*	*75*	*70*	*M*	*H*	*H*	*M*	*H*	-	-	-	*M*	*L*	-	*H*	*M*	*L*	*M*
CLO-4 :	*Develop planning and apply learning algorithms on real world problems*	*2*	*85*	*80*	*M*	*H*	*M*	*H*	*H*	-	-	-	*M*	*L*	-	*H*	*M*	*M*	*M*
CLO-5 :	*Design an expert system and implement natural language processing techniques*	*3*	*85*	*75*	*M*	*H*	*H*	*H*	*H*	-	-	-	*M*	*L*	-	*H*	*H*	*M*	*H*
CLO-6 :	*Implement advance techniques in Artificial Intelligence*	*3*	*80*	*70*	*L*	*H*	*M*	*M*	*H*	-	-	-	*H*	*L*	-	*H*	*H*	*M*	*H*

Duration (hour)		15	15	15	15	15
S-1	SLO-1	*Introduction to AI-AI techniques*	*Searching techniques- Uniformed search-General search Algorithm*	*Knowledge and reasoning-Approaches and issues of knowledge reasoning*	*Planning- Planning problems, Simple planning agent*	*Expert system-Architecture*
	SLO-2	*Problem solving with AI*	*Uniformed search Methods-Breadth first search*	*Knowledge base agents-Logic Basics*	*Planning languages*	*Pros and Cons of expert system*
S-2	SLO-1	*AI Models, Data acquisition and learning aspects in AI*	*Uniformed search Methods-Depth first search*	*Logic-Propositional logic-syntax ,semantics and inferences*	*Blocks world ,Goal stack planning*	*Rule based systems*
	SLO-2	*Problem solving- Problem solving process, Formulating problems*	*Uniformed search Methods-Depth limited search*	*Propositional logic- Reasoning patterns*	*Mean Ends Analysis*	*Frame based expert system*
S-3	SLO-1	*Problem types and characteristics*	*Uniformed search Methods- Iterative Deepening search*	*Predicate logic – Syntax and semantics, instance and is relationship*	*Non-linear Planning*	*Case study*
	SLO-2	*Problem space and search*	*Bi-directional search*	*Unification and Resolution*	*Conditional planning, Reactive planning*	*Case study*
S 4-5	SLO-1 SLO-2	*Lab 1: Implementation of toy problems*	*Lab4: Implementation and Analysis of DFS and BFS for an application*	*Lab 7: Implementation of unification and resolution for real world problems.*	*Lab 10 :Implementation of block world problem*	*Natural language processing-Levels of NLP*
S-6	SLO-1	*Intelligent agent*	*Informed search- Generate and test, Best First search*	*Knowledge representation using rules*	*Learning- Machine learning*	*Syntactic and Semantic Analysis*
	SLO-2	*Rationality and Rational agent with performance measures*	*Informed search-A* Algorithm*	*Knowledge representation using semantic nets*	*Goals and Challenges of machine learning*	*Information retrieval*
S-7	SLO-1	*Flexibility and Intelligent agents*	*AO* research*	*Knowledge representation using frames*	*Learning concepts, models*	*Information Extraction*

	SLO-2	*Task environment and its properties*	*Local search Algorithms-Hill Climbing, Simulated Annealing*	*Inferences*	*Artificial neural network based learning- Back propagation*	*Machine translation*
S-8	SLO-1	*Types of agents*	*Local Beam Search*	*Uncertain Knowledge and reasoning- Methods*	*Support vector machines*	*NLP Applications*
	SLO-2	*Other aspects of agents*	*Genetic Algorithms*	*Bayesian probability and belief network*	*Reinforcement learning*	*NLP Applications*
S 9-10	SLO-1 SLO-2	*Lab 2: Developing agent programs for real world problems*	*Lab 5: Developing Best first search and A* Algorithm for real world problems*	*Lab 8: Implementation of knowledge representation schemes - use cases*	*Lab 11: Implementation of learning algorithms for an application*	*Lab 14:Implementation of NLP programs*
S-11	SLO-1	*Constraint satisfaction problems(CSP)*	*Adversarial search Methods- Game playing-Important concepts*	*Probabilistic reasoning*	*Adaptive learning*	*Advance topics in Artificial Intelligence- Cloud Computing and intelligent agent*
	SLO-2	*Crypto arithmetic puzzles*	*Game playing and knowledge structure*	*Probabilistic reasoning over time*	*Multi agent based learning*	*Business intelligence and analytics*
S-12	SLO-1	*CSP as a search problem-constrains and representation*	*Game as a search problem-Mini max approach*	*Forward and backward reasoning*	*Ensemble learning*	*Sentiment Analysis*
	SLO-2	*CSP-Backtracking, Role of heuristic*	*Mini max Algorithm*	*Other uncertain techniques-Data mining*	*Learning for decision making*	*Deep learning Algorithms*
S-13	SLO-1	*CSP-Forward checking and constraint propagation*	*Alpha beta pruning*	*Fuzzy logic*	*Distributed learning*	*Deep learning Algorithms*
	SLO-2	*CSP-Intelligent backtracking*	*Game theory problems*	*Dempster -shafer theory*	*Speedup learning*	*Planning and logic in intelligent agents*
S 14-15	SLO-1 SLO-2	*Lab 3: Implementation of constraint satisfaction problems*	*Lab 6: Implementation of mini max algorithm for an application*	*Lab 9: Implementation of uncertain methods for an application*	*Lab12: Development of ensemble model for an application*	*Lab 15: Applying deep learning methods to solve an application.*

Learning Resources	1. *Parag Kulkarni, Prachi Joshi, Artificial Intelligence –Building Intelliegent Systems, 1st ed., PHI learning,2015* 2. *DeepakKemhani,FirstcourseinArtificilaIntelligence,McGrawHillPvtLtd,2013* 3. *Stuart J. Russell, Peter Norwig , Artificial Intelligence –A Modern approach, 3rd Pearson Education, 2016*	4. *PrateekJoshi,ArtificialIntelligencewithPhython,1sted.,PacktPublishing,2017* 5. *DenisRothman,ArtificialIntelligencebyExample,Packt,2018*

Learning Assessment

	Bloom's Level of Thinking	Continuous Learning Assessment (50% weightage)								Final Examination (50% weightage)	
		CLA – 1 (10%)		CLA – 2 (15%)		CLA – 3 (15%)		CLA – 4 (10%)#			
		Theory	Practice	Theory	Practice	Theory	Practice	Theory	Practice	Theory	Practice
Level 1	Remember Understand	20%	20%	10%	10%	15%	15%	15%	15%	15%	15%
Level 2	Apply Analyze	20%	20%	20%	20%	20%	20%	20%	20%	20%	20%
Level 3	Evaluate Create	10%	10%	20%	20%	15%	15%	15%	15%	15%	15%
	Total	100 %		100 %		100 %		100 %		-	

CLA – 4 can be from any combination of these: Assignments, Seminars, Tech Talks, Mini-Projects, Case-Studies, Self-Study, MOOCs, Certifications, Conf. Paper etc.,

Course Designers

Experts from Industry	Experts from Higher Technical Institutions	Internal Experts
1. Mr.Jagatheeswaran, Lead, Auxo labs jagatheeswarans.iot@auxolabs.in	*1. Dr. Chitrakala, Anna University, au.chitras@gmail.com*	*1. Dr.M.Pushpalatha, SRMIST*
2.	*2.*	*2. Dr.G..Vadivu, SRMIST*
	3.	*3. Dr.C.Lakshmi, SRMIST*

Course Code	18CSC350T	Course Name	COMPREHENSION	Course Category	C	Professional Core	L	T	P	C
							0	1	0	1

Pre-requisite Courses	Nil	Co-requisite Courses	Nil	Progressive Courses	Nil
Course Offering Department	Computer Science and Engineering	Data Book / Codes/Standards	Nil		

Course Learning Rationale (CLR):	The purpose of learning this course is to:
CLR-1 :	*Acquire skills to solve real world problems in Data Structures and Analysis and Design of Algorithms*
CLR-2 :	*Acquire skills to solve real world problems in Object Oriented Design and Programming and advanced programming concepts*
CLR-3 :	*Acquire skills to solve real world problems in Operating systems , Computer networking and Formal Language and Automata*
CLR-4 :	*Acquire skills to solve real world problems in Compiler Design, Database Management systems and Software Engineering*
CLR-5 :	*Acquire skills to solve real world problems for competitive examinations in Mechanical Engineering*
CLR-6 :	*Acquire skills to solve real world problems in the broad domain of Mechanical Engineering*

Course Learning Outcomes (CLO):	At the end of this course, learners will be able to:	Learning 1: Level of Thinking (Bloom)	2: Expected Proficiency (%)	3: Expected Attainment (%)	PLO 1: Engineering Knowledge	2: Problem Analysis	3: Design & Development	4: Analysis, Design, Research	5: Modern Tool Usage	6: Society & Culture	7: Environment & Sustainability	8: Ethics	9: Individual & Team Work	10: Communication	11: Project Mgt. & Finance	12: Life Long Learning	13: PSO - 1	14: PSO - 2	15: PSO - 3
CLO-1 :	*Practice and gain confidence, competence to solve problems in Data Structures and Analysis and Design of Algorithms*	3	85	80	H	H	H	H	M	M	L	L	M	M	L	H	M	L	H
CLO-2 :	*Practice and gain confidence, competence to solve problems in Object Oriented Design, Programming and advanced programming concepts*	3	85	80	H	H	M	H	H	M	L	L	H	H	M	H	H	H	H
CLO-3 :	*Practice and gain confidence, competence to solve problems in Operating systems , Computer networking, Formal Language and Automata*	3	85	80	H	H	M	M	M	M	L	L	M	H	L	M	M	H	M
CLO-4 :	*Practice and gain confidence, competence to solve problems in Compiler Design, Database Management systems and Software Engineering*	3	85	80	H	H	M	H	H	H	L	L	H	H	H	H	M	H	H
CLO-5 :	*Practice and gain confidence and competence to solve problems for competitive examinations in Computer Science and Engineering*	3	85	80	H	H	H	L	L	L	L	L	L	L	L	L	M	L	M
CLO-6 :	*Practice and gain confidence and competence to solve problems in the broad domain of Computer Science and Engineering*	3	85	80	H	H	M	L	L	L	L	L	L	L	L	L	M	M	M

Duration (hour)		3	3	3	3	3
S-1	SLO-1	*Tutorial on Linear Data Structures*	*Tutorial on Object Oriented Design*	*Tutorial on Operating Systems*	*Tutorial on Compiler Design*	*Problem Solving*
	SLO-2	*Problem Solving*	*Problem Solving*	*Problem Solving*	*Problem Solving*	*Problem Solving*
S-2	SLO-1	*Tutorial on Non Linear Data Structures*	*Tutorial on Object Oriented Programming*	*Tutorial on Computer networking*	*Tutorial on Database Management systems*	*Problem Solving*
	SLO-2	*Problem Solving*	*Problem Solving*	*Problem Solving*	*Problem Solving*	*Problem Solving*
S-3	SLO-1	*Tutorial on Analysis and Design of Algorithms*	*Tutorial on Advanced Programming concepts*	*Tutorial on Formal Language and Automata*	*Tutorial on Software Engineering*	*Problem Solving*
	SLO-2	*Problem Solving*	*Problem Solving*	*Problem Solving*	*Problem Solving*	*Problem Solving*

Learning Resources		
	1. Jushta Jaiswal,Objective "Computer Science & Information Technology", Source books, , 2015 *2. G.K.Mithal, "Objective Computer Science and Information Technology",G.K.Publishing, 10th edition, 2016*	*3. R.Agor, "Computer Science Conventional & Objective type solved questions", Birla Publishing, 2004* *4. Timothy Williams, "MCQs in Computer Science", McGraw Hill, 5th edition, 2017* *5. Surbhi Mitra, "Computer Science and IT",Arihant Handbook series, 2013*

Learning Assessment

	Bloom's Level of Thinking	Continuous Learning Assessment (100% weightage)								Final Examination	
		CLA – 1 (20%)		CLA – 2 (30%)		CLA – 3 (30%)		CLA – 4 (20%)#			
		Theory	Practice	Theory	Practice	Theory	Practice	Theory	Practice	Theory	Practice
Level 1	Remember Understand	-	*40%*	-	*30%*	-	*30%*	-	*30%*	-	-
Level 2	Apply Analyze	-	*40%*	-	*40%*	-	*40%*	-	*40%*	-	-
Level 3	Evaluate Create	-	*20%*	-	*30%*	-	*30%*	-	*30%*	-	-
	Total	100 %		100 %		100 %		100 %		-	

CLA – 4 can be from any combination of these: Assignments, Seminars, Tech Talks, Mini-Projects, Case-Studies, Self-Study, MOOCs, Certifications, Conf. Paper etc.,

Course Designers		
Experts from Industry	Experts from Higher Technical Institutions	Internal Experts
1. Dr. Anbu Rathinavel , Chief Design Officer, Design Intellect	*1. Dr. Viraj Kumar, Professor, CSE, PES University*	*Dr. B.Amutha, Professor & Head, CSE, SRMIST*
		Dr.S.S.Sridhar, Professor,CSE, SRMIST

ACADEMIC CURRICULA

Professional Core Courses

ELECTRICAL & ELECTRONICS ENGINEERING

Regulations - 2018

SRM INSTITUTE OF SCIENCE AND TECHNOLOGY

(Deemed to be University u/s 3 of UGC Act, 1956)

Kattankulathur, Kancheepuram, Tamil Nadu, India

Course Code	18EEC301J	Course Name	CONTROL SYSTEMS	Course Category	C	Professional Core	L	T	P	C
							3	0	2	4

Pre-requisite Courses	Nil	Co-requisite Courses	Nil	Progressive Courses	Nil
Course Offering Department	Electrical and Electronics Engineering	Data Book / Codes/Standards	Nil		

Course Learning Rationale (CLR):	*The purpose of learning this course is to:*
CLR-1 :	*Educate the students on mathematical model of a physical system.*
CLR-2 :	*Provide knowledge on time domain response and stability of a system.*
CLR-3 :	*Explain the concept of frequency domain using mathematical and graphical approach*
CLR-4 :	*Design various controller / compensator to meet system requirement.*
CLR-5 :	*Understand the concept of state space analysis.*
CLR-6 :	*Gain knowledge on the design, control and analysis of physical system.*

Course Learning Outcomes (CLO):	*At the end of this course, learners will be able to:*	Learning			Program Learning Outcomes (PLO)														
		1	2	3	1	2	3	4	5	6	7	8	9	10	11	12	13	14	15
		Level of Thinking (Bloom)	Expected Proficiency (%)	Expected Attainment (%)	Engineering Knowledge	Problem Analysis	Design & Development	Analysis, Design, Research	Modern Tool Usage	Society & Culture	Environment & Sustainability	Ethics	Individual & Team Work	Communication	Project Mgt. & Finance	Life Long Learning	PSO - 1	PSO - 2	PSO – 3
CLO-1 :	*Interpret a physical system in s domain representation.*	3	75	75	H	H	M	M	-	-	-	-	M	M	-	-	M	H	-
CLO-2 :	*Analyze the use of time domain specification and stability in real time application.*	3	75	75	H	H	M	H	M	-	-	-	M	M	-	-	H	H	-
CLO-3 :	*Apply various techniques to understand the frequency response of a system*	3	75	75	H	H	H	H	M	-	-	-	M	M	-	-	H	H	-
CLO-4 :	*Articulate the concept of tuning and design a controller for the given system.*	3	75	75	H	H	H	H	M	-	-	L	M	M	-	-	H	H	L
CLO-5 :	*Comprehend the state and test the controllability, observability of a system.*	3	75	75	H	H	M	M	M	-	-	-	M	M	-	-	M	H	-
CLO-6 :	*Analysis the system stability and performance of physical system.*	3	75	75	H	H	H	H	M	-	-	L	M	M	-	-	H	H	L

Duration (hour)		15	15	15	15	15
S-1	SLO-1	*Classification of control systems.*	*Introduction to time domain analysis.*	*Introduction to frequency domain analysis.*	*Need for controller design and in systems*	*State space analysis.*
	SLO-2	*Terminology of automatic control systems.*	*Standard test signals ; Response of first order systems to standard test signals*	*Frequency response plots of dynamic systems.*	*Important for compensation in system.*	*Concepts of state, state variables, state model.*
S-2	SLO-1	*Principles and effects of feed forward control systems.*	*Step response of second order systems in detail*	*Frequency response measurements, Performance specifications in the frequency domain.*	*Effects of P,PI Controller.*	*State differential equation using physical variables;*
	SLO-2	*Principles and effects of feedback control systems.*	*Different damping conditions.*	*Log magnitude and phase diagrams.*	*Effect of PID Controller.*	*State diagram representation.*
S-3	SLO-1	*Transfer functions SISO & MIMO*	*Transient response analysis.*	*Determination of Frequency domain specifications.*	*Classical PID controller*	*Tutorial – State space analysis by using phase variable form.*
	SLO-2	*Transfer functions for simple electrical, mechanical and electro mechanical systems*	*Time domain specification.*	*Phase margin and Gain margin*	*PID controller tuning using Zigler – Nichols tuning rules.*	*Formation of state space equation.*
S 4-5	SLO-1 SLO-2	*Lab 1: Determination of transfer function parameter of DC motor*	*Lab: 4Generating standard test signals.*	*Lab 7: Frequency response characteristics of second order system.*	*Lab 10: Design, determination of transfer function and frequency response for lag, lead network.*	*Lab 13: State space model for classical transfer function and design and tuning a PID controller.*
S-6	SLO-1	*Tutorial: Formation of transfer functions of mechanical translational and rotational system.*	*Steady state response; Steady state error.*	*Stability Analysis using Bode Plots*	*Feedback compensation –Lead compensation*	*Relationship between state equation and transfer functions.*
	SLO-2	*Tutorial: Formation of electrical analogy of mechanical translational and rotational system.*	*Static & dynamic error coefficients*	*Procedure for plotting bode plot. .*	*Lag compensation*	*Conversion of state space to transfer function.*
S-7	SLO-1	*Block diagram algebra.*	*Effects of additional Pole on the Second-Order System Response*	*Tutorial – Bode plot problem*	*Compensator design in frequency domain using bode plot*	*Solution of state equation;*

	SLO-2	*Representation by Signal flow graph*	*Effects of additional Zero on the Second-Order System Response*	*Stability margin on the bode plot.*	*Design procedure.*	*State Transition Matrix and it's Properties*
S-8	SLO-1	*Tutorial: Block diagram reduction direct method..*	*Routh Hurwitz criterion*	*Nyquist (Polar) Plot*	*Tutorial - Compensator design*	*Importance of controllability and observability.*
	SLO-2	*Tutorial: Block diagram reduction use by Mason's gain formula.*	*Stability condition and its limitation.*	*Gain phase plot.*	*Achieved desired system specification.*	*Tutorial: Formation of controllability and observability matrix*
S 9-10	SLO-1 SLO-2	*Lab 2: Determination of transfer function parameter of AC servo motor.*	*Lab 5: Step response characteristics of second order system.*	*Lab 8: Stability analysis of second order system using time and frequency domain approach.*	*Lab 11 Stability analysis of add a pole / zero and lag lead compensator.*	*Lab 14:. Analysis of twin rotor multi input multi output system.*
S-11	SLO-1	*Linear Approximations of Physical Systems.*	*Properties of the Root Loci*	*Nyquist stability criterion*	*Pole zero cancellation design:*	*Pole zero cancellation for uncontrollability system.*
	SLO-2	*Linearization of nonlinear systems*	*Construction of root loci*	*Stability analysis using nyquist plot.*	*Notch filter*	*Design for controllable system.*
S-12	SLO-1	*Poles and zeros of a transfer function*	*Tutorial – Root locus*	*Relations between closed loop and open loop frequency response.*	*Minor loop feedback control.*	*Tutorial –Pole placement of state feedback system.*
	SLO-2	*Graphical evaluation*	*Gain limitation for stability condition.*	*M and N circle*	*Advantages and Applications*	*Design for pole placement approach.*
S-13	SLO-1	*BIBO Stability and its important*	*Effects of adding poles on the root loci.*	*Time response analysis use by Simulink/ program software.*	*Case Study: IEC61131 Standards*	*Case study: State space analysis of electric vehicle charging system.*
	SLO-2	*Location of poles and stability.*	*Effects of adding zeros on the root loci.*	*Frequency response analysis use by Simulink/ program software.*	*Programming language for industrial automation.*	*Analysis the system response.*
S 14-15	SLO-1 SLO-2	*Lab 3: Performance analysis of a motor driving a load through a gear train.*	*Lab 6. Plotting root locus of a transfer function using a simulator tank level estimation control.*	*Lab 9: Modeling and control analysis of simple electric network*	*Lab 12: Effect of feedback on disturbance and PID control design.*	*Lab 15: Design of speed control of DC motor drive.*

Learning Resources	1. *I J Nagarath and M.Gopal, Control systems Engineering, New age international publication , 6th Edition, 2017.* 2. *FaridGolnaraghi, Benjamin C. Kuo, Automatic Control Systems, McGraw-Hill Professional, 10th Edition, 2017.* 3. *Katsuhiko Ogata,Modern control engineering, Pearson publication, 5th Edition, 2017.* 4. *Stefani, shahian, savant, Hostetter, Design of Feedback control systems, Oxford university press, 4th Edition,2014,*	5. *K.P.Ramachandran, Control Engineering, Wilky India Private Limited,1st Edition,2011.* 6. *Graham C.Goodwin, Stefan F. Graebe, Mario E. Salgado, Control system design ,Pearson Education, 2nd Edition,2001.* 7. *.B.S.Manke, Control System Design, Khanna publisher, 5th Edition,2014.* 8. *Online course material: Plat form- NPTEL, Author – Prof . S.D Agashe, IIT Bombay, Web link: https://nptel.ac.in/syllabus/108101037/*

Learning Assessment

	Bloom's Level of Thinking	Continuous Learning Assessment (50% weightage)								Final Examination (50% weightage)	
		CLA – 1 (10%)		CLA – 2 (15%)		CLA – 3 (15%)		CLA – 4 (10%)#			
		Theory	Practice	Theory	Practice	Theory	Practice	Theory	Practice	Theory	Practice
Level 1	Remember Understand	*20%*	*20%*	*15%*	*15%*	*15%*	*15%*	*15%*	*15%*	*15%*	*15%*
Level 2	Apply Analyze	*20%*	*20%*	*20%*	*20%*	*20%*	*20%*	*20%*	*20%*	*20%*	*20%*
Level 3	Evaluate Create	*10%*	*10%*	*15%*	*15%*	*15%*	*15%*	*15%*	*15%*	*15%*	*15%*
	Total	100 %		100 %		100 %		100 %		100 %	

CLA – 4 can be from any combination of these: Assignments, Seminars, Tech Talks, Mini-Projects, Case-Studies, Self-Study, MOOCs, Certifications, Conf. Paper etc.,

Course Designers

Experts from Industry	Experts from Higher Technical Institutions	Internal Experts
1.Ms.Vijayalakshmi Ramani, Head-Engineering at C2C Engineering, Chennai, vijayalakshmi@c2cengineering.co.in	*1.Dr.S.K.Patnaik, CEG, Anna University, skpatnaik@annauniv.edu*	*1.Mr. A.Sureshkumar, SRM IST*
2.Mr.Senthilkumar,ATI,rskrd1962@gmail.com,	*2.Dr. S. Ramareddy, Jerusalem College of Engineering,srr.victory@gmail.com.*	*2.Dr.N.Chellammal, SRMIST*

Course Code	18EEC302J	Course Name	POWER ELECTRONICS	Course Category	C	Professional Core	L	T	P	C
							3	0	2	4

Pre-requisite Courses	Nil	Co-requisite Courses	Nil	Progressive Courses	Nil
Course Offering Department	Electrical and Electronics Engineering	Data Book / Codes/Standards	Nil		

Course Learning Rationale (CLR):	The purpose of learning this course is to:
CLR-1 :	*Emphasize on basics of various power devices*
CLR-2 :	*Furnish adequate knowledge about the application of power devices in rectifier circuits*
CLR-3 :	*Educate the students on various DC-DC converters and their design*
CLR-4 :	*Illustrate the types and working of DC-AC converters*
CLR-5 :	*Describe the classification of AC-AC converters and their working*
CLR-6 :	*Providebasic knowledge on different industrial applications of power electronic converters*

Course Learning Outcomes (CLO):	At the end of this course, learners will be able to:	Learning 1: Level of Thinking (Bloom)	Learning 2: Expected Proficiency (%)	Learning 3: Expected Attainment (%)	PLO 1: Engineering Knowledge	PLO 2: Problem Analysis	PLO 3: Design & Development	PLO 4: Analysis, Design, Research	PLO 5: Modern Tool Usage	PLO 6: Society & Culture	PLO 7: Environment & Sustainability	PLO 8: Ethics	PLO 9: Individual & Team Work	PLO 10: Communication	PLO 11: Project Mgt. & Finance	PLO 12: Life Long Learning	PLO 13: PSO - 1	PLO 14: PSO - 2	PLO 15: PSO – 3
CLO-1 :	*Understand and analyze the characteristics of different power devices*	2	75	75	H	M	-	-	M	-	-	-	M	M	-	-	M	M	-
CLO-2 :	*Comprehend the operation of AC-DC converters and design a converter of specific range*	3	75	75	H	H	M	M	M	-	-	-	M	M	-	-	M	M	-
CLO-3 :	*Apply the concept of chopper principle and design a DC-DC converter.*	3	75	75	H	H	M	M	M	-	-	-	M	M	-	-	M	M	-
CLO-4 :	*Articulate the concept of DC-AC conversion and model an inverter*	3	75	75	H	H	M	M	M	-	-	-	M	M	-	-	M	M	-
CLO-5 :	*Analyze the function of AC-AC converters*	2	75	75	H	M	-	-	M	-	-	-	M	M	-	-	M	M	-
CLO-6 :	*Acquire and analyze various applications of power electronic circuits*	3	75	75	H	M	M	M	M	-	-	-	M	M	-	-	M	M	-

Duration (hour)		15	15	15	15	15
S-1	SLO-1	*Introduction to Power processing*	*Single phase full controlled rectifiers with R, RL load*	*Principles of chopper circuits*	*Principles of power VSI and CSI inverters*	*Step down Cycloconverter*
	SLO-2	*Construction - Principle of operation of Power diodes*	*Estimation of average & RMS load voltage, RMS load current and input power factor for full controlled rectifiers*	*Control Strategies in chopper circuits*	*Single phase voltage source inverter under various loading conditions*	*Step up Cycloconverter*
S-2	SLO-1	*Dynamic characteristics of Power diodes*	*Single phase full controlled rectifiers with RLE load*	*Multi- quadrant operation of chopper*	*Working of three phase inverter circuits in 180 degree mode of conduction*	*Three phase to single phase Cycloconverter*
	SLO-2	*Construction - Principle of operation of SCR- Dynamic characteristics of SCR*	*Estimation of average & RMS load voltage*	*Types of commutation*	*Determination of RMS ,average values of line and phase voltage*	*Three phase to three phase cyclo converter*
S-3	SLO-1	*Construction - Principle of operation of TRIAC,GTO*	*Estimation of RMS load current and input power factor*	*Forced commutated chopper :Voltage commutated choppers*	*Working of three phase inverter circuits in 120 degree mode of conduction*	*Introduction to matrix converter*
	SLO-2	*Dynamic characteristics of GTO*	*Problems in rectifier circuits*	*Forced commutated chopper : Current commutated choppers*	*Determination of RMS ,average values of line and phase voltage*	*Operation of matrix converter*
S 4-5	SLO-1 SLO-2	*Lab 1: R-RC Triggering Circuits ; UJT Triggering Circuits; HWR-FWR HWR- FWR*	*Lab 4: Single phase half controlled bridge rectifier with resistive and inductive loads*	*Lab 7: Control of DC Voltage in chopper circuits using Time ratio & pulse width control*	*Lab 10: Three phase DC-AC converter for different types of loads*	*Lab 13: Single Phase cycloconverter*
S-6	SLO-1	*SCR: turn-on, methods*	*Three phase full controlled rectifiers with R load*	*Load commutated chopper*	*Introduction to Current source inverter*	*AC Voltage regulator*
	SLO-2	*SCR: turn-off methods*	*Working of three phase full controlled rectifiers with R load for various firing angle*	*Introduction to isolated and Non-isolated topologies*	*Auto sequential current source inverter*	*Active power line conditioner*
S-7	SLO-1	*Over voltage protection:*	*Three phase full controlled rectifiers with RL load*	*Basic non-isolated topologies: Characteristics of Buck converter*	*Single pulse width modulation technique*	*UPS*

	SLO-2	Over current protection	Working of three phase full controlled rectifiers with RL load for various firing angle	Derivation of voltage gain of Buck converter	Multiple pulse width modulation technique	SMPS
S-8	SLO-1	Gate Protection	Estimation of average & RMS load voltage,	Basic non-isolated topologies: Characteristics of Boost converter	Sinusoidal pulse width modulation technique (Unipolar , bipolar schemes)	HVDC systems
	SLO-2	Design of Snubber circuits	Estimation RMS load current and input power factor	Derivation of voltage gain of Boost converter	Introduction to space vector pulse width modulation	Types of HVDC systems
S 9-10	SLO-1	Lab 2: Characteristics of SCR;TRIAC	Lab 5: Three phase fully controlled rectifier with resistive load	Lab 8:Study of forced commutation techniques using chopper circuits	Lab 11: Generation of PWM signals using Sine PWM technique to trigger switches in a three phase inverter	Lab 14: A.C. voltage controllers with R and RL loads
	SLO-2					
S-11	SLO-1	Construction - Principle of operation of Power MOSFET	Single phase semi converter- Construction, working	Steady-State Equivalent Circuit Modeling of dc-dc converters- Losses and Efficiency	Voltage control of inverters	Tap changing of transformers
	SLO-2	Dynamic characteristics of Power MOSFET	Estimation of average & RMS load voltage of single phase semi converter	Resonant converters	Harmonics study and its reduction techniques	Electronic ballast
S-12	SLO-1	Construction - Principle of operation of Power IGBT	Three phase semi converter –Construction	Characteristics of CUK converter	Multilevel inverters: Introduction, Types	Induction heating
	SLO-2	Dynamic characteristics of Power IGBT	Working of three phase converter for different firing angles	Derivation of voltage gain of CUK converter	Working of cascaded seven level Inverter	Light dimmer
S-13	SLO-1	Loss calculation (Switching, conduction and leakage losses)	Estimation of average & RMS load voltage of three phase semi converter	Characteristics of SEPIC converter	Working of Diode clamped five level Inverter	Role of power converters in PV systems
	SLO-2	Problems in calculation of losses of various power devices	Effect of source inductance in full converter	Derivation of voltage gain of SEPIC converter	Working of flying capacitor five level Inverter	Role of power converters in Electric vehicles
S 14-15	SLO-1	Lab 3: Characteristics of MOSFET, IGBT	Lab 6: Three phase semi converter	Lab 9: : case study : Design and Model a Buck-Boost converter a) using real time software b) using discrete components for specific condition	Lab 12: Case study :Design a Single phase DC-AC converter to drive a 0.5 hp Single phase induction motor	Lab 15: Case study Design and analyze a fully controlled rectifier to feed a --- kW inverter using discrete components
	SLO-2					

Learning Resources	1. Mohan N, Undeland T M, and Robbins W P, Power Electronics - Converters, Applications andDesign, Third Edition, John Wiley & Sons, Inc., New York, 2017. 2. Rashid M H, Power Electronics, Circuits, Devices and Applications, Prentice Hall PearsonEducation, Inc., Fourth Edition 2014.	3. P.S.Bimbhra, Power Electronics, Khanna Publishers, New Delhi, Fifth edition 2012;Reprint 2014 4. M.D.Singh, K.B.Khanchandani, Power Electronics, Tata McGraw Hill, New Delhi,2nd Edition,, 2006 5. https://nptel.ac.in/downloads/108105066/

Learning Assessment

	Bloom's Level of Thinking	Continuous Learning Assessment (50% weightage)								Final Examination (50% weightage)	
		CLA – 1 (10%)		CLA – 2 (15%)		CLA – 3 (15%)		CLA – 4 (10%)#			
		Theory	Practice	Theory	Practice	Theory	Practice	Theory	Practice	Theory	Practice
Level 1	Remember Understand	20%	20%	15%	15%	15%	15%	15%	15%	15%	15%
Level 2	Apply Analyze	20%	20%	20%	20%	20%	20%	20%	20%	20%	20%
Level 3	Evaluate Create	10%	10%	15%	15%	15%	15%	15%	15%	15%	15%
	Total	100 %		100 %		100 %		100 %		100 %	

CLA – 4 can be from any combination of these: Assignments, Seminars, Tech Talks, Mini-Projects, Case-Studies, Self-Study, MOOCs, Certifications, Conf. Paper etc

Course Designers

Experts from Industry	Experts from Higher Technical Institutions	Internal Experts
1. Mr. Prakash G- Lead, CoreEL Technologies , Bangalore, prakash.g@coreel.com	1. Dr.S.Senthilkumar, NIT,Trichy;skumar@nitt.edu	1. Dr.N. Chellammal, SRMIST
2. Mr. Pramod Kumar N,CoreELTechnologies, Bangalore	2. Dr.G.Uma, CEG, Anna University, uma@annauniv.edu	2. Dr.R.Sridhar, SRMIST

Course Code	18EEC303T	Course Name	POWER SYSTEM ANALYSIS	Course Category	C	Professional Core	L	T	P	C
							3	0	0	3

Pre-requisite Courses	Nil	Co-requisite Courses	Nil	Progressive Courses	Nil
Course Offering Department	Electrical and Electronics Engineering	Data Book / Codes/Standards	Nil		

Course Learning Rationale (CLR):	*The purpose of learning this course is to:*
CLR-1 :	*Understand the modeling of power system*
CLR-2 :	*Examine power flow analysis using numerical techniques*
CLR-3 :	*Evaluate the behavior of the power system under symmetrical fault conditions*
CLR-4 :	*Evaluate the behavior of the power system under unsymmetrical fault conditions*
CLR-5 :	*Discuss the stability issues of power system under transient condition*
CLR-6:	*Understand the mathematical modeling and analysis of power system*

Course Learning Outcomes (CLO):	*At the end of this course, learners will be able to:*	Learning 1	Learning 2	Learning 3	Program Learning Outcomes (PLO) 1	2	3	4	5	6	7	8	9	10	11	12	13	14	15
		Level of Thinking (Bloom)	Expected Proficiency (%)	Expected Attainment (%)	Engineering Knowledge	Problem Analysis	Design & Development	Analysis, Design, Research	Modern Tool Usage	Society & Culture	Environment & Sustainability	Ethics	Individual & Team Work	Communication	Project Mgt. & Finance	Life Long Learning	PSO - 1	PSO - 2	PSO – 3
CLO-1 :	*Summarize the basics of power system components, formation of network graphs and bus admittance matrix*	*2*	*80*	*75*	*H*	*H*	*L*	-	-	-	-	-	-	-	-	-	*M*	*M*	-
CLO-2 :	*Solve numerical methods in the application of power flow studies*	*3*	*80*	*75*	*H*	*H*	*L*	-	*M*	-	-	-	-	-	-	-	*M*	*M*	-
CLO-3 :	*Analyze the impact of symmetrical faults*	*3*	*80*	*75*	*H*	*H*	*L*	-	-	-	-	-	-	-	-	-	*M*	*M*	--
CLO-4 :	*Analyze different types of unsymmetrical faults*	*3*	*80*	*75*	*H*	*M*	*L*	-	-	-	-	-	-	-	-	-	*M*	*M*	-
CLO-5 :	*Examine transient stability analysis and solve numerical methods for transient stability*	*3*	*80*	*75*	*H*	*H*	*L*	-	-	-	-	-	-	-	-	-	*M*	*M*	-
CLO-6 :	*Analyze the power system under normal and fault conditions*	*3*	*80*	*75*	*H*	*H*	*L*	-	*M*	-	-	-	-	-	-	-	*M*	*M*	-

Duration (hour)		9	9	9	9	9
S-1	SLO-1	*Power scenario in India*	*Necessity of power flow studies*	*Symmetrical short circuit on Synchronous Machine*	*Introduction to symmetrical components*	*Introduction to stability studies*
	SLO-2	*Power system components*	*Bus classification*	*Steady state, transient and sub transient reactances*	*Sequence voltages and currents*	*Illustration of steady state stability limit*
S-2	SLO-1	*Per unit representation*	*Formulation of Power Flow problems*	*Study of symmetrical faults in power system*	*Sequence impedances and networks*	*Synchronizing power co-efficient*
	SLO-2	*Single line diagram*	*Power flow solution using Gauss Seidel method (algorithmic steps)*	*Numericals in short circuit in synchronous generator*	*Zero sequence networks*	*Review of mechanics and swing equation*
S-3	SLO-1	*Per unit quantities*	*Handling of Voltage controlled buses*	*Bus Impedance matrix by building algorithm (without mutual coupling) (algorithmic steps)*	*Types of unsymmetrical faults*	*Representation of swing curves*
	SLO-2	*p.u impedance diagram*	*Power flow solution using Gauss Seidel method excluding PV buses (quantitative analysis)*	*Bus Impedance matrix by building algorithm (without mutual coupling) (quantitative analysis)*	*Fault conditions for single line to ground fault*	*Power-Angle equation*
S-4	SLO-1	*Network graph*	*Conditions for PV buses*	*Bus Impedance matrix by building algorithm (including mutual coupling) (algorithmic steps)*	*Fault conditions for line to line fault*	*Equal area criterion*
	SLO-2	*Bus incidence matrix*	*Power flow solution using Gauss Seidel method including PV buses (quantitative analysis)*	*Bus Impedance matrix by building algorithm (including mutual coupling) (quantitative analysis)*	*Fault conditions for double line to ground fault*	*Impact of sudden load increase in synchronous motor*
S-5	SLO-1	*Primitive parameters*	*Impact of acceleration factor in convergence*	*Symmetrical fault analysis using Thevenin's theorem*	*Single line to ground fault and line to line fault in generator terminals*	*Illustrations of equal area criterion under different system conditions*
	SLO-2	*Graph and oriented graph*	*Power flow solution including acceleration factor*	*Symmetrical fault analysis using Thevenin's theorem (numericals)*	*Double line to ground fault in generator terminals*	*Derivation of Critical clearing angle and time*

S-6	SLO-1	*Links and trees*	*Algorithmic steps of Power Flow Solution by Newton Raphson method*	*Derivation of Bus voltages due to current injection*	*Assumptions for system representation*	*Derivation of Critical clearing angle and time (quantitative analysis)*
	SLO-2	*Bus admittance matrix using singular transformation method without mutual coupling*	*Power Flow Solution by Newton Raphson method (quantitative analysis)*	*Calculation of bus voltages and line currents*	*Formation of positive, negative and zero sequence networks*	*Classical step-by-step solution of the swing curve (theoretical approach)*
S-7	SLO-1	*Bus admittance matrix using singular transformation method without mutual coupling (quantitative analysis)*	*Algorithmic steps of Power Flow Solution by Fast Decoupled method*	*Symmetrical fault analysis through bus impedance matrix (theoretical approach)*	*Bus impedance matrices of positive, negative and zero sequence networks*	*Classical step-by-step solution of the swing curve (numerical approach)*
	SLO-2	*Bus admittance matrix using singular transformation method including mutual coupling*	*Power Flow Solution by Fast Decoupled method (quantitative analysis)*	*Symmetrical fault analysis through bus impedance matrix (quantitative analysis)*	*Analyzing Single line to ground fault and line to line fault with fault impedance*	*Algorithmic steps of swing equation using Runga Kutta method*
S-8	SLO-1	*Representation of off nominal transformer*	*Derivation of Power flow in lines*	*Short circuit level /Fault level*	*Analyzing double line to ground fault with fault impedance*	*Numeric solution of swing equation using Runga Kutta method (quantitative analysis)*
	SLO-2	*Numerical problems in off nominal transformer*	*Numerical solution of Power flow in lines*	*Fault level and short circuit MVA (numericals)*	*Analyzing unsymmetrical fault occurring at any point in a power system*	*Algorithmic steps of swing equation using modified Eulers method*
S-9	SLO-1	*Formation of bus admittance matrix for large scale system (Theoretical approach)*	*Derivation of slack bus power and line losses*	*Current limiting reactors*	*Unsymmetrical fault analysis using bus impedance matrices (algorithmic)*	*Numeric solution of swing equation using modified Euler's method*
	SLO-2	*Formation of bus admittance matrix for large scale system (quantitative analysis)*	*Numerical solution of slack bus power and line losses*	*Design of circuit breakers based on fault analysis*	*Unsymmetrical fault analysis using bus impedance matrices (quantitative analysis)*	*Factors affecting transient stability*

Learning Resources	1. *John.J.Grainger, William D. Stevenson, Jr ,Power System Analysis, McGraw Hill Education (India) Private Limited, New Delhi, 2015.* 2. *William D. Stevenson, Jr. ,Elements of Power System Analysis, McGraw Hill Education (India) Private Limited, New Delhi, 4th Edition, 2014.* 3. *Nagarath I.J. and Kothari D.P.,Modern Power System Analysis, 4th Edition, McGraw Hill Education (India) Private Limited, New Delhi, 2011*	4. *Hadi Sadat, Power System Analysis,McGraw Hill Education (India) Private Limited, New Delhi, 2nd Edition,2002.* 5. *Pai M.A. and Dheeman Chatterjee, Computer Techniques in Power System Analysis,, Mc Graw Hill Education (India) Private Limited, New Delhi, 3rd Edition, 2014.* 6. *https://nptel.ac.in/courses/108105067/1*

Learning Assessment

	Bloom's Level of Thinking	Continuous Learning Assessment (50% weightage)								Final Examination (50% weightage)	
		CLA – 1 (10%)		CLA – 2 (15%)		CLA – 3 (15%)		CLA – 4 (10%)#			
		Theory	Practice	Theory	Practice	Theory	Practice	Theory	Practice	Theory	Practice
Level 1	Remember Understand	*40 %*	-	*30 %*	-	*30 %*	-	*30 %*	-	*30%*	-
Level 2	Apply Analyze	*40 %*	-	*40 %*	-	*40 %*	-	*40 %*	-	*40%*	-
Level 3	Evaluate Create	*20 %*	-	*30 %*	-	*30 %*	-	*30 %*	-	*30%*	-
	Total	100 %		100 %		100 %		100 %		100 %	

CLA – 4 can be from any combination of these: Assignments, Seminars, Tech Talks, Mini-Projects, Case-Studies, Self-Study, MOOCs, Certifications, Conf. Paper etc.,

Course Designers		
Experts from Industry	Experts from Higher Technical Institutions	Internal Experts
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2. Dr.K.Karthikeyan, ABB India Ltd., k.karthikeyan@in.abb.com	*2. Dr. P. Somasundaram, CEG, Anna University, mpsomasundaram@annauniv.edu*	*2. Dr. D. Suchitra, SRMIST*

Course Code	18EEC304J	Course Name	MICROCONTROLLERS	Course Category	C	Professional Core	L	T	P	C
							3	0	2	4

Pre-requisite Courses	Nil	Co-requisite Courses	Nil	Progressive Courses	Nil
Course Offering Department	Electrical and Electronics Engineering	Data Book / Codes/Standards	Nil		

Course Learning Rationale (CLR):	*The purpose of learning this course is to:*
CLR-1 :	*Understand the architecture and instruction set of 8051*
CLR-2 :	*Familiarize with the programming modes of the SFRs in8051*
CLR-3 :	*Introduce 8051 programming in C*
CLR-4 :	*Outline the features of PIC microcontroller, its architecture and instruction set.*
CLR-5 :	*Explain the architecture of ARM Processor and its instruction set.*
CLR-6 :	*Acquire knowledge on microcontrollers and their applications.*

Course Learning Outcomes (CLO):	*At the end of this course, learners will be able to:*	Learning 1	Learning 2	Learning 3	PLO 1	PLO 2	PLO 3	PLO 4	PLO 5	PLO 6	PLO 7	PLO 8	PLO 9	PLO 10	PLO 11	PLO 12	PLO 13	PLO 14	PLO 15
		Level of Thinking (Bloom)	Expected Proficiency (%)	Expected Attainment (%)	Engineering Knowledge	Problem Analysis	Design & Development	Analysis, Design, Research	Modern Tool Usage	Society & Culture	Environment & Sustainability	Ethics	Individual & Team Work	Communication	Project Mgt. & Finance	Life Long Learning	PSO - 1	PSO - 2	PSO – 3
CLO-1 :	*Summarize and program 8051 microcontrollers*	*1*	*75*	*75*	*H*	*M*	*M*	*M*	*M*	-	-	-	*M*	*M*	-	-	*M*	*M*	-
CLO-2 :	*Program the SFRs according to the given requirements*	*3*	*75*	*75*	*H*	*M*	*M*	*M*	*M*	-	-	-	*M*	*M*	-	-	*H*	*H*	-
CLO-3 :	*Interface the various peripherals with 8051 and program 8051 using C*	*3*	*75*	*75*	*H*	*M*	*M*	*M*	*M*	-	-	-	*M*	*M*	-	-	*H*	*H*	-
CLO-4 :	*Decipher the given problem and develop simple programs using PIC microcontrollers*	*3*	*75*	*75*	*H*	*M*	*M*	*M*	-	-	-	-	*M*	*M*	-	-	*H*	*H*	-
CLO-5 :	*Analyze and develop simple programs using ARM processor for simple applications.*	*3*	*75*	*75*	*H*	*M*	*M*	*M*	*M*	-	-	-	*M*	*M*	-	-	*H*	*H*	-
CLO-6 :	*Update their knowledge on microcontrollers and program them for real time applications*	*3*	*75*	*75*	*H*	*M*	*M*	*M*	*M*	-	-	-	*M*	*M*	-	-	*H*	*H*	-

Duration (hour)		15	15	15	15	15
S-1	SLO-1	*Evolution of Microprocessors,Microcontrollers and Computers*	*Counters & timers: modes of operation*	*Introduction to interfacing peripheral devices*	*Introduction to PIC 16F84Amicrocontroller*	*The ARM processor -features*
	SLO-2	*Comparison of Microprocessor and Microcontroller*	*TMOD register*	*8255 PPI – Pin diagram and architecture*	*Applications of PIC 16F84A*	*Applications of ARM processors*
S-2	SLO-1	*Overview of 8-bit / 16-bit / 32-bit microprocessors and microcontrollers*	*TCON register*	*8255 PPI – Modes of operation*	*Architecture overview of PIC 16F84A*	*Architecture overview of ARM processor*
	SLO-2	*CISC and RISC architectures*	*Serial data transmission/ reception: modes*	*8279 keyboard interface - Pin diagram and architecture*	*PIC 16F84A - Block diagram*	*ARM processor - Block diagram*
S-3	SLO-1	*8051 – pin diagram*	*SCON register*	*8279 keyboard interface - modes of operation*	*Working register*	*The ARM programmer's model*
	SLO-2	*8051 - Internal Block Diagram*	*PCON register*	*LCD interfacing*	*Status register*	*ARM Current Program Status Register*
S 4-5	SLO-1 SLO-2	*Lab 1: Introduction to 8051 microcontroller*	*Lab 4:Boolean and logical operations (bit & byte level logical operations) using 8051 microcontroller*	*Lab 7:8 bit ADC using 8051 microcontroller*	*Lab 10:: Transfer data serially between two kits*	*Lab 13:DC motor speed measurement and control.*
S-6	SLO-1	*8051 - architecture*	*Internal Interrupts*	*Parallel and serial ADC interface*	*File selection register*	*ARM exceptions*
	SLO-2	*Internal memory organization*	*External Interrupts*	*DAC interface*	*Indirect data addressing register*	*Introduction to Thumb instructions*
S-7	SLO-1	*Register banks, PSW*	*IE register*	*Sensor interfacing*	*memory organization- Program memory*	*Pipeline ARM organization (3,5 stage)*
	SLO-2	*Ports*	*IP register*	*Stepper motor interfacing*	*Data memory*	*ARM instruction set: data processing instructions – arithmetic operations*
S-8	SLO-1	*Classification of instruction set*	*Clock circuit*	*DC motor interfacing and PWM*	*Watch dog timer*	*data processing instructions –bitwise logical, register movement & comparisons operations*
	SLO-2	*Addressing modes*	*RESET circuit*	*RTC interfacing*	*Power down/ sleep mode*	*Data transfer instructions – single load/store*

S 9-10	SLO-1 / SLO-2	*Lab 2:Arithmetic operation using 8051 microcontrollers*	*Lab 5:Square root computation*	*Lab 8:8 bit DAC using 8051 microcontroller*	*Lab 11: Internal interrupt generation*	*Lab 14: Basic ARM ALP(32-bit addition, subtraction, multiplication)*
S-11	SLO-1	*Instruction set - Data transfer,*	*Semiconductor memory -Types*	*Introduction to 8051 programming in C*	*PIC 16F84A parallel ports*	*Data transfer instructions – multiple load/store*
	SLO-2	*Instruction set - Logical operations, data exchange*	*Memory address decoding*	*Data types for 8051 C*	*Clock and oscillator circuits*	*Data transfer instructions –swap*
S-12	SLO-1	*Instruction set - arithmetic operations*	*8031/51 Interfacing with External ROM and RAM*	*I/O programming and logical operations in 8051 C*	*Instruction set – Arithmetic instructions*	*Control flow instructions – Branch, conditional branch*
	SLO-2	*Instruction set – Call, return*	*Pins PSEN, EA*	*Accessing code ROM space in C*	*logic instructions*	*Control flow instructions –jump*
S-13	SLO-1	*Instruction set – bit jump*	*Data memory space*	*Programming timers in 8051C*	*Instruction set – test and skip instructions*	*AMBA bus architecture*
	SLO-2	*Instruction set – byte jump*	*Problems on external memory interfacing*	*Calculation of time delays*	*jump instructions*	*ARM development tools – ARMulator*
S 14-15	SLO-1 / SLO-2	*Lab 3:Sorting data, Code conversion using 8051 microcontroller*	*Lab 6:: Delay generation using an on-chip timer using 8051 microcontrollers.*	*Lab 9:8279 Keyboard &display using 8051 controllers.LCD Display using 8051*	*Lab 12: Stepper motor control using 8051*	*Lab 15:Basic ARM binary sorting*

Learning Resources	*1. Muhammad. Ali.Mazidi, The 8051 Microcontroller and Embedded Systems: Second edition, Pearson Education Limited, 2013.* *2. K. J. Ayala, 8051 Microcontroller, Delmar Cengage Learning,3rd edition,2007.* *3. Subrata Ghoshal, 8051 Microcontroller Internals, Instructions, Programming and Interfacing, Second edition, Pearson Education Asia, 2014.* *4. John Peatman, Design with PIC Microcontrollers,PearsonEducationAsia, 8th impression 2009*	*5. SteveFurber,ARMSystem-on-chip architecture, PearsonEducation, India,2000.* *6. Tim Wilmshurst, Designing Embedded Systems with PIC Microcontrollers: Principles and applications, Published by Elsevier, 2010* *7.https://nptel.ac.in/courses/117104072/*

Learning Assessment

	Bloom's Level of Thinking	Continuous Learning Assessment (50% weightage)								Final Examination (50% weightage)	
		CLA – 1 (10%)		CLA – 2 (15%)		CLA – 3 (15%)		CLA – 4 (10%)#			
		Theory	Practice	Theory	Practice	Theory	Practice	Theory	Practice	Theory	Practice
Level 1	Remember Understand	*20%*	*20%*	*15%*	*15%*	*15%*	*15%*	*15%*	*15%*	*15%*	*15%*
Level 2	Apply Analyze	*20%*	*20%*	*20%*	*20%*	*20%*	*20%*	*20%*	*20%*	*20%*	*20%*
Level 3	Evaluate Create	*10%*	*10%*	*15%*	*15%*	*15%*	*15%*	*15%*	*15%*	*15%*	*15%*
	Total	100 %		100 %		100 %		100 %		100%	

CLA – 4 can be from any combination of these: Assignments, Seminars, Tech Talks, Mini-Projects, Case-Studies, Self-Study, MOOCs, Certifications, Conf. Paper etc.,

Course Designers

Experts from Industry	Experts from Higher Technical Institutions	Internal Experts
1. Mr.Roosefart Mohan, Nelcast Limited, Chennai,roosefart@gmail.com	*1. Dr.R.Subha, Sir MVIT, Bangalore, subha.mvit@gmail.com*	*1. Dr.D. Suchitra, SRMIST*
2.Mr.Muralikrishna, National Instruments, emkkrishnan@gmail.com	*2. Dr. A. Venkadesan, NIT, Puducherry, venkadesan@nitpy.ac.in*	*2. Ms. D. Anitha, SRMIST*

Course Code	18EEC305T	Course Name	POWER SYSTEM PROTECTION	Course Category	C	Professional Core	L	T	P	C
							3	0	0	3

Pre-requisite Courses	Nil	Co-requisite Courses	Nil	Progressive Courses	Nil
Course Offering Department	Electrical and Electronics Engineering	Data Book / Codes/Standards	Nil		

Course Learning Rationale (CLR):	*The purpose of learning this course is to:*
CLR-1 :	*Understand the principles of modern power system protection*
CLR-2 :	*Enumerate the various protection schemes*
CLR-3 :	*Acquire the knowledge of protection of Generator, Transformer and Busbar protection system*
CLR-4 :	*Understand the various types of digital protection and relay coordination*
CLR-5 :	*Describe the protection of switchgears in sub-station and its relay setting calculations*
CLR-6 :	*Gain an overall knowledge of power system protection concepts in various applications*

Course Learning Outcomes (CLO):	*At the end of this course, learners will be able to:*	Learning 1: Level of Thinking (Bloom)	Learning 2: Expected Proficiency (%)	Learning 3: Expected Attainment (%)	PLO 1: Engineering Knowledge	PLO 2: Problem Analysis	PLO 3: Design & Development	PLO 4: Analysis, Design, Research	PLO 5: Modern Tool Usage	PLO 6: Society & Culture	PLO 7: Environment & Sustainability	PLO 8: Ethics	PLO 9: Individual & Team Work	PLO 10: Communication	PLO 11: Project Mgt. & Finance	PLO 12: Life Long Learning	PLO 13: PSO - 1	PLO 14: PSO - 2	PLO 15: PSO – 3
CLO-1 :	*Recognize the power system protection basics and standards*	*2*	*80*	*75*	*H*	-	-	-	-	-	-	*M*	-	-	-	-	*M*	*M*	*M*
CLO-2 :	*Employ various protective schemes and needed instruments*	*3*	*80*	*75*	*H*	*H*	-	-	-	-	-	-	-	-	-	-	*M*	*M*	-
CLO-3 :	*Explain the various equipment protection and its characteristics*	*3*	*80*	*75*	*H*	*H*	-	-	-	-	-	-	-	-	-	-	*M*	*M*	-
CLO-4 :	*Familiarise various relay algorithms and applications of digital protection*	*3*	*80*	*75*	*H*	*H*	-	-	*M*	-	-	-	-	-	-	-	*H*	*H*	-
CLO-5 :	*Analyse the use of protection and switchgears*	*3*	*80*	*75*	*H*	*H*	-	-	-	-	-	-	-	-	-	-	*M*	*M*	-
CLO-6 :	*Apply power system protection concepts in real time environment*	*3*	*80*	*75*	*H*	*H*	-	-	*M*	-	-	*M*	-	-	-	-	*H*	*H*	*M*

Duration		9	9	9	9	9
S-1	SLO-1	*Introduction to power system protection*	*Over current protection*	*Transformer protection*	*Introduction to Digital relays - Numerical relays*	*Fuses – Types*
	SLO-2	*Basic requirements*	*Characteristics of over current protection*	*Differential protection*	*Functional blocks of numerical relay*	*Construction of fuse*
S-2	SLO-1	*Main components of protections*	*Over current protection coordination*	*Percentage biased differential protection*	*Numerical over current relay algorithm*	*Fuse characteristics*
	SLO-2	*Functions of protection*	*Relay setting calculation*	*Differential protection scheme for various types of three phase transformé*	*Numerical over current relay Flow chart*	*Applicaion of fuse*
S-3	SLO-1	*IEC – IEEE standards for protection*	*Numerical problems for over current setting*	*Numerical problems for differential protection*	*Numerical differential relay algorithm*	*Theory of current interruption,*
	SLO-2	*ANSI standards for protection*	*Numerical problems for over current setting*	*Numerical problems for differential protection*	*Numerical differential relay Flow chart*	*Arc quenching – Interruption theories*
S-4	SLO-1	*Zone of protection - overlapping*	*Directional over current relay*	*Magnetizing inrush current and harmonics restraint method*	*Numerical distance relay algorithm*	*Recovery and Restriking voltages*
	SLO-2	*Primary – back up protection*	*Charcateristics of directional over current relay*	*Over fluxing protection, Incipient fault protection - Buchholz Relay*	*Numerical distance relay Flow chart*	*RRRV*
S-5	SLO-1	*Unit, Non – Unit protection*	*Principle of distance protection*	*Alternator protection*	*Fibre Optic based relaying*	*Types of circuit breakers -Bulk oil, Minimum oil circuit breakers*
	SLO-2	*Applications of unit, non-unit protection*	*Charcateristics of distance relay*	*stator protection*	*Fibre optic relay Functions - application*	*Functions - applications*
S-6	SLO-1	*Other types of protection schemes*	*Simple impedance, Reactance and Mho relay*	*Rotor protection*	*Wide Area Protection - functions*	*Air break, Air blast circuit breakers*
	SLO-2	*Applications of protection schemes*	*Characteristics of impedance realy*	*Protection against abnormal condition - unbalanced loading, Over-speeding*	*Introduction to simulation of relay coordination*	*Functions - applications*
S-7	SLO-1	*Current Transformer for protection*	*Three step distance protection*	*Loss of excitation*	*Applications of digital signal processing tool for protection*	*Sulphur hexafluoride (SF6) and Vacuum circuit breakers*
	SLO-2	*Characteristics – numerical problems*	*Application of three step distance protection*	*Loss of prime mover*	*Functional blocks DSP*	*Applications of SF6 and vacuum circuit breakers*

S-8	SLO-1	*Voltage Transformer for protection*	*Carrier aided protection*	*Bus bar protection scheme*	*AI techniques to power system protection*	*Comparison of circuit breakers*
	SLO-2	*Characteristics of current transformer*	*Main components of carrier aided protection*	*Types of bus bar protection*	*Applications Of artificial intelligence in protection*	*Testing of circuit breaker*
S-9	SLO-1	*Electromechanical relays – construction*	*Bus bar protection scheme*	*Protection against over voltage - diverters,*	*Digital protection - Introduction to RTDS*	*Circuit breakers rating*
	SLO-2	*Relay operation - application*	*Types of bus bar*	*Lightning arrestor*	*Digital substation*	*Relay setting calculation and its operation*

Learning Resources	*1. Badriram & Vishwakarma, Power System Protection, Tata McGraw-Hill Education,10th reprint, 2015* *2. Paithankar Y. G., S. R. Bhide., Fundamentals of power system protection', PHI Learning Pvt. Ltd., 10th reprint,2010.* *3. J. Lewis Blackburn & Thomas J. Domin, Protective Relaying - Principles and Applications, Fourth Edition, CRC Press.*	*4. Bhavesh R. Bhalja, R. P. Maheshwari, Nilesh Chothani, oxford university press, Second Edition, 2018* *5. A. Kalam, D.P. Kothari, Power System Protection and Communication, New Age Science Ltd, 2009.* *6. Paul M. Anderson, Power System Protection, IEEE press series on Power Engineering, 1999.* *7. https://nptel.ac.in/courses/108101039/*

Learning Assessment											
	Bloom's Level of Thinking	Continuous Learning Assessment (50% weightage)								Final Examination (50% weightage)	
		CLA – 1 (10%)		CLA – 2 (15%)		CLA – 3 (15%)		CLA – 4 (10%)#			
		Theory	Practice	Theory	Practice	Theory	Practice	Theory	Practice	Theory	Practice
Level 1	Remember Understand	*40 %*	-	*30 %*	-	*30 %*	-	*30 %*	-	*30%*	-
Level 2	Apply Analyze	*40 %*	-	*40 %*	-	*40 %*	-	*40 %*	-	*40%*	-
Level 3	Evaluate Create	*20 %*	-	*30 %*	-	*30 %*	-	*30 %*	-	*30%*	-
	Total	100 %		100 %		100 %		100 %		100 %	

CLA – 4 can be from any combination of these: Assignments, Seminars, Tech Talks, Mini-Projects, Case-Studies, Self-Study, MOOCs, Certifications, Conf. Paper etc.,

Course Designers		
Experts from Industry	Experts from Higher Technical Institutions	Internal Experts
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Course Code	18EEC401J	Course Name	POWER SYSTEM OPERATION AND CONTROL	Course Category	C	Professional Core	L	T	P	C
							3	0	2	4

Pre-requisite Courses	18EES101J	Co-requisite Courses	Nil	Progressive Courses	Nil
Course Offering Department	Electrical and Electronics Engineering	Data Book / Codes/Standards	Nil		

Course Learning Rationale (CLR):	The purpose of learning this course is to:
CLR-1 :	*Understand the control methods of frequency in power system*
CLR-2 :	*Understand voltage control methods in power system*
CLR-3 :	*Formulate the economic operation of power system*
CLR-4 :	*Discuss the different methods to reduce losses and cost in power system*
CLR-5 :	*Develop knowledge on operation and control strategies of power system*
CLR-6 :	*Summarize the operation and control of power system*

Course Learning Outcomes (CLO):	At the end of this course, learners will be able to:	Learning 1: Level of Thinking (Bloom)	2: Expected Proficiency (%)	3: Expected Attainment (%)
CLO-1 :	*Analyze frequency control in single area and two area system*	3	75	75
CLO-2 :	*Model excitation systems and develop methods of voltage control*	3	75	75
CLO-3 :	*Examine numerical methods of economic dispatch*	3	75	75
CLO-4 :	*Solve unit commitment and optimal power flow problem*	3	75	75
CLO-5 :	*Analyze the functions of modern energy control centre on monitoring, data acquisition and control*	3	75	75
CLO-6 :	*Evaluate the strategies of operation and control*	3	75	75

Program Learning Outcomes (PLO)

	1 Engineering Knowledge	2 Problem Analysis	3 Design & Development	4 Analysis, Design, Research	5 Modern Tool Usage	6 Society & Culture	7 Environment & Sustainability	8 Ethics	9 Individual & Team Work	10 Communication	11 Project Mgt. & Finance	12 Life Long Learning	13 PSO - 1	14 PSO - 2	15 PSO – 3
CLO-1	H	H	M	L	H	-	-	M	M	-	-	-	M	M	M
CLO-2	H	H	M	L	H	-	-	M	M	-	-	-	M	M	M
CLO-3	H	H	M	L	H	-	-	-	M	-	-	-	M	M	-
CLO-4	H	H	M	H	H	-	-	-	M	-	-		M	M	-
CLO-5	H	H	-	-	H	-	-	-	M	-	-		M	M	-
CLO-6	H	H	M	L	H	-	-	M	M	-	-	-	M	M	M

Duration (hour)		15	15	15	15	15
S-1	SLO-1	*Basic concepts of operation and control of power system*	*Need for voltage control*	*Input-output characteristics of thermal units and Heat rate Curve*	*Statement of Unit Commitment problem*	*Operating strategies*
	SLO-2	*Plant and system level control*	*Requirement of reactive power*	*Input-output characteristics of Cost Curve.*	*Problem constraints*	*Control Strategies under abnormal state*
S-2	SLO-1	*Interaction of AVR and ALFC loops*	*DC Excitation system with amplidyne voltage regulator*	*Optimum generation allocation neglecting network losses and inequality constraints*	*Priority List method*	*Concept of modern control centre: monitoring, data acquisition and control*
	SLO-2	*Speed load characteristics*	*Field controlled alternator rectifier excitation*	*Optimum generation allocation neglecting network losses and inequality constraints-numerical approach*	*Priority List method-numerical approach*	*Introduction to SCADA system*
S-3	SLO-1	*Modelling of speed governing mechanisms*	*Static Excitation systems*	*Optimum generation allocation neglecting network losses and including inequality constraints*	*Dynamic programming to unit commitment problem*	*Components of SCADA system*
	SLO-2	*Regulation of two alternators in parallel*	*Brushless AC Excitation systems*	*Optimum generation allocation neglecting network losses and including inequality constraints- numerical approach*	*Algorithmic steps of Dynamic programming*	*Applications of SCADA in power systems*
S 4-5	SLO-1 SLO-2	*Lab 1: Real time data acquisition of electrical parameters*	*Lab 4: Development of voltage controllers using simulation tool*	*Lab 7: Economic dispatch neglecting losses*	*Lab 10: Unit commitment using priority method*	*Lab 13: Study of SCADA systems*
S-6	SLO-1	*Concept of Control area*	*Schematic diagram of brushless excitation system*	*Loss Coefficients*	*Dynamic programming-numerical approach*	*PLC architecture and communication links*
	SLO-2	*Closing ALFC loop*	*Modelling of AVR and Exciter*	*Transmission line loss formula*	*Lagrange Relaxation method*	*State estimation by weighted least square method*
S-7	SLO-1	*Static response of single area system-uncontrolled case*	*Modelling of synchronous generator*	*Incremental cost of received power*	*OPF problem formulations*	*State estimation by weighted least square method-numerical approach*
	SLO-2	*Dynamic response of single area system--uncontrolled case*	*Static performance of AVR loop*	*Penalty factors*	*Constraints in OPF problem*	*Wide area monitoring systems*

S-8	SLO-1	*Proportional plus integral controller*	*Dynamic response of AVR loop*	*Base point and Participation factor method*	*Gradient method of OPF problem*	*Introduction to phasor measurement units*
	SLO-2	*Static response of single area system-controlled case*	*Stability compensation and stability analysis using Bode Plot*	*Base point and Participation factor method-numerical approach*	*Gradient method of OPF problem-numerical approach*	*Comparison of SCADA with PMU*
S 9-10	SLO-1 SLO-2	*Lab 2: Automatic Load frequency control in single area system using simulation tool*	*Lab 5: Stability analysis of AVR loop*	*Lab 8: Economic dispatch including losses*	*Lab 11: Gradient method of OPF problem*	*Lab 14: State estimation using weighted least square method*
S-11	SLO-1	*Dynamic response of single area system-controlled case*	*IEEE Excitation models*	*Economic dispatch by gradient method*	*Linear programming OPF*	*PMU architecture*
	SLO-2	*Modelling of tie line*	*Voltage drop/rise in transmission lines*	*Economic dispatch by gradient method-numerical approach*	*Newton method of OPF*	*Levels of PDC*
S-12	SLO-1	*Modeling of Two area frequency control*	*Methods of voltage control- shunt capacitors, shunt reactors*	*Objectives and constraints in Security constrained economic dispatch*	*Security Constrained OPF-objectives*	*Mathematical formulation of optimal placement of PMUs*
	SLO-2	*Block diagram representation of two area system*	*Methods of voltage control- FACTS devices*	*Security constrained economic dispatch using linear programming*	*Security Constrained OPF-contraints*	*Optimal placement of PMU using linear programming*
S-13	SLO-1	*Static response of two area system*	*Methods of voltage control- tap changing transformer*	*Economic dispatch added to LFC control*	*Introduction to multi objective OPF*	*Need for Integration of Distributed generation*
	SLO-2	*Dynamic response of two area system*	*Numerical approach in tap changing transformer*	*Hydrothermal scheduling neglecting network losses –long term*	*Formulation of combined active and reactive power dispatch*	*Control and operation of distributed generation*
S 14-15	SLO-1 SLO-2	*Lab 3: Automatic Load frequency control in two area system using simulation tool*	*Lab 6: Study of voltage control techniques*	*Lab 9:Economic dispatch using gradient method*	*Lab 12: Study of numerical methods of OPF problem*	*Lab 15: Performance characteristics of Solar PV system and study of PV emulator*

Learning Resources	1. *Olle.I.Elgerd, Electric Energy systems theory- An Introduction, Tata Mc Graw Hill publishing Ltd, New Delhi, 27th reprint, 2007.* 2. *I.J.Nagrath and D.P.Kothari, Power system engineering, Tata Mc Graw Hill publishing Ltd, 2nd edition, 2007.*	3. *Allen J.Wood and Bruce F. Woollenburg, Gerald B.Sheble, Power generation, operation and control, 3rd edition, John Wiley and sons, 2013.* 4. *Prabha Kundur, Power system stability and control, Tata Mc Graw Hill publishing Ltd, New Delhi, 1st edition, 2006* 5. *https://nptel.ac.in/courses/108101040/*

Learning Assessment

	Bloom's Level of Thinking	Continuous Learning Assessment (50% weightage)								Final Examination (50% weightage)	
		CLA – 1 (10%)		CLA – 2 (15%)		CLA – 3 (15%)		CLA – 4 (10%)#			
		Theory	Practice	Theory	Practice	Theory	Practice	Theory	Practice	Theory	Practice
Level 1	Remember Understand	*20%*	*20%*	*15%*	*15%*	*15%*	*15%*	*15%*	*15%*	*15%*	*15%*
Level 2	Apply Analyze	*20%*	*20%*	*20%*	*20%*	*20%*	*20%*	*20%*	*20%*	*20%*	*20%*
Level 3	Evaluate Create	*10%*	*10%*	*15%*	*15%*	*15%*	*15%*	*15%*	*15%*	*15%*	*15%*
	Total	100 %		100 %		100 %		100 %		100 %	

CLA – 4 can be from any combination of these: Assignments, Seminars, Tech Talks, Mini-Projects, Case-Studies, Self-Study, MOOCs, Certifications, Conf. Paper etc.,

Course Designers

Experts from Industry	Experts from Higher Technical Institutions	Internal Experts
1. Mr.Sudharsan, L&T, sudharsand@lntecc.com	*1.Dr.D.Devaraj,Kalasalingam Academy of Research and Education, deva230@yahoo.com*	*1.Dr.J.Preetha Roselyn, SRMIST*
2. Dr.K.Karthikeyan, ABB India Ltd., k.karthikeyan@in.abb.com	*2.Dr. P. Somasundaram, CEG, Anna University, mpsomasundaram@annauniv.edu*	*2.Dr.R.Jegatheesan, SRMIST*

Course Code	18EEC350T	Course Name	COMPREHENSION	Course Category	C	Professional Core	L	T	P	C
							0	1	0	1

Pre-requisite Courses	Nil	Co-requisite Courses	Nil	Progressive Courses	Nil
Course Offering Department	Electrical and Electronics Engineering	Data Book / Codes/Standards	Nil		

Course Learning Rationale (CLR):	The purpose of learning this course is to:
CLR-1 :	*Acquire skills to solve real world problems in analyzing the electric circuits, analog and digital electronics*
CLR-2 :	*Acquire skills to solve real world problems in electromagnetic theory, power electronics and control system*
CLR-3 :	*Acquire skills to solve real world problems in electrical machines, measurements and Instrumentation*
CLR-4 :	*Acquire skills to solve real world problems in Generation, Transmission and Distribution networks and its analysis*
CLR-5 :	*Acquire skills to solve real world problems in microcontrollers and its applications*
CLR-6 :	*Acquire skills to solve real world problems for competitive examinations in Electrical and Electronics Engineering*

Course Learning Outcomes (CLO):	At the end of this course, learners will be able to:	Learning 1 Level of Thinking (Bloom)	2 Expected Proficiency (%)	3 Expected Attainment (%)	PLO 1 Engineering Knowledge	2 Problem Analysis	3 Design & Development	4 Analysis, Design, Research	5 Modern Tool Usage	6 Society & Culture	7 Environment & Sustainability	8 Ethics	9 Individual & Team Work	10 Communication	11 Project Mgt. & Finance	12 Life Long Learning	13 PSO - 1	14 PSO - 2	15 PSO - 3
CLO-1 :	*Practice and gain confidence and competence to solve problems in analyzing the electric circuits, analog an ,digital electronics*	3	85	80	H	H	H	H	-	L	L	L	L	L	-	L	H	H	M
CLO-2 :	*Practice and gain confidence and competence to solve problems in electromagnetic theory, power electronics and control system*	3	85	80	H	H	M	M	-	L	L	L	L	L	-	L	H	H	M
CLO-3 :	*Practice and gain confidence and competence in electrical machines, measurements and Instrumentation*	3	85	80	H	H	M	M	-	L	L	L	L	L	-	L	H	H	L
CLO-4 :	*Practice and gain confidence and competence in Generation, Transmission and Distribution networks and its analysis*	3	85	80	H	H	M	M	-	L	L	L	L	L	-	L	H	H	M
CLO-5 :	*Practice and gain confidence and competence in microcontrollers and its applications*	3	85	80	H	H	H	H	-	L	L	L	L	L	-	L	H	H	L
CLO-6 :	*Practice and gain confidence and competence to solve problems for competitive examinations in Electrical and Electronics Engineering*	3	85	80	H	H	M	M	-	L	L	L	L	L	-	L	H	H	L

Duration (hour)		3	3	3	3	3
S-1	SLO-1	*Tutorial on AC and DC circuits*	*Tutorial on Electric Field, Dielectric concepts, Maxwell Equation*	*Tutorial on Transformers, generators and motors*	*Tutorial on ac and dc transmission concepts and distribution systems*	*Tutorial on 8085 microcontroller basic design*
	SLO-2	*Problem Solving*	*Problem Solving*	*Problem Solving*	*Problem Solving*	*Problem Solving*
S-2	SLO-1	*Tutorial on characteristics of diode, amplifiers and OPAMP*	*Tutorial on semiconductor power devices , rectifier and inverter operation*	*Tutorial on bridges and potentiometer*	*Tutorial on per unit quantities and load flow methods*	*Tutorial on microcontroller programming*
	SLO-2	*Problem Solving*	*Problem Solving*	*Problem Solving*	*Problem Solving*	*Problem Solving*
S-3	SLO-1	*Tutorial on combinational and sequential logic circuit*	*Tutorial on Controllers, transient and steady state analysis of LTI systems*	*Tutorial on phase, time and frequency measurement*	*Tutorial on protection methods and circuit breakers*	*Tutorial on interface*
	SLO-2	*Problem Solving*	*Problem Solving*	*Problem Solving*	*Problem Solving*	*Problem Solving*

Learning Resources

1. *Jegatheesan R, Analysis of Electric Circuits, McGraw Hill, 2014*
2. *Jacob Millman, Christos C.Halkias, SatyabrataJit, Millman's Electronic Devices and Circuits, 4th ed., Tata McGraw Hill, 2015*
3. *M. Morris Mano, Michael D. Ciletti, Digital Design: With an Introduction to Verilog HDL, VHDL and System Verilog, 6th ed., Pearson, 2018*
4. *William Hayt, Engineering Electromagnetics, 7th ed., McGraw Hill, 2014*
5. *Mohan N, Undeland T M, and Robbins W P, Power Electronics - Converters, Applications andDesign, Third Edition, John Wiley & Sons, Inc., New York, 2017*
6. *I J Nagarath and M.Gopal, Control systems Engineering, New age international publication , 6th Edition, 2017.*
7. *J. B. Gupta, Theory & Performance of Electrical Machines, 15th ed., S.K.Kataria & Sons, 2015*
8. *A.K.Sawhney, A Course in Electrical and Electronic Measurements and Instrumentation, Dhanpat Rai & Co, 2012.*
9. *R.S.Goankar, Microprocessor Architecture Programming and Applications with the 8085,6th edition, Penram International Publishing (India) Pvt.Ltd,2013.*
10. *C. L. Wadwa, Electric Power Systems, 7th ed., New Age International Publishers,2016*
11. *https://ocw.mit.edu/courses/electrical-engineering-and-computer-science/6-071j-introduction-to-electronics-signals-and-measurement-spring-2006/lecture-notes/*
12. *https://ocw.mit.edu/courses/electrical-engineering-and-computer-science/6-632-electromagnetic-wave-theory-spring-2003/index.htm*
13. *https://nptel.ac.in/downloads/108105066/*
14. *Online course material: Plat form- NPTEL, Author – Prof . S.D Agashe, IIT Bombay, Web link: https://nptel.ac.in/syllabus/108101037/*

Learning Assessment											
	Bloom's Level of Thinking	Continuous Learning Assessment (100% weightage)								Final Examination	
		CLA – 1 (20%)		CLA – 2 (30%)		CLA – 3 (30%)		CLA – 4 (20%)#			
		Theory	Practice	Theory	Practice	Theory	Practice	Theory	Practice	Theory	Practice
Level 1	Remember Understand	-	40%	-	30%	-	30%	-	30%	-	-
Level 2	Apply Analyze	-	40%	-	40%	-	40%	-	40%	-	-
Level 3	Evaluate Create	-	20%	-	30%	-	30%	-	30%	-	-
	Total	100 %		100 %		100 %		100 %		-	

CLA – 4 can be from any combination of these: Assignments, Seminars, Tech Talks, Mini-Projects, Case-Studies, Self-Study, MOOCs, Certifications, Conf. Paper etc.,

Course Designers		
Experts from Industry	Experts from Higher Technical Institutions	Internal Experts
1.Ms.Vijayalakshmi Ramani, Head-Engineering at C2C Engineering, Chennai, vijayalakshmi@c2cengineering.co.in	*1.Dr.S.K.Patnaik, CEG, Anna University, skpatnaik@annauniv.edu*	*1. Dr. D. Karthikeyan, SRMIST*
2.Mr.Senthilkumar,ATI,rskrd1962@gmail.com,	*2.Dr. S. Ramareddy, Jerusalem College of Engineering,srr.victory@gmail.com.*	*2. Mr. V. Pradeep, SRMIST*

ACADEMIC CURRICULA

Professional Core Courses

ELECTRONICS AND COMMUNICATION ENGINEERING

Regulations - 2018

SRM INSTITUTE OF SCIENCE AND TECHNOLOGY

(Deemed to be University u/s 3 of UGC Act, 1956)

Kattankulathur, Kancheepuram, Tamil Nadu, India

Course Code	18ECC203J	Course Name	MICROPROCESSOR, MICROCONTROLLER AND INTERFACING TECHNIQUES	Course Category	C	Professional Core	L	T	P	C
							3	0	2	4

Pre-requisite Courses	18ECC103J	Co-requisite Courses	Nil	Progressive Courses	18ECE204J, 18ECE205J
Course Offering Department	Electronics and Communication Engineering	Data Book / Codes/Standards	Nil		

Course Learning Rationale (CLR):	*The purpose of learning this course is to:*
CLR-1 :	*Understand basic architecture of Intel 8086 microprocessor and Intel 8051 Microcontroller*
CLR-2 :	*Familiarize with the programming and interfacing of microprocessors,microcontrollers with memory and peripheral chips*
CLR-3 :	*Interface microprocessor/microcontroller to external input/output devices, perform input/output device programming*
CLR-4 :	*Use computer to write assembly language programs, run them by downloading them to the target microprocessor*
CLR-5 :	*Understand hardware, software interrupts, their applications, properties and interfacing of the parallel and serial ports*
CLR-6 :	*Provide strong foundation for designing real world applications using microprocessors and microcontrollers.*

		Learning			Program Learning Outcomes (PLO)														
		1	2	3	1	2	3	4	5	6	7	8	9	10	11	12	13	14	15
Course Learning Outcomes (CLO):	*At the end of this course, learners will be able to:*	Level of Thinking (Bloom)	Expected Proficiency (%)	Expected Attainment (%)	Engineering Knowledge	Problem Analysis	Design & Development	Analysis, Design, Research	Modern Tool Usage	Society & Culture	Environment & Sustainability	Ethics	Individual & Team Work	Communication	Project Mgt. & Finance	Life Long Learning	PSO - 1	PSO - 2	PSO – 3
CLO-1 :	*Recall and apply a basic concept of digital fundamentals to Microprocessor based personal computer system*	*1*	*80*	*70*		*H*			*L*										
CLO-2 :	*Solve basic binary math operations using the microprocessor. / microcontroller*	*2*	*90*	*80*	*M*											*M*			
CLO-3 :	*Demonstrate programming proficiency using the various addressing modes and data transfer instructions of the target microprocessor / microcontroller*	*3*	*90*	*80*		*M*	*H*		*H*										*L*
CLO-4 :	*Distinguish and analyze the properties of Microprocessors & Microcontrollers.*	*1*	*80*	*70*		*M*										*H*			
CLO-5 :	*Train their practical knowledge through laboratory experiments.*	*3*	*90*	*80*		*M*	*M*		*H*					*H*					*H*
CLO-6 :	*Design, program, interface external devices, memory chips, various peripheral chips with microprocessor / microcontroller*	*3*	*90*	*80*			*M*		*H*							*H*	*L*		*M*

		Intel 8086 – Architecture, Signals and Features	Programming with Intel 8086	8086 Interfacing with Memory and Programmable Devices	Intel 8051 – Architecture and Programming	Interfacing of 8051
Duration (hour)		15	15	15	15	15
S-1	SLO-1	*Introduction: History of computers, Block diagram of a microcomputer*	*Addressing modes of 8086*	*Semiconductor memory interfacing*	*Introduction: Differences between microprocessor and microcontroller*	*8051 parallel ports, and*
	SLO-2	*Intel 80x86 evolutions*		*Dynamic RAM interfacing*	*Intel's family of 8-bit microcontrollers, and feature of 8051 microcontroller*	*its programming*
S-2	SLO-1	*Features of 8086 microprocessor*	*Instruction Set of 8086: Data Transfer Instructions*	*Programmable Peripheral Interface 8255*	*Architecture of 8051*	*8051 timers, and*
	SLO-2	*Register organization of 8086*	*Example programs*	*Interfacing 8255 with 8086 and programming*		*its programming*
S-3	SLO-1	*Architecture of 8086*	*Data Conversion Instructions, Arithmetic Instructions*	*Interfacing ADC with 8086 and programming*	*Signal descriptions of 8051*	*8051 interrupts, and*
	SLO-2		*Example programs*	*Interfacing DAC with 8086 and programming*		*its programming*
S-4,5	SLO-1 SLO-2	*Lab-1: (a) Learning to Program with 8086 processor kit; Learning the hardware features of the 8086 processor kit*	*Lab-4: General Purpose Programming in 8086*	*Lab-7: Interfacing DAC / ADC with 8086 / 8051*	*Lab-10: Programming timer / counter in 8086 / 8051*	*Lab-13: Simulation of 8051 using Keil Software*
S-6	SLO-1	*Instruction queue and pipelining*	*Logical instructions and Processor control instructions*	*Stepper Motor interfacing*	*Register set of 8051*	*8051 serial port, and*
	SLO-2	*Segmentation of memory used with 8086*	*Example programs*		*Operational features of 8051*	*its programming*
S-7	SLO-1	*Methods of generating physical address in 8086*	*String instructions*	*Programmable Interval Timer 8254*	*Memory and I/O addressing by 8051*	*Interfacing program memory with 8086*
	SLO-2	*Pin signals of 8086: Common signals*	*Example programs*	*Interfacing 8254 with 8086 and programming*	*Interrupts and Stack of 8051*	*Interfacing data memory with 8086*

S-8	SLO-1	*Minimum mode signals*	*Branch Instructions*	*Programmable Interrupt Controller 8259*	*Addressing modes of 8051*	*Interfacing input devices: push-button / matrix keypad*
	SLO-2	*Maximum mode signals*	*Example programs*	*Interfacing 8259 with 8086 and programming*		*Example programs*
S-9,10	SLO-1 SLO-2	*Lab-2: General Purpose Programing in 8086*	*Lab-5: Simulation of 8086 using MASM Software / 8086 Emulator*	*Lab-8: Interfacing DC motor / stepper motor / servo motor with 8086 / 8051*	*Lab-11: Programming interrupts in 8086 / 8051*	*Lab-14: Model Practical Exam*
S-11	SLO-1	*Minimum mode 8086 system, and*	*Assembly Language Programming of 8086*	*Programmable Keyboard / Display Controller 8279*	*8051 Instruction Set: Arithmetic and Logical Instructions*	*Interfacing display devices: LED / 7-segment / LCD displays*
	SLO-2	*Timings*	*Assembly Language Programming of 8086*	*Interfacing 8279 with 8086 and programming*	*Example Programs*	*Example programs*
S-12	SLO-1	*Maximum mode 8086 system, and*	*Stack structure, and*	*Programmable Communication Interface 8251 USART*	*Data Transfer Instructions*	*Interfacing DAC*
	SLO-2	*Timings*	*related programming*	*Interfacing 8251 with 8086 and programming*	*Example Programs*	*Interfacing ADC*
S-13	SLO-1	*Intel 8088 Microprocessor: Pins signals and Architecture*	*Interrupt structure, and*	*DMA Controller 8257*	*Boolean Variable Instructions and Branch Instructions*	*Interfacing DC motor / stepper motor / servo motor*
	SLO-2	*Differences between 8086 & 8088 microprocessors*	*related programming*	*Interfacing 8257 with 8086 and programming*	*Example Programs*	*Example programs*
S-14,15	SLO-1 SLO-2	*Lab-3: General Purpose Programing in 8086*	*Lab-6: Interfacing 8255 with 8086 / 8051*	*Lab-9: General Purpose Programming in 8051*	*Lab-10: Programming serial communication in 8086 / 8051*	*Lab-15: End-Semester Exam*

Learning Resources	1. *K. M. Bhurchandi and A. K. Ray, "Advanced Microprocessors and Peripherals-with ARM and an Introduction to Microcontrollers and Interfacing ", Tata McGraw Hill, 3rd edition 2015* 2. *Muhammad Ali Mazidi and Janice GillispieMazidi, "The 8051 - Microcontroller and Embedded systems", 7th Edition, Pearson Education, 2011.* 3. *Doughlas.V.Hall, "Microprocessor and Interfacing : Programming and Hardware", 3rd edition, McGraw Hill, 2015*	4. *Kenneth.J.Ayala, "8051 Microcontroller Architecture, Programming and Applications", 3rd edition, Thomson, 2007* 5. *Subrataghoshal " 8051 Microcontroller Internals Instructions ,Programming And Interfacing",2nd edition Pearson 2010* 6. *Yu-cheng Liu, Glenn A.Gibson, "Microcomputer systems: The 8086/8088 family-Architecture,programming and design",2nd edition, Prentice Hall of India,2007*

Learning Assessment											
	Bloom's Level of Thinking	Continuous Learning Assessment (50% weightage)								Final Examination (50% weightage)	
		CLA – 1 (10%)		CLA – 2 (15%)		CLA – 3 (15%)		CLA – 4 (10%)#			
		Theory	Practice	Theory	Practice	Theory	Practice	Theory	Practice	Theory	Practice
Level 1	Remember Understand	*20%*	*20%*	*15%*	*15%*	*15%*	*15%*	*15%*	*15%*	*15%*	*15%*
Level 2	Apply Analyze	*20%*	*20%*	*20%*	*20%*	*20%*	*20%*	*20%*	*20%*	*20%*	*20%*
Level 3	Evaluate Create	*10%*	*10%*	*15%*	*15%*	*15%*	*15%*	*15%*	*15%*	*15%*	*15%*
	Total	100 %		100 %		100 %		100 %		100 %	

CLA – 4 can be from any combination of these: Assignments, Seminars, Tech Talks, Mini-Projects, Case-Studies, Self-Study, MOOCs, Certifications, Conf. Paper etc.,

Course Designers		
Experts from Industry	Experts from Higher Technical Institutions	Internal Experts
1. Mr. Anuj Kumar, Bombardier Transportation, Ahmedabad, kumaranuj.anii@gmail.com	*1. Dr. Meenakshi, Professor of ECE, CEG, Anna University, meena68@annauniv.edu*	*1. Mr. Manikandan AVM, SRMIST*
2. Mr. Hariharasudhan - Johnson Controls, Pune, hariharasudhan.v@jci.com	*2. Dr. Venkatesan, Sr. Scientist, NIOT, Chennai, venkat@niot.res.in*	

Course Code	18ECC204J	Course Name	DIGITAL SIGNAL PROCESSING	Course Category	C	Professional Core	L	T	P	C
							3	0	2	4

Pre-requisite Courses	18ECC104T	Co-requisite Courses	Nil	Progressive Courses	18ECE243J, 18ECE244J, 18ECE245T
Course Offering Department	Electronics and Communication Engineering	Data Book / Codes/Standards	Nil		

Course Learning Rationale (CLR):	*The purpose of learning this course is to:*
CLR-1 :	*Understand the operations involved in digital conversion of analog signals.*
CLR-2 :	*Realize a digital filter in direct, cascade and parallel forms. Perform efficient computation of DFT using radix 2 FFT*
CLR-3 :	*Design digital FIR filter using windowing technique and frequency sampling methods.*
CLR-4 :	*Design IIR filters using both direct method and method involving conversion of analog filter to digital filter*
CLR-5 :	*Understand sampling rate conversion and apply it for applications like QMF, sub band coding.*
CLR-6 :	*Utilize the techniques for digital conversions, filter designs and multi rate signal processing to solve real time problems*

Course Learning Outcomes (CLO):	*At the end of this course, learners will be able to:*	Learning 1 Level of Thinking (Bloom)	2 Expected Proficiency (%)	3 Expected Attainment (%)	PLO 1 Engineering Knowledge	2 Problem Analysis	3 Design & Development	4 Analysis, Design, Research	5 Modern Tool Usage	6 Society & Culture	7 Environment & Sustainability	8 Ethics	9 Individual & Team Work	10 Communication	11 Project Mgt. & Finance	12 Life Long Learning	13 PSO - 1	14 PSO - 2	15 PSO – 3
CLO-1 :	*Acquire knowledge of sampling and quantization and understand the errors that arise due to quantization.*	2	90	70	H	M	-	L	-	-	-	-	-	-	-	-	L	L	M
CLO-2 :	*Understand the concept of DFT and its efficient computation by using FFT algorithm.*	2	95	75	H	M	-	L	-	-	-	-	-	-	-	-	L	L	M
CLO-3 :	*Design FIR filters using several methods*	2	85	70	-	M	H	H	-	-	-	-	-	-	-	-	L	L	H
CLO-4 :	*Design IIR filters using several methods*	2	85	80	-	M	H	H	-	-	-	-	-	-	-	-	L	L	H
CLO-5 :	*Understand the basics of multirate DSP and its applications.*	2	90	75	H	M	-	M	-	-	-	-	-	-	-	-	L	L	M
CLO-6 :	*Apply the concepts of digital filter designs and multi rate signal processing for real time signals*	2	80	70	H	M	-	H	-	-	-	-	-	-	-	-	M	M	H

		Signals and Waveforms	Frequency Transformations	FIR Filters	IIR Filters	Multirate signal Processing
Duration (hour)		15	15	15	15	15
S-1	SLO-1	*Basic Elements of DSP*	*Realization of digital filters Direct form of realization*	*Design of Linear Phase FIR filters General consideration*	*Design of digital IIR filters Comparison of FIR and IIR filters*	*Introduction to Multirate signal processing*
	SLO-2	*Advantages and applications of DSP*	*Cascade form of realization*	*Causality, its implication Characteristics of practical frequency selective filters*	*Analog IIR filter design*	*Decimation*
S-2	SLO-1	*Continuous Time vs Discrete time signals*	*Parallel form of realization*	*Frequency response of symmetric FIR filter*	*Properties of Butterworth filters*	*Interpolation*
	SLO-2	*Continuous valued vs discrete valued signals*	*Introduction to DFT*	*N is odd*	*Properties of chebyshev filters Comparison of Butterworth and chebyshev filters*	*Spectrum of interpolated signal*
S-3	SLO-1	*Concepts of frequency in analog signals*	*Computation of DFT*	*Frequency response of symmetric FIR filter*	*Analog IIR filter design*	*Sampling rate conversion by a rational factor I/D*
	SLO-2	*Continuous and discrete time sinusoidal signals*	*Properties of DFT Periodicity, linearity and symmetry properties*	*N is even*	*Design of low pass Butterworth filter*	*Anti-aliasing and anti-imaging filters*
S-4	SLO-1 SLO-2	*Lab 1 :Generation of basic signals*	*Lab 7: Linear convolution*	*Lab 13: Design of digital FIR Low Pass, High Pass filter using rectangular window*	*Lab 19: Design of analog Butterworth filter*	*Lab 25: Interpolation*
S-5	SLO-1 SLO-2	*Lab 2: Unit step, ramp and impulse*	*Lab 8: Circular convolution*	*Lab14: Design of digital FIR Band Pass, Band Stop filter using rectangular window*	*Lab 20: Design of analog Chebyshev filter*	*Lab 26: Effect of interpolation in frequency domain*
S-6	SLO-1	*Sampling of analog signals Sampling theorem*	*Circular convolution*	*Frequency response of anti-symmetric FIR filter*	*Analog IIR filter design*	*Polyphase structure of decimator Polyphase decimation using z transform*
	SLO-2	*Aliasing Quantization of continuous amplitude signals*	*Matrix method and concentric circle method*	*N is odd and N is even*	*Design of low pass Chebyshev filter*	*Polyphase structure of interpolator Polyphase interpolation using z transform*
S-7	SLO-1	*Analog to digital conversion Sample and hold,*	*Efficient Computation of the DFT*	*Design of FIR filters Fourier series method*	*Design of digital filters Impulse invariance method*	*Advantages of multirate DSP*

	SLO-2	Quantization and coding	Divide and Conquer Approach to Computation of the DFT Using FFT	Need for filter design using window Comparison of various windowing techniques	Design of digital filters Bilinear transformation	Applications of multirate DSP
S-8	SLO-1	Oversampling A/D converters	N Point DFT Decimation-in-Time FFT Radix-2 FFT Algorithm	Filter Design using windowing technique	Design of digital filters Impulse invariance method	Practical Applications of multirate DSP
	SLO-2	Digital to analog conversion Sample and hold	N Point DFT Decimation-in-Frequency FFT	Rectangular window	Design of digital filters Bilinear transformation	interfacing of digital systems with different sampling rates
S-9	SLO-1 SLO-2	Lab 3: Generation of waveforms	Lab9: Autocorrelation and cross correlation	Lab 15: Design of digital FIR Low Pass and High Pass filter using Hanning and Hamming window	Lab 21: Design of digital Butterworth filter using impulse invariance method	Lab 27: Decimation
S-10	SLO-1 SLO-2	Lab 4: Continuous and discrete time	Lab10: Spectrum analysis using DFT	Lab 16: Design of digital FIR Band Pass and Band Stop filter using Hanning and Hamming window	Lab 22: Design of digital Butterworth filter using bilinear transformation	Lab 28: Effect of decimation in frequency domain
S-11	SLO-1	Oversampling D/A converters	Radix-2 FFT Algorithm Implementation of FFT Using DIT	Filter Design using windowing technique Hanning window	Design of digital Chebyshev filters	Practical Applications of multirate DSP Sub band coding of speech signals
	SLO-2	Quantization noise	Implementation of FFT Using DIF	Filter Design using windowing technique Hamming window	Impulse invariance method	Filter banks Analysis filter bank
S-12	SLO-1	Errors due to truncation	IDFT	Filter Design using windowing technique	Design of digital Chebyshev filters	Synthesis filter bank
	SLO-2	Probability of error	Using DIT FFT	Black mann window	Bilinear transformation	Subband coding filterbank
S-13	SLO-1	Errors due to rounding	IDFT	Design of FIR filters	Frequency transformation in analog domain	Quadrature Mirror Filter
	SLO-2	Probability of error	Using DIF FFT	Frequency sampling method	Frequency transformation in digital domain	Alias free filter bank
S-14	SLO-1 SLO-2	Lab 5: Study of sampling theorem	Lab 11: Efficient computation of DFT using FFT	Lab 17: Design of digital FIR Low Pass, High Pass, Band pass and band stop filter using Black mann window	Lab 23: Design of digital Cheby shev filter using impulse invariance method	Lab 29: Design of anti-aliasing filter
S-15	SLO-1 SLO-2	Lab 6: Aliasing effects	Lab12: Computation of IDFT	Lab 18: Design of digital FIR filter using frequency sampling method	Lab 24: Design of digital Cheby shev filter using bilinear transformation	Lab 30: Design of anti-imaging filter

Learning Resources	1. John G. Proakis, Dimitris G. Manolakis, “Digital Signal Processing, Principles, Algorithms and Applications”, Pearson Education, 4th edition, 2014 2. Alan V. Oppenheim, Ronald W. Schafer, “Discrete-Time Signal Processing”, Pearson Education, 1st edition, 2015	3. Sanjit Mitra, “Digital Signal Processing –A Computer Based Approach”, McGraw Hill, India, 4th Edition, 2013. 4. Fredric J. Harris, “Multirate Signal Processing for Communication Systems”,1st edition, Pearson Education, 2007

Learning Assessment

	Bloom’s Level of Thinking	Continuous Learning Assessment (50% weightage)								Final Examination (50% weightage)	
		CLA – 1 (10%)		CLA – 2 (15%)		CLA – 3 (15%)		CLA – 4 (10%)#			
		Theory	Practice	Theory	Practice	Theory	Practice	Theory	Practice	Theory	Practice
Level 1	Remember Understand	20%	20%	15%	15%	15%	15%	15%	15%	15%	15%
Level 2	Apply Analyze	20%	20%	20%	20%	20%	20%	20%	20%	20%	20%
Level 3	Evaluate Create	10%	10%	15%	15%	15%	15%	15%	15%	15%	15%
	Total	100 %		100 %		100 %		100 %		100 %	

CLA – 4 can be from any combination of these: Assignments, Seminars, Tech Talks, Mini-Projects, Case-Studies, Self-Study, MOOCs, Certifications, Conf. Paper etc.,

Course Designers

Experts from Industry	Experts from Higher Technical Institutions	Internal Experts
1. Mr. Anuj Kumar, Bombardier Transportation, Ahmedabad, kumaranuj.anii@gmail.com	1. Dr. Meenakshi, Professor of ECE, CEG, Anna University, meena68@annauniv.edu	Dr. M.S. Vasanthi,,SRMIST
2. Mr. Hariharasudhan - Johnson Controls, Pune, hariharasudhan.v@jci.com	2. Dr. Venkatesan, Sr. Scientist, NIOT, Chennai, venkat@niot.res.in	

Course Code	18ECC205J	Course Name	ANALOG AND DIGITAL COMMUNICATION	Course Category	C	Professional Core	L	T	P	C
							3	0	2	4

Pre-requisite Courses	18MAB203T	Co-requisite Courses	Nil	Progressive Courses	18ECC301T, 18ECC302J, 18ECE221T & 18ECE223T
Course Offering Department	ECE	Data Book / Codes/Standards	Nil		

Course Learning Rationale (CLR):	*The purpose of learning this course is to:*
CLR-1 :	*Understand the need for modulation, various Amplitude modulators/demodulators, frequency modulators, demodulators*
CLR-2 :	*Comprehend the radio transmitters, receivers using modulators and demodulators and to analyze the noise performance*
CLR-3 :	*To introduce basics of Digital modulation and detection techniques*
CLR-4 :	*To analyze the pass band data transmission techniques in terms of probability of error*
CLR-5 :	*To introduce basics of spread spectrum techniques and information theory concepts*
CLR-6 :	*Gain hands-on experience to put theoretical concepts learned in the course to practice.*

Course Learning Outcomes (CLO):	*At the end of this course, learners will be able to:*	Learning 1: Level of Thinking (Bloom)	Learning 2: Expected Proficiency (%)	Learning 3: Expected Attainment (%)	PLO 1: Engineering Knowledge	PLO 2: Problem Analysis	PLO 3: Design & Development	PLO 4: Analysis, Design, Research	PLO 5: Modern Tool Usage	PLO 6: Society & Culture	PLO 7: Environment & Sustainability	PLO 8: Ethics	PLO 9: Individual & Team Work	PLO 10: Communication	PLO 11: Project Mgt. & Finance	PLO 12: Life Long Learning	PLO 13: PSO - 1	PLO 14: PSO - 2	PLO 15: PSO – 3
CLO-1 :	*Understand the concepts of analog modulation and demodulation techniques*	*2*	*80*	*70*	*M*	-	-	-	-	-	-	-	-	*H*	-	-	*H*	-	-
CLO-2 :	*Learn the function of radio transmitters and receivers and familiarize with noise performance of various receivers*	*2*	*85*	*75*	-	*M*	*H*	-	-	-	-	-	-	-	-	-	*H*	-	-
CLO-3 :	*Understand various digital modulation schemes and matched filter receiver*	*2*	*75*	*70*	*M*	-	-	-	-	-	-	-	-	-	-	-	-	*M*	*H*
CLO-4 :	*Understand and analyze various digital pass band data transmission schemes*	*2*	*85*	*80*	-	-	-	*M*	-	-	-	-	-	-	-	-	-	*M*	-
CLO-5 :	*Understanding data transmission using spread spectrum and error coding techniques*	*2*	*85*	*75*	-	*H*	-	-	-	-	-	-	-	-	-	-	*M*	-	*H*
CLO-6 :	*Analyze the operation of analog and digital communication systems and take measurement of various communication systems to compare experimental results in the laboratory with theoretical analysis*	*2*	*85*	*75*	-	-	*H*	-	*H*	-	-	-	*H*	-	-	*M*	-	*M*	*H*

		Analog Modulation	Radio Transmitters and Receivers	Digital Modulation System and Baseband Detection	Passband Data Transmission	Spread Spectrum Techniques and Information theory Concepts
Duration (hour)		15	15	15	15	15
S-1	SLO-1	*Modulation, Need for Modulation,*	*AM transmitter : Low Level,*	*Pulse modulation systems, Overview of PAM,PWM,PPM*	*Overview of ASK, FSK, PSK*	*Spread spectrum Communications, Frequency Hopping Spread Spectrum (FHSS)*
	SLO-2	*Amplitude Modulation, Types of Amplitude Modulation*	*AM transmitter : High Level Transmitter*	*Pulse modulation systems, Overview of PAM,PWM,PPM*	*Overview of ASK, FSK, PSK*	*Spread spectrum Communications, Frequency Hopping Spread Spectrum (FHSS)*
S-2	SLO-1	*Double sideband Full carrier*	*FM transmitter: Direct Method*	*Pulse modulation systems, Sampling and quantization*	*Generation, Signal Space Diagram and detection of FSK*	*Direct Sequence Spread Spectrum (DSSS)*
	SLO-2	*Double sideband Full carrier*	*FM transmitter: Direct Method*	*Pulse modulation systems, Sampling and quantization*	*Generation, Signal Space Diagram and detection of FSK*	*Direct Sequence Spread Spectrum (DSSS)*
S-3	SLO-1	*Double sideband Suppressed carrier*	*FM transmitter: Indirect Method*	*PCM systems*	*Probability of Error for FSK*	*Direct Sequence Spread Spectrum (DSSS)*
	SLO-2	*Single sideband Suppressed carrier, VSB*	*FM transmitter: Indirect Method*	*Bandwidth of PCM, PCM TDM signal multiplexing, Limitations of PCM system*	*Probability of Error for FSK*	*Code Division Multiple Access of DSSS*
S 4-5	SLO-1 SLO-2	*Lab-1: AM modulator and Demodulator*	*Lab-4: Pre emphasis and De-emphasis*	*Lab-7: DPCM and its Demodulation*	*Lab-10: QPSK Modulation and Demodulation*	*Lab-13: Mini Project*
S-6	SLO-1	*Generation of AM waves: Linear method-Collector modulator*	*Classification of radio receiver, Functions and Characteristics of radio receiver*	*Data formatting*	*Generation, Detection, Signal Space Diagram of PSK*	*Code Division Multiple Access of DSSS*
	SLO-2	*Generation of AM waves: Linear method- Collector modulator*	*Tuned Radio Frequency receiver*	*Data formatting*	*Generation, Detection, Signal Space Diagram of PSK*	*OFDM Communication*
S-7	SLO-1	*Non-linear Modulation-Balanced Modulator*	*Super-heterodyne receiver- AM*	*Differential PCM (DPCM)*	*Probability of Error for PSK*	*OFDM Communication*
	SLO-2	*Non-linear Modulation-Balanced Modulator*	*Super-heterodyne receiver- AM*	*Differential PCM (DPCM)*	*Probability of Error for PSK*	*OFDM Communication*

S-8	SLO-1	Demodulation of AM waves : Linear diode detector	Super-heterodyne receiver- FM	Delta modulation (DM)	Generation, signal space diagram and detection of QPSK	Measures of Information
	SLO-2	Demodulation of AM waves : Linear diode detector	Super-heterodyne receiver- FM	Delta modulation (DM), Noise in DM	Generation, signal space diagram and detection of QPSK	Measures of Information
S 9-10	SLO-1 SLO-2	Lab-2: DSB-SC modulator and demodulator	Lab-5: PAM,PPM,PWM modulation and demodulation	Lab-8: DM and its Demodulation	Lab-11: DPSK Modulation and Demodulation	Lab-14: Model Practical Exam
S-11	SLO-1	Frequency modulation, Types of FM	Sources of Noise	Demodulation and detection process	Probability of Error for QPSK	Source encoding, Shannon's Channel capacity theorem
	SLO-2	Narrow Band FM, Wide Band FM, Phase modulation	Sources of Noise	Demodulation and detection process	Probability of Error for QPSK	Shannon's Channel capacity theorem
S-12	SLO-1	Generation of Narrowband FM	Noise in AM (Envelope Detection),	Maximum likelihood receiver structure, Matched filter receiver	Generation, signal space diagram and detection of π/4 QPSK	Linear block codes
	SLO-2	Generation of Narrowband FM	Noise in AM (Envelope Detection),	Maximum likelihood receiver structure, Matched filter receiver	Generation, signal space diagram and detection of π/4 QPSK	Linear block codes
S-13	SLO-1	Demodulation of FM : Foster seely discriminator	Noise in FM	Probability error of the Matched filter, Inter symbol interference, Eye pattern	Generation, signal space diagram and detection of QAM	Cyclic codes
	SLO-2	Demodulation of FM : Foster seely discriminator	Threshold effect, Pre-emphasis and De-emphasis	Probability error of the Matched filter, Inter symbol interference, Eye pattern	Generation, signal space diagram and detection of QAM	Cyclic codes
S 14-15	SLO-1 SLO-2	Lab-3: FM Modulator and Demodulator	Lab-6: Pulse Code Modulation and Demodulation	Lab-9: PSK Modulation and Demodulation	Lab-12: BER performance analysis of various Modulation Schemes	Lab-15: University Practical Exam

Learning Resources	1. Simon Haykin and Michael Moher, "Communication Systems," 5th edition, John Wiley & Sons, 2013 2. Singh. R. P & Sapre. S. D, "Communication Systems: Analog & Digital," 3rd edition, McGrawHill Education, Seventh Reprint, 2016. 3. Simon Haykin, "Communication Systems", John Wiley & Sons, 4th Edition, 20008. 4. Bernard Sklar, "Digital Communication, Fundamentals and Application", Pearson Education Asia, 2nd Edition, 2001	5. Taub & Schilling, "Principle of Communication Systems", McGraw Hill Inc, 2nd Edition, 2003. 6. John G. Proakis, "Digital Communication", McGraw Hill Inc, 5th Edition, 2008. 7. B.P. Lathi, "Modern Digital and Analog Communication System", Oxford University Press, 3rd Edition, 2005. 8. Shu Lin, Daniel Costello, "Error control coding – Fundamentals and Applications", Prentice Hall, Upper Saddle River, NJ, 2nd Edition, 2004. 9. Lab Manual

Learning Assessment

	Bloom's Level of Thinking	Continuous Learning Assessment (50% weightage)								Final Examination (50% weightage)	
		CLA – 1 (10%)		CLA – 2 (15%)		CLA – 3 (15%)		CLA – 4 (10%)#			
		Theory	Practice	Theory	Practice	Theory	Practice	Theory	Practice	Theory	Practice
Level 1	Remember Understand	20%	20%	15%	15%	15%	15%	15%	15%	15%	15%
Level 2	Apply Analyze	20%	20%	20%	20%	20%	20%	20%	20%	20%	20%
Level 3	Evaluate Create	10%	10%	15%	15%	15%	15%	15%	15%	15%	15%
	Total	100 %		100 %		100 %		100 %		-	

CLA – 4 can be from any combination of these: Assignments, Seminars, Tech Talks, Mini-Projects, Case-Studies, Self-Study, MOOCs, Certifications, Conf. Paper etc.,

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2. Mr. Hariharasudhan - Johnson Controls, Pune, hariharasudhan.v@jci.com	2. Dr. Venkatesan, Sr. Scientist, NIOT, Chennai, venkat@niot.res.in	

Course Code	18ECC206J	Course Name	VLSI DESIGN	Course Category	C	Professional Core	L	T	P	C
							3	0	2	4

Pre-requisite Courses	18ECC103J	Co-requisite Courses	Nil	Progressive Courses	18ECE301J
Course Offering Department	Electronics and Communication Engineering	Data Book / Codes/Standards	Nil		

Course Learning Rationale (CLR):	*The purpose of learning this course is to:*
CLR-1 :	*Use Verilog HDL as a design-entry language for FPGA in electronic design automation of digital circuits*
CLR-2 :	*Design, construct and simulate VLSI adders and multipliers.*
CLR-3 :	*Understand MOSFET operation*
CLR-4 :	*Implement a given logic function using appropriate logic styles for improved performance*
CLR-5 :	*Understand basic processes in IC fabrication, steps in the fabrication of MOS ICs, and as well the layout design rules.*
CLR-6 :	*Use engineering tools such as HSPICE / Modelsim / Xilinx to design experiments, gain experience with the design and analysis of MOS circuits and systems.*

Course Learning Outcomes (CLO):	*At the end of this course, learners will be able to:*	Learning 1: Level of Thinking (Bloom)	Learning 2: Expected Proficiency (%)	Learning 3: Expected Attainment (%)	PLO 1: Engineering Knowledge	PLO 2: Problem Analysis	PLO 3: Design & Development	PLO 4: Analysis, Design, Research	PLO 5: Modern Tool Usage	PLO 6: Society & Culture	PLO 7: Environment & Sustainability	PLO 8: Ethics	PLO 9: Individual & Team Work	PLO 10: Communication	PLO 11: Project Mgt. & Finance	PLO 12: Life Long Learning	PLO 13: PSO - 1	PLO 14: PSO - 2	PLO 15: PSO – 3
CLO-1 :	*Design and implement digital circuits using Verilog HDL to simulate and verify the designs.*	*3*	*85*	*75*	-	*H*	*H*	-	*H*	-	-	-	-	-	-	-	-	-	-
CLO-2 :	*Design general VLSI system components, adder cells and multipliers to address the design of datapath subsystem.*	*3*	*85*	*75*	-	*H*	*H*	-	*H*	-	-	-	-	-	-	-	-	-	-
CLO-3 :	*Examine the characteristics of MOS transistors*	*2*	*80*	*70*	*H*	*M*	-	-	-	-	-	-	-	-	-	-	-	-	-
CLO-4 :	*Examine CMOS inverter and other complex logic gates designed using different logic styles*	*2*	*80*	*70*	-	*L*	*L*	-	-	-	-	-	-	-	-	-	-	-	-
CLO-5 :	*Explain how the transistors are built, and understand the physical implementation of circuits.*	*2*	*80*	*70*	-	*L*	*L*	-	-	-	-	-	-	-	-	-	-	-	-
CLO-6 :	*Use HSPICE computer analysis program and Verilog HDL for simulation and analysis of MOS circuits and building blocks*	*3*	*85*	*75*	-	-	-	-	-	-	-	-	*H*	*M*	*L*	*M*	-	*L*	*M*

Duration (hour)		Introduction to Verilog HDL & Coding	Subsystem Design	MOS Transistor	CMOS Inverter and Circuit Design Styles	Microelectronic Materials
		15	15	15	15	15
S-1	SLO-1	*Introduction to HDL & Verilog HDL*	*General VLSI System Components: Multiplexers*	*Generic overview of the MOS device: MOS transistor symbols*	*CMOS Inverter Characteristics: Operation and properties of static CMOS inverter*	*Properties of basic materials used in microelectronics: Silicon, Silicon dioxide*
	SLO-2	*Introduction to Verilog HDL, modules and ports*	*Decoders*	*MOS structure: accumulation, depletion, inversion; nMOS transistor: cutoff, linear, saturation regions of operation*	*VTC of static CMOS inverter*	*Polysilicon and Silicon Nitride*
S-2	SLO-1	*Lexical Conventions: White Space and Comments, Operators*	*Comparators*	*MOS Transistor under Static Conditions: The threshold voltage*	*DC Inverter Calculations*	*IC Fabrication: Wafer Formation, Photolithography,Well,Channel Formation*
	SLO-2	*Numbers, Strings, Identifiers, System Names, and Keywords*	*priority encoder*	*Resistive operation*	*Symmetrical Inverter*	*Silicon Dioxide (SiO_2), Isolation, Gate Oxide*
S-3	SLO-1	*Verilog Data Types: Nets, Register Variables, Constants*	*shift and rotate operations*	*Saturation region*	*Inverter switching characteristics*	*Gate, Source/Drain Formations, Contacts and Metallization, Passivation, Metrology*
	SLO-2	*Referencing Arrays of Nets or Regs*	*Adders: Standard adder cells*	*Current-voltage characteristics*	*Output capacitance*	*Recurring Process: Diffusion, Ion Implantation, Deposition, Etching, Planarization*
S-4, 5	SLO-1 SLO-2	*Lab-0: Verilog Operators: Arithmetic, Bitwise, Reduction, Logical, Relational, Shift, Conditional, Concatenation, Expressions and Operands, Operator Precedence*	*Lab-3: Design using FSM and ASM charts*	*Lab-6: Realization of VLSI multipliers - I*	*Lab-9: Design and Analysis of CMOS Inverter using HSPICE*	*Lab-12: Design and Analysis of 4-input Dynamic NAND gate using HSPICE*
S-6	SLO-1	*Verilog modelling: Gate-level modelling*	*Ripple Carry Adder (RCA)*	*Dynamic behavior: MOSFET Capacitances, MOS structure capacitances*	*Secondary Parasitic Effects: Leakage Currents, Parasitic Resistances*	*Simplified CMOS Process flow*
	SLO-2	*Realization of Combinational and sequential circuits*	*Carry Look-Ahead Adder (CLA)*	*Channel capacitance and Junction (or, depletion) capacitances*	*Inverter layout*	
S-7	SLO-1	*Compilation and simulation of Verilog code*	*Carry Select Adder (CSL)*	*Parasitic Resistances, viz., Drain and Source Resistance, Contact Resistance*	*Power-Delay Product: Static Power Consumption*	*Layout design rules: Well rules, transistor rules*

	SLO-2	Test bench	Carry Save Adder (CSA)	Non-ideal I-V effects: Mobility Degradation, Velocity Saturation	Dynamic Power Consumption, Total Power Consumption, PDP	Contact rules, metal rules, via rules and other rules
S-8	SLO-1	Dataflow modelling	Carry Skip Adder (CSK)	Channel Length Modulation, Threshold Voltage Effects	CMOS Circuit Design Styles: Static CMOS logic styles	Gate Layouts
	SLO-2	Realization of Combinational and sequential circuits	Carry Bypass Adder (CBA)	Leakage, Temperature Dependence, Geometry Dependence, Subthreshold Current	CMOS circuits, pseudo-nMOS, tristate circuits, clocked CMOS circuits	Stick diagrams
S-9, 10	SLO-1	Lab-1: Realization of combinational and sequential circuits using gate-level and dataflow modeling	Lab-4: Realization of VLSI adders - I	Lab-7: Realization of VLSI multipliers - II	Lab-10: (a) Design, Analysis of complex CMOS gate using HSPICE (b) Design, Analysis of Pseudo-NMOS gates using HSPICE	Lab-13: Model Practical Examination
	SLO-2					
S-11	SLO-1	Behavioral modelling	Multipliers: Multiplication (unsigned, shift/add multiplication algorithms, multiplication of signed numbers, types of multiplier architectures)	Short-channel MOSFETS: Hot carriers, Lightly-Doped Drain (LDD)	Differential Cascade Voltage Switch Logic (DCVSL), Pass Transistor Logic (PTL)	CMOS Process Enhancements: Transistors (Multiple Threshold Voltages and Oxide Thicknesses, Silicon-on-Insulator, High-k Gate Dielectrics, Higher Mobility, Plastic Transistors,)
	SLO-2	Realization of Combinational and sequential circuits	Braun multiplier	MOSFET scaling	Dynamic CMOS logic styles: Basic dynamic logic	
S-12	SLO-1	Switch-level modelling	Baugh-Wooley multiplier	Short-channel effects: Negative Bias Temperature Instability, oxide breakdown	Signal integrity issues in dynamic design	Interconnects
	SLO-2	Realization of MoS circuits	Wallace Tree multiplier	Drain-Induced Barrier Lowering (DIBL), Gate-Induced Drain Leakage (GIDL), Gate Tunnel Current	Signal integrity issues in dynamic design	Circuit elements
S-13	SLO-1	Design using FSM	Booth multiplier	Tutorials	Domino Logic Circuits: Differential Domino logic, multiple-output domino	Beyond conventional CMOS
	SLO-2	Realization of sequential circuits	Booth multiplier	Tutorials	Compound domino, NORA, TSPC	Tutorials
S-14, 15	SLO-1	Lab-2: (a) Realization of digital circuits using behavioral modeling (b) Realization of MOS circuits using switch-level mdeling	Lab-5: Realization of VLSI adders - II	Lab-8: Realization of RAM & ROM	Lab-11:(a)Design,Analysis of AND/NAND gate in DCVSL using SPICE (b) Design, Analysis of Pass-Transistor gates and CPL gates using HSPICE	Lab-14: End-Semester Practical Examination
	SLO-2					

Learning Resources	1. Jan Rabaey, Anantha Chandrakasan, B Nikolic, "Digital Integrated Circuits: A Design Perspective". Second Edition, Feb 2003, Prentice Hall of India. 2. Weste, Harris, "CMOS VLSI Design: A Circuits and Systems Perspective", 4th ed., Addision-Wesley, 2011. 3. Wayne Wolf, "Modern VLSI Design: IP-based Design", 4th edition, PHI, 2009.	4. R. Jacob Baker, "CMOS Circuit Design, Layout, and Simulation", Wiley, (3/e), 2010. 5. John P. Uyemura, "CMOS Logic Circuit Design", Kluwer, 2001. 6. S. Palnitkar , Verilog HDL – A Guide to Digital Design and Synthesis, Pearson , 2003 7. Paul. R.Gray, Robert G. Meyer, "Analysis and Design of Analog Integrated Circuits", Wiley, (4/e), 2001. 8. M.D.Ciletti , Modeling, Synthesis and Rapid Prototyping with the Verilog HDL, Prentice Hall, 1999

Learning Assessment

	Bloom's Level of Thinking	Continuous Learning Assessment (50% weightage)								Final Examination (50% weightage)	
		CLA – 1 (10%)		CLA – 2 (15%)		CLA – 3 (15%)		CLA – 4 (10%)#			
		Theory	Practice	Theory	Practice	Theory	Practice	Theory	Practice	Theory	Practice
Level 1	Remember Understand	20%	20%	15%	15%	15%	15%	15%	15%	15%	15%
Level 2	Apply Analyze	20%	20%	20%	20%	20%	20%	20%	20%	20%	20%
Level 3	Evaluate Create	10%	10%	15%	15%	15%	15%	15%	15%	15%	15%
	Total	100 %		100 %		100 %		100 %		100 %	

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Course Code	18ECC301T	Course Name	WIRELESS COMMUNICATION	Course Category	C	Professional Core	L	T	P	C
							3	1	0	4

Pre-requisite Courses	18ECC205J, 18ECC105T	Co-requisite Courses	Nil	Progressive Courses	18ECE220T
Course Offering Department	Electronics and Communication Engineering	Data Book / Codes/Standards	Nil		

Course Learning Rationale (CLR):	*The purpose of learning this course is to:*
CLR-1 :	*Understand the elements of Wireless Communication and mobile communications*
CLR-2 :	*Understand the Mobile Radio Wave Propagation - Large Scale Fading*
CLR-3 :	*Analyze how to apply Mobile Radio Wave Propagation - Small Scale Fading*
CLR-4 :	*Study the Capacity and Diversity concepts in wireless communications*
CLR-5 :	*Acquire the knowledge of Wireless System and Standards*
CLR-6 :	*Understand and design various wireless systems*

Course Learning Outcomes (CLO):	*At the end of this course, learners will be able to:*	Learning 1: Level of Thinking (Bloom)	Learning 2: Expected Proficiency (%)	Learning 3: Expected Attainment (%)	PLO 1: Engineering Knowledge	PLO 2: Problem Analysis	PLO 3: Design & Development	PLO 4: Analysis, Design, Research	PLO 5: Modern Tool Usage	PLO 6: Society & Culture	PLO 7: Environment & Sustainability	PLO 8: Ethics	PLO 9: Individual & Team Work	PLO 10: Communication	PLO 11: Project Mgt. & Finance	PLO 12: Life Long Learning	PLO 13: PSO - 1	PLO 14: PSO - 2	PLO 15: PSO – 3
CLO-1 :	*Acquire the knowledge of Wireless communication and basic cellular concepts*	2	75	60	H	-	-	-	-	-	-	-	-	-	-	M	M	-	L
CLO-2 :	*Understand` the essential Radio wave propagation and mobile channel models*	2	75	60	H	H	H	H	-	-	-	-	-	-	-	M	M	-	H
CLO-3 :	*Familiarize about Various performance analysis of mobile communication system.*	2	75	60	H	H	H	-	-	-	-	-	-	-	-	-	-	-	H
CLO-4 :	*Attain the knowledge of Diversity and capacity concepts*	2	75	60	H	H	-	-	-	-	-	-	-	-	-	-	-	-	H
CLO-5 :	*Be familiar with the various standards of Mobile Communication Systems*	2	75	60	H	-	-	-	-	-	-	-	-	-	-	M	M	-	L
CLO-6 :	*Explore the various concepts of wireless communication, its design with respect to fading and link performance*	2	75	60	H	H	H	H	M	-	-	-	-	M	-	M	M	-	H

Duration (hour)		Wireless communication: Mobile communications	Large Scale Fading	Small Scale Fading	Improvement on Link performance	Wireless systems and standards
		12	12	12	12	12
S-1	SLO-1	*Introduction to wireless communication and mobile radio communication*	*Introduction to Radio wave Propagation*	*Introduction Small scale multipath propagation*	*Introduction to diversity, equalization and capacity*	*AMPS Voice modulation Process*
	SLO-2	*Classification of wireless communications - simplex, half duplex, dull duplex*	*Large scale and small scale fading*	*Impulse response model of multipath channel*		
S-2	SLO-1	*Paging and Cordless systems*	*Friis transmission equation- Free space propagation model - pathloss model*	*Impulse response model of multipath channel*	*Space diversity*	*GSM system architecture and its interfaces*
	SLO-2	*Cellular telephone systems*		*Small scale multipath measurements - Direct Pulse measurement*	*Scanning diversity*	
S-3	SLO-1	*Timing diagram - landline to mobile*	*Two Ray model*	*Small scale multipath measurements - Sliding correlator measurement*	*Maximal ratio combiner*	*GSM frame structure*
	SLO-2	*Timing diagram - mobile to mobile*		*Small scale multipath measurements - Swept frequency measurement*	*Equal gain diversity*	
S-4	SLO-1	*Basic antenna parameters, Far field and near field*	*Simplified pathloss model*	*Parameters of mobile multipath channels - Time dispersion and Coherent bandwidth*	*Rake Receiver*	*GSM speech operations input - output*
	SLO-2	*Frequency reuse, sectored and omni-directional antennas*	*Emperical model - Okumara*			
S-5	SLO-1	*Channel assignment strategies*	*Emperical model - Hata model*	*Parameters of mobile multipath channels - Doppler spread and Coherent time*	*Capacity in AWGN*	*Forward CDMA process*
	SLO-2	*Handoff and its types*	*Emperical model - Walfish and bertoni model*			
S-6	SLO-1	*Interference and system capacity*	*Piecewise linear model - log normal model*	*Types of fading: Flat and Frequency selective fading*	*Capacity of flat fading channels*	*Reverse CDMA Process*
	SLO-2					
S-7	SLO-1	*Trunking and Grade of Service*	*Shadowing*	*Types of fading: Flat and Frequency selective fading*	*Equalizer and its mode*	*Multicarrier modulation*
	SLO-2		*Combined pathloss and shadowing*			

S-8	SLO-1 SLO-2	*Cell splitting*	*Outage Probabilty*	*Types of fading: Fast and Slow fading*	*Adaptive equalizer block diagram*	*OFDM Transmitter Block diagram*
S-9	SLO-1 SLO-2	*Sectoring*	*Cell Coverage Area*	*Types of fading: Fast and Slow fading*	*Types of Equalizers - elementary level only*	*OFDM Receiver Block diagram*
S-10	SLO-1 SLO-2	*Microcell zone concepts*	*Solving problems – Brewster angle*	*Ricean distribution*	*Introduction to MIMO antennas*	*Importance of Cyclic Prefix*
S-11	SLO-1 SLO-2	*Umbrella cells*	*Solving problems –empirical model*	*Rayleigh distribution*	*Introduction to MIMO antennas*	*Case study - Modern antennas*
S-12	SLO-1 SLO-2	*Solving Problems*	*Solving problems – friis transmission formula*	*Solving problems – Doppler effect*	*Case study :Recent trends in Diversity and MIMO antennas*	*Case study - Modern antennas*

Learning Resources	1. *Rappaport.T.S., "Wireless Communications: Principles and Practice", 2nd Edition, Pearson, 2011.* 2. *John D Kraus , Ronald J Marhefka, Ahmed S Khan "Antenna and Wave Propagation", 4th Edition, Tata McGraw Hill, 2010* 3. *Constantine Balanis. A, "Antenna Theory: Analysis and Design", 3rd Edition, John Wiley, 2012.* 4. *Andreas.F.Molisch., "Wireless Communications", Wiley, 2nd Edition-2005, Reprint-2014*	5. *Andrea Goldsmith, " Wireless Communications", Cambridge University Press, Aug 2005* 6. *Schiller, "Mobile Communications", Pearson Education Asia Ltd., Reprint 2012* 7. *Lee W.C.Y., " Mobile Communications Engineering: Theory and Applications", McGraw Hill, New York, 2nd Edition, 1998*

Learning Assessment

	Bloom's Level of Thinking	Continuous Learning Assessment (50% weightage)								Final Examination (50% weightage)	
		CLA – 1 (10%)		CLA – 2 (15%)		CLA – 3 (15%)		CLA – 4 (10%)#			
		Theory	Practice	Theory	Practice	Theory	Practice	Theory	Practice	Theory	Practice
Level 1	Remember Understand	*40 %*	-	*30 %*	-	*30 %*	-	*30 %*	-	*30%*	-
Level 2	Apply Analyze	*40 %*	-	*40 %*	-	*40 %*	-	*40 %*	-	*40%*	-
Level 3	Evaluate Create	*20 %*	-	*30 %*	-	*30 %*	-	*30 %*	-	*30%*	-
	Total	100 %		100 %		100 %		100 %		100 %	

CLA – 4 can be from any combination of these: Assignments, Seminars, Tech Talks, Mini-Projects, Case-Studies, Self-Study, MOOCs, Certifications, Conf. Paper etc.,

Course Designers

Experts from Industry	Experts from Higher Technical Institutions	Internal Experts
1. Mr. Anuj Kumar, Bombardier Transportation, Ahmedabad, kumaranuj.anii@gmail.com	*1. Dr. Meenakshi, Professor of ECE, CEG, Anna University, meena68@annauniv.edu*	*1. Dr. Sandeep Kumar P, SRMIST*
2. Mr. Hariharasudhan - Johnson Controls, Pune, hariharasudhan.v@jci.com	*2. Dr. Venkatesan, Sr. Scientist, NIOT, Chennai, venkat@niot.res.in*	*2. Dr. T. Ramarao, SRMIST*

Course Code	18ECC302J	Course Name	MICROWAVE & OPTICAL COMMUNICATIONS	Course Category	C	Professional Core	L	T	P	C
							3	0	2	4

Pre-requisite Courses	18ECC205J	Co-requisite Courses	Nil	Progressive Courses	18ECE226T & 18ECE323T
Course Offering Department	Electronics and Communication Engineering	Data Book / Codes/Standards	Nil		

Course Learning Rationale (CLR):	*The purpose of learning this course is to:*
CLR-1 :	*Identify Microwave active devices and Microwave generators*
CLR-2 :	*Analyze Microwave passive devices*
CLR-3 :	*Explore Microwave Measurements*
CLR-4 :	*Analyze Optical Fibers Optical Sources, Amplifier and Transmitter Optical Detectors , Receiver and Performance Measurements*
CLR-5 :	*Explore Optical Communication System Design and Concepts*
CLR-6 :	*Analyze Microwave and optical components*

Course Learning Outcomes (CLO):	*At the end of this course, learners will be able to:*	Learning 1: Level of Thinking (Bloom)	Learning 2: Expected Proficiency (%)	Learning 3: Expected Attainment (%)	PLO 1: Engineering Knowledge	PLO 2: Problem Analysis	PLO 3: Design & Development	PLO 4: Analysis, Design, Research	PLO 5: Modern Tool Usage	PLO 6: Society & Culture	PLO 7: Environment & Sustainability	PLO 8: Ethics	PLO 9: Individual & Team Work	PLO 10: Communication	PLO 11: Project Mgt. & Finance	PLO 12: Life Long Learning	PLO 13: PSO - 1	PLO 14: PSO - 2	PLO 15: PSO – 3
CLO-1 :	*Acquire knowledge on the theory of microwave transmission, microwave generators and associated components.*	2	80	70	H	-	-	L	-	-	-	-	-	-	-	-	-	-	L
CLO-2 :	*Analyse microwave passive devices and components.*	2	80	70	H	M	H	H	-	-	-	-	-	-	-	-	L	-	M
CLO-3 :	*Understand microwave measurements and associated techniques with equipment*	2	80	70	H	M	H	M	-	-	-	-	-	-	-	-	M	-	H
CLO-4 :	*Familiarize with the fundamentals of light transmission through fiber*	2	80	70	H	H	-	M	-	-	-	-	-	-	-	-	L	-	L
CLO-5 :	*Design a basic optical communication system.*	2	80	70	H	H	-	H	-	-	-	-	-	-	-	-	M	-	M
CLO-6:	*Understand working principle of microwave components , Microwave measurements, optical sources, detector and fibers*	2	80	70	H	H	H	H	-	-	-	-	-	-	-	-	M	-	H

Duration (hour)		15	15	15	15	15
S-1	SLO-1	*Introduction to microwaves and optical communications*	*High frequency parameters: S parameters, S matrix analysis for N-port microwave device*	*Impedance matching.*	*Elements of Optical fiber communication*	*Point-to-Point link –Analog system design considerations and design steps*
	SLO-2					
S-2	SLO-1	*History of Microwave Engineering, Microwave transmission and Applications; Maxwell Equations*	*Directional coupler*	*VSWR and Impedance measurement*	*Functional block diagram of a Transmitter and receiver module*	*Point-to-Point link – Digital system design considerations and design steps*
	SLO-2					
S-3	SLO-1	*Microwave Tubes*	*E and H plane Tee*	*Measurement of Power*	*Optical fiber structure, Light Propagation in Optical fibers: Ray theory , Total Internal reflection, Skew rays*	*Digital Link Design: Link power budget*
	SLO-2	*Klystron amplifier*				
S-4-5	SLO-1	*Lab- 1 Characteristics of Reflex Klystron*	*Lab- 4 Gain and radiation pattern of Horn antenna*	*Lab- 7 Practice session*	*Lab- 10 Measurement of Numerical Aperture, propagation and bending losses of optical fiber*	*Lab- 13 Design of basic Optical Communication system using computational tool*
	SLO-2					
S-6	SLO-1	*Reflex Klystron oscillators*	*Magic Tee*	*Measurement of Frequency and Q factor*	*Optical Sources: Light source materials, LED Structures*	*Rise time budget*
	SLO-2					
S-7	SLO-1	*Magnetron oscillators*	*Microwave Circulators, Isolators*	*Insertion loss measurements*	*LED Characteristics*	*Overview of Analog links: Radio over Fiber;*
	SLO-2					
S-8	SLO-1	*Microwave Bipolar Transistors Field effect transistor*	*Attenuators and Phase Shifters*	*Attenuation measurements*	*Semiconductor Laser Diode, Laser Characteristics*	*Key link parameters*
	SLO-2					
S-9-10	SLO-1	*Lab- 2 Study of power distribution in Directional coupler, E plane, H plane and Magic Tee*	*Lab- 5 Characteristics of filters, Microstrip patch antenna and parallel line coupler*	*Lab- 8 DC characteristics of LED and Laser diode*	*Lab- 11 Analysis of Analog optical link*	*Lab- 14 Practice Session*
	SLO-2					
S-11	SLO-1	*IMPATT, TRAPATT and Tunnel diode*	*Rectangular Waveguides*	*Measurement of Scattering parameters*	*Optical Detectors: PIN and APD photo detector*	*Multichannel System: Need for multiplexing*
	SLO-2					*Operational principles of WDM, DWDM*

S-12	SLO-1 SLO-2	*Gunn diode*	*Rectangular Waveguides*	*Measurement of Scattering parameters*	*Responsivity and efficiency of APD*	*WDM Components: Coupler/Splitter, Fabry Perot Filter*
S-13	SLO-1 SLO-2	*Gunn Oscillation modes*	*Power Dividers*	*Functioning details of Vector Network Analyzer; Signal Analyzer; Spectrum analyzers*	*Fiber attenuation and dispersion*	*WDM Components: Optical MEMS switches*
S-14-15	SLO-1 SLO-2	*Lab- 3 Impedance measurement by slotted line method*	*Lab- 6 Design of RF Filters and Amplifier using computational tool*	*Lab- 9 DC characteristics of PIN and APD photo-diode*	*Lab- 12 Analysis of Digital optical link*	*Lab- 15 Study experiment - Gunn Diode (Microwave) and Optical WDMA (Optical)*

Learning Resources

1. *David M. Pozar, "Microwave Engineering", 4th Edition, John Wiley & Sons, 2012.*
2. *David M. Pozar, "Microwave & RF Design of Wireless Systems", John Wiley & Sons, 2001.*
3. *Samuel Y. Liao, "Microwave Devices and Circuits", 3rd Edition, Pearson Education, 2013.*
4. *Robert. E. Collin, "Foundations for Microwave Engineering", 2nd edition, Wiley, Reprint 2014.*
5. *Annapurna Das, Sisir K. Das, "Microwave Engineering", 3rd Ed., McGraw Hill, 2015.*
6. *I. Hunter, "Theory and design of microwave filters", The Institution of Engineering &Technology, 2001.*
7. *Keiser G, "Optical Fiber Communication Systems", 5th Edition, 6th Reprint, McGraw Hill Education (India), 2015.*
8. *Vivekanand Mishra, Sunita P. Ugale, "Fiber Optic Communication: Systems and Components", Wiley-India, 1st edition, 2013*
9. *Djafar.K. Mynbaev and Lowell and Scheiner, "Fiber Optic Communication Technology", Pearson Education Asia, 9th impression, 2013*
10. *John M. Senior, " Optical fiber Communications: Principles and Practice", Pearson Education, 3rd Edition, 2009*
11. *R.P. Khare, "Fiber Optics and Optoelectronics", Oxford University Press, 2007.*
12. *Rajiv Ramaswami, Kumar N. Sivaranjan, Galen H.Sasaki "Optical Networks A practical perspective", 3nd edition, 2013*

Learning Assessment

	Bloom's Level of Thinking	Continuous Learning Assessment (50% weightage)								Final Examination (50% weightage)	
		CLA – 1 (10%)		CLA – 2 (15%)		CLA – 3 (15%)		CLA – 4 (10%)#			
		Theory	Practice	Theory	Practice	Theory	Practice	Theory	Practice	Theory	Practice
Level 1	Remember Understand	*20%*	*20%*	*15%*	*15%*	*15%*	*15%*	*15%*	*15%*	*15%*	*15%*
Level 2	Apply Analyze	*20%*	*20%*	*20%*	*20%*	*20%*	*20%*	*20%*	*20%*	*20%*	*20%*
Level 3	Evaluate Create	*10%*	*10%*	*15%*	*15%*	*15%*	*15%*	*15%*	*15%*	*15%*	*15%*
	Total	100 %		100 %		100 %		100 %		100 %	

CLA – 4 can be from any combination of these: Assignments, Seminars, Tech Talks, Mini-Projects, Case-Studies, Self-Study, MOOCs, Certifications, Conf. Paper etc.,

Course Designers		
Experts from Industry	Experts from Higher Technical Institutions	Internal Experts
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2. Mr. Hariharasudhan - Johnson Controls, Pune, hariharasudhan.v@jci.com	*2. Dr. Venkatesan, Sr. Scientist, NIOT, Chennai, venkat@niot.res.in*	*2. Dr. T. Ramarao, SRMIST*

Course Code	18ECC303J	Course Name	COMPUTER COMMUNICATION NETWORKS	Course Category	C	Professional Core	L	T	P	C
							3	0	2	4

Pre-requisite Courses	18CSS101J	Co-requisite Courses	Nil	Progressive Courses	18ECE320T
Course Offering Department	Electronics and Communication Engineering	Data Book / Codes/Standards	Nil		

Course Learning Rationale (CLR):	*The purpose of learning this course is to:*
CLR-1 :	*Introduce the basic concepts in the field of computer networks.*
CLR-2 :	*Understand the functional aspects of OSI model architecture.*
CLR-3 :	*Acquire knowledge of the Network Layer protocols*
CLR-4 :	*Analyze the various issues and challenges of Transport Layer.*
CLR-5 :	*Familiarize the various Application Layer Protocols.*
CLR-6:	*Utilize the networking concepts to analyze the performance of Routing protocols.*

Course Learning Outcomes (CLO):	*At the end of this course, learners will be able to:*	Learning 1 Level of Thinking (Bloom)	2 Expected Proficiency (%)	3 Expected Attainment (%)	Program Learning Outcomes (PLO) 1 Engineering Knowledge	2 Problem Analysis	3 Design & Development	4 Analysis, Design, Research	5 Modern Tool Usage	6 Society & Culture	7 Environment & Sustainability	8 Ethics	9 Individual & Team Work	10 Communication	11 Project Mgt. & Finance	12 Life Long Learning	13 PSO - 1	14 PSO - 2	15 PSO – 3
CLO-1 :	*Understand the basic services and concepts related to internetworking.*	2	80	70	H	-	-	-	-	M	M	-	-	-	-	M	H	M	-
CLO-2 :	*Explain the basic OSI model architecture and its lower layer functions.*	2	85	75	H	-	-	-	-	M	M	-	-	-	-	M	H	M	-
CLO-3 :	*Give an insight of the various Network Layer concepts, mechanisms and protocols.*	2	75	70	H	-	-	-	-	M	M	-	-	-	-	M		M	H
CLO-4 :	*Appreciate the services and techniques of Transport Layer.*	2	85	80	H	-	-	-	-	M	M	-	-	-	-	M	-	H	M
CLO-5 :	*Discuss the various services and protocols in Application Layer.*	2	85	75	H	-	-	-	-	M	M	M	-	-	-	M	H		M
CLO-6 :	*Implement and analyze the various Networking concepts and Routing protocols.*	2	80	70	-	-	-	-	H	-	-	-	-	-	-		M		H

Duration (hour)		Data Communication & Networking Basics	Osi Lower Layers	Network Layer	Transport Layer	Application Layer
		15	15	15	15	15
S-1	SLO-1	*Introduction to Data Communication and Networking*	*Network models*	*Introduction to Network Layer*	*Introduction to Transport Layer*	*Introduction to Application Layer*
	SLO-2	*Data transfer modes-Serial and Parallel transmission*	*OSI layer architecture*	*Need for Internetworking*	*TCP/IP Model*	*Application Layer Paradigms*
S-2	SLO-1	*Protocols & Standards*	*Data Link Layer-Introduction*	*Addressing-Classful*	*User Datagram Protocol(UDP)*	*Client Server Interaction*
	SLO-2	*Layered Architecture*	*Link Layer Addressing*	*Addressing-Classful*	*User Datagram Protocol(UDP)*	*Client Server Interaction*
S-3	SLO-1	*Principles of Layering & Description*	*Error Detection*	*Addressing-Classless*	*Transmission Control Protocol(TCP)*	*SIP*
	SLO-2	*Brief description of concepts in OSI & TCP/IP model*	*Error Detection*	*Addressing-Classless*	*Transmission Control Protocol(TCP)*	*SIP*
S 4-5	SLO-1 SLO-2	*Lab 1: To build and configure a simple network of four nodes connected with point-to-point links.*	*Lab 4: To simulate token ring protocol and to study its performance.*	*Lab 7:To simulate CSMA/CA protocol and to study its performance*	*Lab 10: Implementation and study of Selective Repeat protocol.*	*Lab 13: Create a Socket (TCP&UDP) between two computers and enable file transfer between them.*
S-6	SLO-1	*Switching Types- Circuit- & Packet switching*	*Error Correction*	*Network Layer Protocol-IPV4*	*TCP Services & Features*	*Compression Techniques*
	SLO-2	*Switching Types- Message switching, Comparison of switching types*	*Error Correction*	*Internet Protocol(IP)-IPV4*	*TCP Services & Features*	*Compression Techniques*
S-7	SLO-1	*LAN, MAN & WAN*	*Data link control-LLC*	*Internet Protocol(IP)-IPV6*	*Congestion Control*	*Introduction to Cryptography*
	SLO-2	*LAN, MAN & WAN*	*Data link control-LLC*	*Internet Protocol(IP)-IPV6*	*Congestion Control*	*Types, Attacks and Services*
S-8	SLO-1	*Network topologies-Types*	*Data link control-MAC*	*Routing Protocols- Distance Vector& Link State*	*Congestion Control*	*DES*
	SLO-2	*Comparison of topologies*	*Data link control-MAC*	*Routing Issues-Delivery, Forwarding and Routing*	*Congestion Control*	*DES*
S 9-10	SLO-1 SLO-2	*Lab 2: To simulate star and bus network topologies.*	*Lab 5: Implementation of Error detection and Correction scheme.*	*Lab 8: Implementation and study of stop and wait protocols*	*Lab 11: To configure a network using Link State Routing protocol.*	*Lab 14: Implementation of Data Encryption and Decryption.*

S-11	SLO-1	*IEEE standards for LAN-Ethernet*	*Flow & Error Control Protocol*	*Routing Information Protocol-RIP*	*QOS-Quality of Service*	*RSA*
	SLO-2	*Types of Ethernet*	*Flow & Error Control Protocol*	*Routing Information Protocol-RIP*	*QOS-Quality of Service*	*RSA*
S-12	SLO-1	*Token Bus*	*ARQ Schemes*	*Open Shortest Path First-OSPF*	*Techniques to improve QOS*	*Email*
	SLO-2	*Token Ring*	*ARQ Schemes*	*Open Shortest Path First-OSPF*	*Techniques to improve QOS*	*FTP*
S-13	SLO-1	*FDDI*	*HDLC*	*Border Gateway Protocol-BGP*	*Techniques to improve QOS*	*HTTP*
	SLO-2	*FDDI*	*HDLC*	*Border Gateway Protocol-BGP*	*Techniques to improve QOS*	*SNMP*
S 14-15	SLO-1 SLO-2	*Lab 3: To simulate token bus protocol and to study its performance.*	*Lab 6:To simulate CSMA/CD protocol and to study its performance*	*Lab 9: Implementation and study of Go back N protocol.*	*Lab 12: To configure a network using Distance Vector Routing protocol.*	*Lab 15: Mini Project*

Learning Resources	1. *Behrouz A.Fehrouzan, "Data communication & Networking", Mc-Graw Hill, 5th Edition Reprint, 2014.* 2. *Andrew S.Tanenbaum, "Computer Networks", Pearson Education India, 5th Edition, 2013.* 3. *William Stallings, "Data & Computer Communication", Pearson Education India, 10th Edition, 2014*	4. *James F. Kurose, Keith W. Ross, "Computer Networking: A Top–Down Approach Featuring the Internet", Pearson Education,6th Edition, 2013.* 5. *"Lab Manual" , Department of ECE, SRM Institute of Science and Technology*

Learning Assessment

	Bloom's Level of Thinking	Continuous Learning Assessment (50% weightage)								Final Examination (50% weightage)	
		CLA – 1 (10%)		CLA – 2 (15%)		CLA – 3 (15%)		CLA – 4 (10%)#			
		Theory	Practice	Theory	Practice	Theory	Practice	Theory	Practice	Theory	Practice
Level 1	Remember Understand	*20%*	*20%*	*15%*	*15%*	*15%*	*15%*	*15%*	*15%*	*15%*	*15%*
Level 2	Apply Analyze	*20%*	*20%*	*20%*	*20%*	*20%*	*20%*	*20%*	*20%*	*20%*	*20%*
Level 3	Evaluate Create	*10%*	*10%*	*15%*	*15%*	*15%*	*15%*	*15%*	*15%*	*15%*	*15%*
	Total	100 %		100 %		100 %		100 %		100 %	

CLA – 4 can be from any combination of these: Assignments, Seminars, Tech Talks, Mini-Projects, Case-Studies, Self-Study, MOOCs, Certifications, Conf. Paper etc.,

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Experts from Industry	Experts from Higher Technical Institutions	Internal Experts
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2. Mr. Hariharasudhan - Johnson Controls, Pune, hariharasudhan.v@jci.com	*2. Dr. Venkatesan, Sr. Scientist, NIOT, Chennai, venkat@niot.res.in*	

Course Code	18ECC350T	Course Name	COMPREHENSION	Course Category	C	Professional Core	L	T	P	C
							0	1	0	1

Pre-requisite Courses	Nil	Co-requisite Courses	Nil	Progressive Courses	Nil
Course Offering Department	Electronics and Communication Engineering	Data Book / Codes/Standards	Nil		

Course Learning Rationale (CLR):	The purpose of learning this course is to:
CLR-1 :	*Acquire skills to solve real world problems in Analog and Digital Electronics (Discrete & IC)*
CLR-2 :	*Acquire skills to solve real world problems in Analog and Digital Communication*
CLR-3 :	*Acquire skills to solve real world problems in Signals & Systems, and DSP*
CLR-4 :	*Acquire skills to solve real world problems in Microprocessors & Microcontrollers, and VLSI Design*
CLR-5 :	*Acquire skills to solve real world problems in Electromagnetics and Transmission Lines*
CLR-6 :	*Acquire skills to solve real world problems in Microwave and Optical Communications*

Course Learning Outcomes (CLO):	At the end of this course, learners will be able to:	Learning 1	2	3	Program Learning Outcomes (PLO) 1	2	3	4	5	6	7	8	9	10	11	12	13	14	15
		Level of Thinking (Bloom)	Expected Proficiency (%)	Expected Attainment (%)	Engineering Knowledge	Problem Analysis	Design & Development	Analysis, Design, Research	Modern Tool Usage	Society & Culture	Environment & Sustainability	Ethics	Individual & Team Work	Communication	Project Mgt. & Finance	Life Long Learning	PSO - 1	PSO - 2	PSO - 3
CLO-1 :	*Practice and gain confidence and competence to solve problems in Analog and Digital Electronics (Discrete & IC)*	*3*	*85*	*80*	*H*	*H*	*H*	*L*	*L*	*L*	*L*	*L*	*L*	*L*	*L*	*L*	*M*	*L*	*M*
CLO-2 :	*Practice and gain confidence and competence to solve problems in Analog and Digital Communication*	*3*	*85*	*80*	*H*	*H*	*M*	*L*	*L*	*L*	*L*	*L*	*L*	*L*	*L*	*L*	*M*	*M*	*M*
CLO-3 :	*Practice and gain confidence and competence to solve problems in Signals & Systems, and DSP*	*3*	*85*	*80*	*H*	*H*	*M*	*L*	*L*	*L*	*L*	*L*	*L*	*L*	*L*	*L*	*M*	*L*	*M*
CLO-4 :	*Practice and gain confidence and competence to solve problems in Microprocessors & Microcontrollers, and VLSI Design*	*3*	*85*	*80*	*H*	*H*	*M*	*L*	*L*	*L*	*L*	*L*	*L*	*L*	*L*	*L*	*M*	*M*	*M*
CLO-5 :	*Practice and gain confidence and competence to solve problems in Electromagnetics and Transmission Lines*	*3*	*85*	*80*	*H*	*H*	*H*	*L*	*L*	*L*	*L*	*L*	*L*	*L*	*L*	*L*	*M*	*L*	*M*
CLO-6 :	*Practice and gain confidence and competence to solve problems in Microwave and Optical Communications*	*3*	*85*	*80*	*H*	*H*	*M*	*L*	*L*	*L*	*L*	*L*	*L*	*L*	*L*	*L*	*M*	*M*	*M*

Duration (hour)		3	3	3	3	3
S-1	SLO-1	*Tutorial on Analog Electronics (Discrete & IC)*	*Tutorial on Digital Communication*	*Tutorial on Microprocessors & Interfacing*	*Tutorial on Transmission Lines*	*Tutorial on Optical Communication*
	SLO-2	*Problem Solving*	*Problem Solving*	*Problem Solving*	*Problem Solving*	*Problem Solving*
S-2	SLO-1	*Tutorial on Digital Electronics*	*Tutorial on Signals and Systems*	*Tutorial on Microcontrollers & Interfacing*	*Tutorial on VLSI Design*	*Model Test*
	SLO-2	*Problem Solving*	*Problem Solving*	*Problem Solving*	*Problem Solving*	*Model Test*
S-3	SLO-1	*Tutorial on Analog Communication*	*Tutorial on Digital Signal Processing*	*Tutorial on Electromagnetics*	*Tutorial on Microwave Communication*	*Final Test*
	SLO-2	*Problem Solving*	*Problem Solving*	*Problem Solving*	*Problem Solving*	*Final Test*

Learning Resources	1. *R.S.Khurmi, J.K.Gupta, Mechanical Engineering: Conventional and Objective Types, S.Chand & Co., 2018*	2. *R.K.Jain, Conventional & Objective Type Question & Answers on Mechanical Engineering for Competitions, Khanna Publishers, 2014*

Learning Assessment

	Bloom's Level of Thinking	Continuous Learning Assessment (100% weightage)								Final Examination	
		CLA – 1 (20%)		CLA – 2 (30%)		CLA – 3 (30%)		CLA – 4 (20%)#			
		Theory	Practice	Theory	Practice	Theory	Practice	Theory	Practice	Theory	Practice
Level 1	Remember / Understand	-	40%	-	30%	-	30%	-	30%	-	-
Level 2	Apply / Analyze	-	40%	-	40%	-	40%	-	40%	-	-
Level 3	Evaluate / Create	-	20%	-	30%	-	30%	-	30%	-	-
	Total	100 %		100 %		100 %		100 %		-	

CLA – 4 can be from any combination of these: Assignments, Seminars, Tech Talks, Mini-Projects, Case-Studies, Self-Study, MOOCs, Certifications, Conf. Paper etc.,

Course Designers

Experts from Industry	Experts from Higher Technical Institutions	Internal Experts
1. Mr. Anuj Kumar, Bombardier Transportation, Ahmedabad, kumaranuj.anii@gmail.com	*1. Dr. Meenakshi, Professor of ECE, CEG, Anna University, meena68@annauniv.edu*	*Mr. Manikandan AVM, SRMIST*
2. Mr. Hariharasudhan - Johnson Controls, Pune, hariharasudhan.v@jci.com	*2. Dr. Venkatesan, Sr. Scientist, NIOT, Chennai, venkat@niot.res.in*	*Dr. V. Nithya, SRMIST*

ACADEMIC CURRICULA

Professional Core Courses

MECHANICAL ENGINEERING

Regulations - 2018

SRM INSTITUTE OF SCIENCE AND TECHNOLOGY

(Deemed to be University u/s 3 of UGC Act, 1956)

Kattankulathur, Kancheepuram, Tamil Nadu, India

Course Code	18MEC201T	Course Name	MACHINES AND MECHANISMS	Course Category	C	Professional Core	L	T	P	C
							3	1	0	4

Pre-requisite Courses	Nil	Co-requisite Courses	Nil	Progressive Courses	Nil
Course Offering Department	Mechanical Engineering	Data Book / Codes/Standards	Nil		

Course Learning Rationale (CLR):	The purpose of learning this course is to:
CLR-1 :	*understand motion of linked mechanisms in terms of displacement, velocity and acceleration at any point in a rigid link*
CLR-2 :	*be able to synthesis cam profile and to understand the kinematics of gear trains*
CLR-3 :	*understand the Balancing of rotating masses and friction*
CLR-4 :	*Know the concepts of free vibration of single degree of freedom systems.*
CLR-5 :	*Know the concepts of forced vibration of single degree of freedom systems.*
CLR-6 :	*understand the concepts of kinematics and machine dynamics*

Course Learning Outcomes (CLO):	At the end of this course, learners will be able to:	Learning 1: Level of Thinking (Bloom)	Learning 2: Expected Proficiency (%)	Learning 3: Expected Attainment (%)	PLO 1: Engineering Knowledge	PLO 2: Problem Analysis	PLO 3: Design & Development	PLO 4: Analysis, Design, Research	PLO 5: Modern Tool Usage	PLO 6: Society & Culture	PLO 7: Environment & Sustainability	PLO 8: Ethics	PLO 9: Individual & Team Work	PLO 10: Communication	PLO 11: Project Mgt. & Finance	PLO 12: Life Long Learning	PLO 13: PSO - 1	PLO 14: PSO - 2	PLO 15: PSO – 3
CLO-1 :	*explain the basics of mechanism and perform kinematic analysis.*	1&2	90	85	H	H	-	-	-	-	-	-	-	-	-	-	-	-	-
CLO-2 :	*construct various cam profiles based on follower motion and performkinematic analysis and Epicyclic Gear train*	1,2&3	85	85	H	H	-	-	-	-	-	-	-	-	-	-	-	-	-
CLO-3 :	*perform balancing of rotating masses and describe friction in machine elements*	1&2	90	85	H	-	-	H	-	-	-	-	-	-	-	-	-	-	-
CLO-4 :	*analyze free vibration single degree of freedom systems.*	1&2	90	85	H	H	-	-	-	-	-	-	-	-	-	-	-	-	-
CLO-5 :	*define the concepts of forced vibration and critical speed or whirling of shaft*	1&2	90	90	H	-	H	-	-	-	-	-	-	-	-	-	-	-	-
CLO-6 :	*apply the concepts of kinematics and machine dynamics in real time applications*	1&2	80	80	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-

Duration (hour)		12	12	12	12	12
S-1	SLO-1	*Introduction to mechanism and its elements, Degrees of Freedom, its application in different mechanism*	*circular Cam terminology, types of cams and followers*	*Friction- Introduction, Types of friction, Laws of solid and dry friction, Limiting angle of friction*	*Introduction to vibration terminologies and types of vibration*	*Equation of motion for harmonically excited single Degree of Freedom system*
S-2	SLO-1	*Four Bar Chain, Grashof's law, Kutzback's and Grubler's criterion*	*Types of follower motion and its derivatives, under cutting*	*Friction Clutches- single plate and multiplate Clutches*	*Equation of motion for free un-damped single Degree of Freedom system by Newton's and energy method- Longitudinal vibration*	*Forced vibration –Beating Phenomenon*
S-3	SLO-1	*Kinematic Inversions of kinematic chain: Four bar chain, Single and double slider crank chain*	*Displacement, velocity and acceleration for different follower motion*	*Cone and Centrifugal Clutches*	*Equation of motion for free un-damped single Degree of Freedom system by Newton's and energy method- torsional vibration*	*Forced vibration due to unbalanced rotating and reciprocating masses*
S-4	SLO-1	*Tutorial-simple problems*	*Tutorial-simple problems*	*Tutorial on Clutches*	*Tutorials on single Degree of Freedom un-damped free vibration systems*	*Tutorials on harmonically excited single Degree of Freedom system*
S-5	SLO-1	*Velocity analysis of Four bar and single slider crank mechanism by relative velocity (RV) method*	*construction of circular cam profile for radial follower with different motion*	*Friction in Brakes-Block or shoe brake*	*Equation of motion for free damped single Degree of Freedom systems*	*Forced vibration due to Base excitation by Relative amplitude Method*
S-6	SLO-1	*Acceleration analysis of Four bar mechanism and single slider crank linkages by relative*	*construction of circular cam profile for offset follower with different motion*	*Friction in Brakes-Band brake principle*	*Free vibration with viscous damping*	*Forced vibration due to Base excitation by Absolute Method*
S-7	SLO-1	*Velocity and Acceleration of double slider crank mechanism.*	*basic principles of tangent cam profile*	*Friction in Brakes-Band brake principle*	*Logarithmic decrement*	*Force Transmissibility and vibration isolation*
S-8	SLO-1	*Tutorial on Velocity and Acceleration by relative method*	*Tutorial on cam profile construction*	*Tutorial for Friction Brakes*	*Tutorials on free damped single Degree of Freedom systems*	*Tutorials on Forced vibration due to Base excitation by Absolute and Relative amplitude Method*

S-9	SLO-1	*Velocity and Acceleration of six bar mechanism by relative method*	*Gear terminology, types, law of gearing Tutorial on path of contact, arc of contact, sliding velocity*	*Balancing of rotating masses- Need for balancing, Static and dynamic balancing of rotating masses*	*Torsional system with viscous damping*	*Critical speed or whirling of shaft*
S-10	SLO-1	*Instantaneous center (IC) method, Kennedy's theorem*	*Gear train, types and applications*	*Balancing of several masses rotating in same plane by analytical and graphical methods*	*Torsional Vibration of Two Rotor and three rotor Systems*	*Critical speed or whirling of shaft-with air damping*
S-11	SLO-1	*Velocity analysis of Four bar and single slider crank mechanism by Instantaneous center method*	*velocity ratio, torque calculations in epicyclic gear train*	*balancing of several masses rotating in different planes using couple and force polygon*	*Torsional Vibration of Geared Systems with Two and Three rotor System*	*Critical speed or whirling of shaft-without air damping*
S-12	SLO-1	*Tutorial on Instantaneous center method*	*Tutorials on epicyclic gear train*	*Tutorial on balancing of several masses rotating in same plane and different planes using couple and force polygon*	*Tutorials on Torsional Vibration of Two Rotor and three rotor Systems*	*Tutorials on Critical speed or whirling of shaft-with air damping*

Learning Resources	*1. Rattan, S. S, "Theory of Machines",McGrawHill Education, 4th edition, 2015* *2. Thomas Bevan, "The Theory of Machines", Pearson India Education Services Pvt. Ltd., 3rd Edition, 2010.*	*3. L Norton, "Design of machinery - An introduction to the synthesis and analysis of mechanisms and machines", McGrawHill Education, 5th edition, 2011.* *4. William Cleghorn, Nikolai Dechev, "Mechanics of Machines", Oxford University Press, 2nd Edition, 2014.*

Learning Assessment

	Bloom's Level of Thinking	Continuous Learning Assessment (50% weightage)								Final Examination (50% weightage)	
		CLA – 1 (10%)		CLA – 2 (15%)		CLA – 3 (15%)		CLA – 4 (10%)#			
		Theory	Practice	Theory	Practice	Theory	Practice	Theory	Practice	Theory	Practice
Level 1	Remember Understand	*40 %*	-	*30 %*	-	*30 %*	-	*30 %*	-	*30%*	-
Level 2	Apply Analyze	*40 %*	-	*40 %*	-	*40 %*	-	*40 %*	-	*40%*	-
Level 3	Evaluate Create	*20 %*	-	*30 %*	-	*30 %*	-	*30 %*	-	*30%*	-
	Total	100 %		100 %		100 %		100 %		100 %	

CLA – 4 can be from any combination of these: Assignments, Seminars, Tech Talks, Mini-Projects, Case-Studies, Self-Study, MOOCs, Certifications, Conf. Paper etc.,

Course Designers

Experts from Industry	Experts from Higher Technical Institutions	Internal Experts
1. Dr.R.Kalimuthu, ISRO, Mahendragiri, r_kalimuthu@vssc.gov.in	*1. Dr. Sudheesh Kumar, sudheeshkumar3@gmail.com, GCE, Kannur*	*1. Dr.P.Nandakumar, SRMIST*
2. Dr.A.Velayutham, DRDO, Avadi, velayudham.a@cvrde.drdo.in	*2. Dr.R.Prabhusekar, rprabhusekar@mnnit.ac.in, MNNIT Allahabad*	*2. Dr.P V Jeyakarthikeyan, SRMIST*

Course Code	18MEC202T	Course Name	HEAT AND MASS TRANSFER	Course Category	C	Professional core	L	T	P	C
							3	1	0	4

Pre-requisite Courses	18MEC101T & 18MEC102T	Co-requisite Courses	Nil	Progressive Courses	Nil
Course Offering Department	Mechanical Engineering	Data Book / Codes/Standards	Heat and Mass transfer data book and steam tables		

Course Learning Rationale (CLR):	*The purpose of learning this course is to:*
CLR-1 :	*Understand the concept of conduction heat transfer*
CLR-2 :	*Understand the concepts of fins and unsteady state heat transfer*
CLR-3 :	*Understand the concept of convection heat transfer*
CLR-4 :	*Understand the concept of radiation heat transfer*
CLR-5 :	*Understand the phase change heat transfer and mass transfer*
CLR-6 :	*Understand the concepts of heat and mass transfer*

Course Learning Outcomes (CLO):	*At the end of this course, learners will be able to:*	Learning 1: Level of Thinking (Bloom)	2: Expected Proficiency (%)	3: Expected Attainment (%)	PLO 1: Engineering Knowledge	2: Problem Analysis	3: Design & Development	4: Analysis, Design, Research	5: Modern Tool Usage	6: Society & Culture	7: Environment & Sustainability	8: Ethics	9: Individual & Team Work	10: Communication	11: Project Mgt. & Finance	12: Life Long Learning	13: PSO - 1	14: PSO - 2	15: PSO – 3
CLO-1 :	*Analyse and evaluate steady state heat conduction in simple and composite systems*	3	90	80	H	H	L	H	L	L	L	L	L	L	L	L	L	H	L
CLO-2 :	*Analyse and evaluate steady state heat conduction in finned systems and unsteady state heat conduction in simple geometries*	3	90	80	H	H	L	H	L	L	L	L	L	L	L	L	L	H	L
CLO-3 :	*Evaluate the heat transfer coefficient under free and forced convection in various geometries and simple design of heat exchangers*	3	90	80	H	H	L	H	L	L	L	L	L	L	L	L	L	H	L
CLO-4 :	*Evaluate surface and gas radiation for black and grey bodies*	3	90	80	H	H	L	H	L	L	L	L	L	L	L	L	L	H	L
CLO-5 :	*Analyse and evaluate heat and mass transfer coefficient for phase change process and mass transfer*	3	90	80	H	H	L	H	L	L	L	L	L	L	L	L	L	H	L
CLO-6 :	*Apply the concepts of heat transfer in real time applications*	3	90	80	H	H	L	H	L	L	L	L	L	L	L	L	L	H	L

Duration (hour)		12	12	12	12	12
S-1	SLO-1	*Modes and mechanism of heat transfer in solids, liquids and gases*	*Fins – types,Differential equation,Types of fin boundary conditions*	*Hydrodynamic and thermal boundary layer,Principles and governing equations*	*Basic concepts of radiation ,Laws of radiation*	*Nusselt theory of condensation,Film condensation on a vertical plate and its flow regimes*
S-2	SLO-1	*General conduction equation, boundary and initial conditions*	*Circumferential and longitudinal fins*	*Dimensional analysis for free convection*	*Atmospheric and solar radiation*	*Heat transfer correlations for film condensation,Film condensation inside horizontal tubes*
S-3	SLO-1	*One dimensional steady state heat conduction in plane wall, cylinder and sphere, electrical analogy*	*Fin efficiency,Fin effectiveness*	*Dimensional analysis for forced convection*	*Black body radiation Grey body radiation*	*Dropwise condensation*
S-4	SLO-1	*Tutorial on plane wall, cylinders and spheres*	*Tutorial on fins*	*Tutorial on hydrodynamic and thermal boundary layer*	*Tutorial on laws of radiation*	*Tutorial on Filmwise condensation*
S-5	SLO-1	*One dimensional steady state heat conduction in composite plane wall*	*Unsteady state heat conduction in Lumped heat model*	*Forced convection: Flow over flat plate, cylinders and spheres*	*Shape factor algebra*	*Modes of Boiling*
S-6	SLO-1	*One dimensional steady state heat conduction in composite cylinders*	*Unsteady state heat conduction in semi-infinite solid*	*Forced convection : Internal flow*	*Electrical analogy*	*Pool boiling regimes, Correlations for pool boiling heat transfer*
S-7	SLO-1	*One dimensional steady state heat conduction in composite spheres*	*Unsteady state heat conduction in infinite solid*	*Free convection : Flow over plates, cylinders and spheres*	*Radiation shield*	*Flow boiling regimes*
S-8	SLO-1	*Tutorial on composite systems*	*Tutorial on unsteady state heat conduction*	*Tutorial on free and forced convection*	*Tutorial on shape factor, radiation shield and electrical analogy*	*Tutorial on pool boiling*
S-9	SLO-1	*Critical thickness of insulation for cylinders*	*Numerical solution for one dimensional steady state heat conduction*	*Heat Exchangers – Types, overall heat transfer coefficient, fouling factor*	*Introduction to Solar radiation*	*Diffusion mass transfer – Fick's law of diffusion,Steady state diffusion through plane membrane*
S-10	SLO-1	*Critical thickness of insulation for spheres*	*Numerical solution for one dimensional steady state heat conduction*	*LMTD and Effectiveness – NTU method method of analysis*	*Radiation properties of gases*	*Equimolar counter diffusion,Isothermal evaporation of water vapour into air*

S-11	SLO-1	*One dimensional steady state heat conduction with internal heat generation*	*Numerical solution for two dimensional steady state heat conduction*	*Heat transfer enhancement methods, Selection of heat exchangers*	*Gaseous emission and absorption - water vapour and carbon dioxide*	*Convective mass transfer,Convective mass transfer correlations, Simultaneous heat and mass transfer*
S-12	SLO-1	*Tutorial on critical thickness of insulation and internal heat generation*	*Tutorial on one and two dimensional steady state heat conduction*	*Tutorial on heat exchangers*	*Tutorial on gas radiation*	*Tutorial on diffusion and convective mass transfer*

Learning Resources	*1. Sachdeva, R.C., Fundamentals of Heat and Mass Transfer, 2nd Edition, New Age International (P) Ltd., New Delhi,2017.* *2. Nag, P.K., Heat Transfer and Mass Transfer, Tata McGraw Hill, 3rd Edition, New Delhi, 2011.* *3. Ozisik. M. N, "Heat Transfer", McGraw-Hill Book Co., 2003.* *4. Holman. J. P "Heat and Mass Transfer" Tata McGraw-Hill, 2008.* *5. Yunus A. Çengel, Afshin J. Ghajar "Heat and Mass Transfer", Tata McGraw Hill Education, 2017.* *6. Theodore L. Bergman, Adrienne S. Lavine, Frank P. Incropera, David P. DeWitt, "Fundamentals of Heat and Mass Transfer", John Wiley and Sons, 2016.* *DATA BOOKS* *7. Kothandaraman. C. P, Subramanyan, S, "Heat and Mass Transfer Data Book", New Age International, 7th edition, 2012.* *8. K.K.Ramalingam "Steam Tables", SciTech Publications, 2015.*

Learning Assessment

	Bloom's Level of Thinking	Continuous Learning Assessment (50% weightage)								Final Examination (50% weightage)	
		CLA – 1 (10%)		CLA – 2 (15%)		CLA – 3 (15%)		CLA – 4 (10%)#			
		Theory	Practice	Theory	Practice	Theory	Practice	Theory	Practice	Theory	Practice
Level 1	Remember Understand	*40 %*	-	*30 %*	-	*30 %*	-	*30 %*	-	*30%*	-
Level 2	Apply Analyze	*40 %*	-	*40 %*	-	*40 %*	-	*40 %*	-	*40%*	-
Level 3	Evaluate Create	*20 %*	-	*30 %*	-	*30 %*	-	*30 %*	-	*30%*	-
	Total	100 %		100 %		100 %		100 %		100 %	

CLA – 4 can be from any combination of these: Assignments, Seminars, Tech Talks, Mini-Projects, Case-Studies, Self-Study, MOOCs, Certifications, Conf. Paper etc.,

Course Designers

Experts from Industry	Experts from Higher Technical Institutions	Internal Experts
1. Dr.R.Kalimuthu, ISRO, Mahendragiri, r_kalimuthu@vssc.gov.in	*1. Dr. M. R. Kamesh, Dayanada Sagar College of Engineering*	*1. Mr. D. Premnath, SRMIST*
2. Dr.A.Velayutham, DRDO, Avadi, velayudham.a@cvrde.drdo.in	*2. Dr.N. Saravanan, Smart Implements and Machinery and Sustainability*	*2. Dr.P. Chandrasekaran, SRMIST*

Course Code	18MEC203L	Course Name	MACHINE DYNAMICS LABORATORY	Course Category	C	Professional core	L	T	P	C
							0	0	2	1

Pre-requisite Courses	Nil	Co-requisite Courses	18MEC201T	Progressive Courses	Nil
Course Offering Department	Mechanical Engineering	Data Book / Codes/Standards	Nil		

Course Learning Rationale (CLR):	The purpose of learning this course is to:
CLR-1 :	*understand the static and kinematics behavior of machines*
CLR-2 :	*understand the dynamic behavior of machines*
CLR-3 :	*understand the balancing of masses in machines*
CLR-4 :	*understand the effect of centrifugal forces in machine*
CLR-5 :	*understand the free and forced vibration analysis*
CLR-6 :	*acquire the ability to analyze the dynamics behavior of machines*

Course Learning Outcomes (CLO):	At the end of this course, learners will be able to:	Learning 1: Level of Thinking (Bloom)	2: Expected Proficiency (%)	3: Expected Attainment (%)	PLO 1: Engineering Knowledge	2: Problem Analysis	3: Design & Development	4: Analysis, Design, Research	5: Modern Tool Usage	6: Society & Culture	7: Environment & Sustainability	8: Ethics	9: Individual & Team Work	10: Communication	11: Project Mgt. & Finance	12: Life Long Learning	13: PSO - 1	14: PSO - 2	15: PSO – 3
CLO-1 :	*Draw cam profiles based on follower motion*	3	80	85	H	H	M	M	H	-	-	-	H	-	-	-	-	-	-
CLO-2 :	*Analyze Epicyclic Gear train and Gyroscopic effect*	3	80	85	H	H	M	M	M	-	-	-	H	-	-	-	-	-	-
CLO-3 :	*Do balancing of rotating masses in machines*	3	80	85	H	H	M	M	H	-	-	-	H	-	-	-	-	-	-
CLO-4 :	*Determine the frequency of single degree of freedom systems.*	3	80	85	H	H	M	M	M	-	-	-	H	-	-	-	-	-	-
CLO-5 :	*Find the Critical speed or whirling of shaft*	3	80	85	H	H	M	M	M	-	-	-	H	-	-	-	-	-	-
CLO-6 :	*Do dynamic analysis of machines*	3	80	85	H	H	M	M	M	-	-	-	H	-	-	-	-	-	-

Duration (hour)		6	6	6	6	6
S-1		*Cam and Follower Analysis*	*Dynamic analysis of Proelland porter Governor*	*Measurement of cutting forces using Drill tool Dynamometers*	*Free damped and un-damped torsional vibration of single rotor systems*	*Transmissibility Ratio in Vibrating Systems*
S-2						
S-3		*Dynamic analysis of Gyroscope*	*Dynamic Balancing of massesin machine*	*Measurement of cutting forces using Milling Dynamometers*	*Free & forced vibration of equivalent spring mass system*	*Free and forced transverse vibration analysis for beams*
S-4						
S-5		*Dynamic analysis of Epi cyclic gear trains*	*Measurement of cutting forces using, Lathe tool Dynamometer*	*Free Vibration of helical springs*	*Whirling of shaft*	*Vibration measurement using strain gauge*
S-6						

Learning Resources	
	1. *Laboratory Manual* 2. *Thomas Bevan, “The Theory of Machines”, Pearson India Education Services Pvt. Ltd., 3rd Edition, 2010.* 3. *Robert L Norton, “Design of machinery - An introduction to the synthesis and analysis of mechanisms and machines”, McGrawHill Education, 5th edition, 2011.*

Learning Assessment

	Bloom’s Level of Thinking	Continuous Learning Assessment (50% weightage)								Final Examination (50% weightage)	
		CLA – 1 (10%)		CLA – 2 (15%)		CLA – 3 (15%)		CLA – 4 (10%)#			
		Theory	Practice	Theory	Practice	Theory	Practice	Theory	Practice	Theory	Practice
Level 1	Remember Understand	-	40 %	-	30 %	-	30 %	-	30 %	-	30%
Level 2	Apply Analyze	-	40 %	-	40 %	-	40 %	-	40 %	-	40%
Level 3	Evaluate Create	-	20 %	-	30 %	-	30 %	-	30 %	-	30%
	Total	100 %		100 %		100 %		100 %		100 %	

CLA – 4 can be from any combination of these: Assignments, Seminars, Tech Talks, Mini-Projects, Case-Studies, Self-Study, MOOCs, Certifications, Conf. Paper etc.,

Course Designers

Experts from Industry	Experts from Higher Technical Institutions	Internal Experts
1. Dr.R.Kalimuthu, ISRO, Mahendragiri, r_kalimuthu@vssc.gov.in	*1. Dr. Sudheesh Kumar, sudheeshkumar3@gmail.com, GCE, Kannur*	*1. Dr.P.Nandakumar, SRMIST*
2. Dr.A.Velayutham, DRDO, Avadi, velayudham.a@cvrde.drdo.in	*2. Dr.R.Prabhusekar, rprabhusekar@mnnit.ac.in, MNNIT Allahabad*	*2. Dr.P V Jeyakarthikeyan, SRMIST*

Course Code	18MEC204L	Course Name	SIMULATION LABORATORY	Course Category	C	Professional core	L	T	P	C
							0	0	2	1

Pre-requisite Courses	Nil	Co-requisite Courses	18MEE305T Finite Element Method	Progressive Courses	Nil
Course Offering Department	Mechanical Engineering	Data Book / Codes/Standards	Nil		

Course Learning Rationale (CLR):	*The purpose of learning this course is to:*
CLR-1 :	*Upon learning the students shall understand the need of software tools to analyze the Engineering problems.*
CLR-2 :	*Understand and practice structural analysis of components.*
CLR-3 :	*Understand and practice modaland vibrational analysis of components.*
CLR-4 :	*Understand and practice Thermal analysis of components.*
CLR-5 :	*Understand and practice Dynamic analysis of components.*
CLR-6 :	*Simulate any engineering problem numerically.*

Course Learning Outcomes (CLO):	*At the end of this course, learners will be able to:*	Learning 1: Level of Thinking (Bloom)	2: Expected Proficiency (%)	3: Expected Attainment (%)	PLO 1: Engineering Knowledge	2: Problem Analysis	3: Design & Development	4: Analysis, Design, Research	5: Modern Tool Usage	6: Society & Culture	7: Environment & Sustainability	8: Ethics	9: Individual & Team Work	10: Communication	11: Project Mgt. & Finance	12: Life Long Learning	13: PSO - 1	14: PSO - 2	15: PSO – 3
CLO-1 :	*Learn data exchange standard and integration of FEA with software tools.*	3	85	80	H	H		H	H		H					H			
CLO-2 :	*learnand practice structural analysisof components using software tools.*	3	75	80	H	H		H	H							H			
CLO-3 :	*Earn and practice modal and vibrational analysis of components using software tools.*	3	75	80	H	H		H	H							H			
CLO-4 :	*Learn and practice Thermal analysis of components using software tools.*	3	75	80	H	H		H	H							H			
CLO-5 :	*Learn and practice Dynamic analysis of components of components using software tools.*	3	75	80	H	H		H	H							H			
CLO-6 :	*Practice numerical simulation of any engineering problem using softeare.*	3	75	80	H	H		H	H							H			

Duration (hour)		6	6	6	6	6
S-1, S-2	SLO-1	*Displacement bar structures with different support conditions.*	*Stress and deflection analysis in beams with different support condition.*	*Modal analysis of beam – Finding natural frequency –Cantilever beam, Simply supported beam etc with UDL*	*Dynamic analysis of thin circular cylindrical shell.*	*Thermal analysis – Steady state and Transient - 3D problem.*
S-3, S-4	SLO-1	*Force and stress analysis using link elements in Trusses.*	*Plane stress and Plane strain problems – Simple examples – flat plate with hole, circular disc with hole Tapper plate etc.*	*Modal analysis of beam – Finding natural frequency –Cantilever beam, Simply supported beam etc with UVL*	*Thermal analysis – Steady state and Transient - 1D problem.*	*Kinematic analysis of Four bar mechanism.*
S-5, S-6	SLO-1	*Stress and deflection analysis in beams with different loading condition.*	*Stress analysis of axi -symmetric component.*	*Vibrational analysis - plate with dynamic condition.*	*Thermal analysis – Steady state and Transient - 2D problem.*	*Dynamic analysis of slider crank mechanism.*

Learning Resources	
	1. *Laboratory Manual* 2. *Reddy .J.N., An Introduction to finite Element Method, 3 rd .,Tata McGraw Hill.2005.* 3. *Chandrupatla, T.R., Belegundu, A.D., “Introduction to Finite Elements in Engineering”, Prentice Hall,1990.1990ndia, 1997.*

Learning Assessment

	Bloom’s Level of Thinking	Continuous Learning Assessment (50% weightage)								Final Examination (50% weightage)	
		CLA – 1 (10%)		CLA – 2 (15%)		CLA – 3 (15%)		CLA – 4 (10%)#			
		Theory	Practice	Theory	Practice	Theory	Practice	Theory	Practice	Theory	Practice
Level 1	Remember / Understand	-	*40 %*	-	*30 %*	-	*30 %*	-	*30 %*	-	*30%*
Level 2	Apply / Analyze	-	*40 %*	-	*40 %*	-	*40 %*	-	*40 %*	-	*40%*
Level 3	Evaluate / Create	-	*20 %*	-	*30 %*	-	*30 %*	-	*30 %*	-	*30%*
	Total	100 %		100 %		100 %		100 %		100 %	

CLA – 4 can be from any combination of these: Assignments, Seminars, Tech Talks, Mini-Projects, Case-Studies, Self-Study, MOOCs, Certifications, Conf. Paper etc.,

Laboratory Course Designers

Experts from Industry	Experts from Higher Technical Institutions	Internal Experts
1. Dr.R.Kalimuthu, ISRO, Mahendragiri, r_kalimuthu@vssc.gov.in	*Dr. Davidson Jebaseelan, davidson.jd@vit.ac.in,VIT, Chennai*	*Mr. S. Balamurugan, SRMIST*
2. Dr.A.Velayutham, DRDO, Avadi, velayudham.a@cvrde.drdo.in	*Mr. Vignesh Shanmugam.s,Hyundai Motors Limited, Chennai, 273357@hmil.net*	*Dr.P V Jeyakarthikeyan, SRMIST*

Course Code	18MEC205L	Course Name	HEAT AND MASS TRANSFER LABORATORY	Course Category	C	Professional core	L	T	P	C
							0	0	2	1

Pre-requisite Courses	Nil	Co-requisite Courses	18MEC202T Heat and Mass Transfer	Progressive Courses	Nil
Course Offering Department	Mechanical Engineering	Data Book / Codes/Standards	Heat and Mass Transfer Data Book and Refrigerant Tables and Charts		

Course Learning Rationale (CLR):	*The purpose of learning this course is to:*
CLR-1 :	*Conduction, Convection and Radiation modes of Heat Transfer.*
CLR-2 :	*The Performance of Heat Exchangers, condensation and boiling apparatus.*
CLR-3 :	*The Performance of Refrigeration and Air Conditioning systems.*

Course Learning Outcomes (CLO):	*At the end of this course, learners will be able to:*	Learning 1: Level of Thinking (Bloom)	Learning 2: Expected Proficiency (%)	Learning 3: Expected Attainment (%)
CLO-1 :	*Analyze Conduction, Convection and Radiation modes of heat transfer and evaluate the thermal conductivity, heat transfer coefficients and radiation constants.*	*3*	*95*	*90*
CLO-2 :	*Evaluate the effectiveness of heat exchangers,heat transfer rate in condensation and boiling.*	*3*	*95*	*90*
CLO-3 :	*Evaluate the Coefficient of performance of refrigeration and air conditioning systems.*	*3*	*95*	*90*

Program Learning Outcomes (PLO)

	1 Engineering Knowledge	2 Problem Analysis	3 Design & Development	4 Analysis, Design, Research	5 Modern Tool Usage	6 Society & Culture	7 Environment & Sustainability	8 Ethics	9 Individual & Team Work	10 Communication	11 Project Mgt. & Finance	12 Life Long Learning	13 PSO - 1	14 PSO - 2	15 PSO – 3
CLO-1	*H*	*H*	*L*	*L*	*L*		*M*		*H*						
CLO-2	*H*	*H*	*H*	*L*	*L*		*M*		*H*						
CLO-3	*H*	*H*	*L*	*L*	*L*		*M*		*H*						

Duration (hour)		Conduction Heat Transfer	Convection Heat Transfer	Radiation Heat Transfer	Heat Exchangers, Boiling and Condensation	Refrigeration and Air Conditioning Systems
		6	8	4	8	4
S-1	SLO-1	*Heat Transfer through Composite wall.*	*Heat transfer by Natural Convection.*	*Study of the Emissivity apparatus.*	*Study of parallel flow and counter flow Heat Exchanger.*	*Study of Refrigeration Test Rig.*
	SLO-2	*Determination of heat transfer rate.*	*Determination of convective heat transfer coefficient*	*Determination of the emissivity of grey surface.*	*Determination of overall heat transfer coefficient, heat transfer rate and effectiveness of heat exchanger.*	*Determination of CoP of the Refrigeration Test Rig.*
	SLO-1	*Heat Transfer through Composite lagged pipe.*	*Heat transfer by Forced Convection.*	*Study of Stefan – Boltzmann's Apparatus.*	*Study of Shell and tube Heat Exchanger.*	*Study of Air Conditioning Test Rig.*
	SLO-2	*Determination of Thermal Conductivity of the materials.*	*Determination of convective heat transfer coefficient*	*Determination of Stefan Boltzmann Constant.*	*Determination of overall heat transfer coefficient, heat transfer rate and effectiveness of heat exchanger.*	*Determination of CoP of the Air Conditioning Test Rig.*
S-3	SLO-1	*Thermal conductivity of an insulating Material.*	*Heat transfer through Pin Fin by Natural Convection.*	-	*Study of Film wise and drop wise condensation apparatus.*	
	SLO-2	*Determination of Thermal Conductivity of insulating material.*	*Determination of Efficiency and Effectiveness of the pin fin*		*Determination of Condensate rate.*	
S-4	SLO-1	-	*Heat transfer through Pin Fin by Forced Convection.*		*Study on Critical heat Flux Apparatus.*	
	SLO-2	-	*Determination of Efficiency and Effectiveness of the pin fin*		*Determination of Critical heat Flux.*	

Learning Resources	*1.Laboratory Manual* *2.Kothandaraman.C.P, Subramanyan.S, "Heat and Mass Transfer Data Book", New age International, 8th edition, 2014.* *3.Mehta.F.S, Mathur.M.L, "Refrigeration &Psychrometric Properties Tables & Charts",3rd Edition, Jain Publishers, 2014.*

Learning Assessment

	Bloom's Level of Thinking	Continuous Learning Assessment (50% weightage)								Final Examination (50% weightage)	
		CLA – 1 (10%)		CLA – 2 (15%)		CLA – 3 (15%)		CLA – 4 (10%)#			
		Theory	Practice	Theory	Practice	Theory	Practice	Theory	Practice	Theory	Practice
Level 1	Remember Understand	-	*40 %*	-	*30 %*	-	*30 %*	-	*30 %*	-	*30%*
Level 2	Apply Analyze	-	*40 %*	-	*40 %*	-	*40 %*	-	*40 %*	-	*40%*
Level 3	Evaluate Create	-	*20 %*	-	*30 %*	-	*30 %*	-	*30 %*	-	*30%*
	Total	100 %		100 %		100 %		100 %		100 %	

CLA – 4 can be from any combination of these: Assignments, Seminars, Tech Talks, Mini-Projects, Case-Studies, Self-Study, MOOCs, Certifications, Conf. Paper etc.,

Course Designers		
Experts from Industry	Experts from Higher Technical Institutions	Internal Experts
Dr.R.Kalimuthu,ISRO, Mahendragiri, r_kalimuthu@vssc.gov.in	*Dr. M.R.Kamesh, Dayananda Sagar College of Engineering, Bangalore*	*Mr.M.D.Kathir Kaman , SRM IST*
Dr.A.Velayutham, DRDO, Avadi, velayudham.a@cvrde.drdo.in	*Dr.N.Saravanan, Smart Implements & Machinery and Sustainability, Mahindra Research Valley, Chennai*	*Dr.C.Selvam, SRM IST*

Course Code	18MEC206T	Course Name	METROLOGY AND QUALITY CONTROL	Course Category	C	Professional core	L	T	P	C
							3	0	0	3

Pre-requisite Courses	Nil	Co-requisite Courses	Nil	Progressive Courses	Nil
Course Offering Department	Mechanical Engineering	Data Book / Codes /Standards	Approved Metrology & Quality Control Tables and Charts		

Course Learning Rationale (CLR):	*The purpose of learning this course is to:*
CLR-1 :	*Be familiar with standards of measurements and types of measurement errors*
CLR-2 :	*Know the basics of measurement for thread, gear and surface finish*
CLR-3 :	*Be familiar with optical and other non-contact measurements*
CLR-4 :	*Be familiar with working of coordinate measuring machines and alignments of machine tool*
CLR-5 :	*Select the appropriate control chart and sampling plan*
CLR-6 :	*Be familiar with dimensional and form measurements using conventional and coordinate metrology, together with quality control techniques*

Course Learning Outcomes (CLO):	*At the end of this course, learners will be able to:*	Learning 1: Level of Thinking (Bloom)	Learning 2: Expected Proficiency (%)	Learning 3: Expected Attainment (%)	PLO 1: Engineering Knowledge	PLO 2: Problem Analysis	PLO 3: Design & Development	PLO 4: Analysis, Design, Research	PLO 5: Modern Tool Usage	PLO 6: Society & Culture	PLO 7: Environment & Sustainability	PLO 8: Ethics	PLO 9: Individual & Team Work	PLO 10: Communication	PLO 11: Project Mgt. & Finance	PLO 12: Life Long Learning	PLO 13: PSO - 1	PLO 14: PSO - 2	PLO 15: PSO – 3
CLO-1 :	*Understand the types of measurement errors, design of limit gauges and various comparative measurement methods*	*3*	*90*	*85*	*H*	*H*	*M*	*L*	*L*								*M*	*L*	*L*
CLO-2 :	*Acquire the fundamentals of the gear, thread and surface finish measurements*	*3*	*90*	*85*	*H*	*H*	*M*		*L*								*L*	*L*	*L*
CLO-3 :	*Perceive the knowledge about the optical metrology and non-contact measurement*	*3*	*90*	*85*	*H*	*M*			*H*								*L*	*L*	*L*
CLO-4 :	*Learn the fundamentals of CMMs*	*3*	*90*	*85*	*H*	*M*			*H*								*H*	*L*	*L*
CLO-5 :	*Choose the appropriate control charts*	*3*	*90*	*85*	*H*	*H*	*L*		*M*					*H*		*L*	*H*	*L*	*L*
CLO-6 :	*Choose the types of sampling and methods in acceptance sampling for SQC*	*3*	*90*	*85*	*H*	*H*	*M*		*M*							*L*	*H*	*L*	*L*

		Introduction To Metrology	Measurements Of Screw Thread - Gear Elements – Surface Finish	Optical And Other Non-Contact Measurement Techniques	Coordinate Metrology And Form Measurement; Machine Tool Metrology	Theory Of Control Charts & Acceptance Sampling
Duration (hour)		9	9	9	9	9
S-1	SLO-1	*Introduction to metrology; Need for inspection; Physical measurements*	*Measurements of various elements of external and internal threads: Measurement of major and minor diameters, pitch and flank angle*	*Principle of light wave interference, light sources, measurements using optical flats*	*Introduction to coordinate metrology; Coordinate metrology versus conventional metrology*	*Definition of quality; Assignable causes and Chance causes; SQC: Benefits and limitations*
S-2	SLO-1	*Methods of measurement; Classification and characteristics of measuring instruments*	*Measurement of effective diameter: two and three wire methods; best size wire; error corrections*	*Types of interferometers: Michelson, Twyman Green Specialization of Michelson*	*Types and construction of CMM; Components: Bearings; Drive systems*	*Theory of Control Charts; Control Charts for Variables: X bar and R charts*
S-3	SLO-1	*Role of NPL; Sources and types of errors*	*Measurements of various elements of spur gears: gear tooth vernier*	*NPL flatness interferometer, The Pitter NPL gauge interferometer*	*Components: Transducers; Probes*	*Control Charts for attributes: P chart, np chart*
S-4	SLO-1	*Statistical treatment of errors; tutorial*	*Constant chord method: derivation and tutorial*	*Laser interferometer, Laser micrometer*	*Measuring accuracy, causes of errors and calibration of CMM: Tutorial*	*Control charts for Non Conformities - C and U chart*
S-5	SLO-1	*Standards of measurements; Classification of standards; Calibration*	*Base tangent method: derivation and tutorial*	*Surface roughness measurement using Lasers*	*Performance of CMM and its applications*	*Basic Concepts of acceptance sampling and OC curve, AQL, LTPD ,AOQL*
S-6	SLO-1	*Limits, fits, and tolerances: tutorial*	*Circular pitch and composite error measurement*	*Measurement of straightness using Autocollimator, Tutorial*	*Overview of alignment tests in machine tools using dial gauge, sprit level, straight edges*	*Tutorial*
S-7	SLO-1	*Interchangeability and Selective Assembly*	*Surface finish: Surface topography definitions*	*Measurement of flatness using Autocollimator*	*Measurement of squareness and parallelism*	*Sampling Plans: Simple*
S-8	SLO-1	*Inspection Gauges, Types of Gauges*	*Measurement of surface finish: measuring instruments*	*Machine vision, Image processing techniques*	*Circularity: tutorial*	*Sampling Plans: Double and Multiple - tutorial*
S-9	SLO-1	*Introduction to Comparators; Mechanical (Sigma), Electrical, and Pneumatic comparators*	*Methods of evaluation of surface finish*	*Edge detection, feature extraction - applications*	*Measurement of cylindrical and conical features, and runout*	*Sequential sampling plans*

Learning Resources	1. Jain, R. K., *"Engineering Metrology", Khanna Publishers, New Delhi, 2012.* 2. *Gupta, R. C, "Statistical Quality Control", Khanna Publishers, New Delhi, 1994.* 3. *Kevin Harding, "Handbook of Optical Dimensional Metrology", CRC Press, A Taylor & Francis group, 2013.* 4. *Robert J. Hocken, Paulo H. Pereira, "Coordinate Measuring Machines and Systems", CRC Press, Taylor & Francis Group, 2011.* 5. *Connie Dotson, Roger Harlow and Richard L. Thompson, "Fundamentals of Dimensional Metrology", Thomson Delmar Learning", 4th edition, 2005.* 6. *Galyer, J. F. W., and Shotbolt, C. R., Metrology for Engineering, Cassell London, 5th Edition* 7. *Toru Yoshizawa, "Handbook of Optical Metrology: Principles and Applications", CRC Press, 2009.* 8. *Grant E. L., "Statistical Quality Control", McGraw Hill, New York, 1972* 9. *M. Mahajan, Statistical Quality Control, Dhanpat Rai & co. Gagankapur, 2010.* 10 *Heinrich Schwenke, Ulrich Neuschaefer-Rube, Tilo Pfeifer, Horst Kunzmann ,"Optical Methods for Dimensional Metrology in Production Engineering", CIRP Annals - Manufacturing Technology, 51(2) (2002) 685–699* 11. *A. Weckenmann, T. Estler, G. Peggs, D. McMurtry ,"Probing Systems in Dimensional Metrology", CIRP Annals - Manufacturing Technology, 53 (2) (2004) 657–684* 12. *A.M.A. Al-Ahmari, Javed Aalam, "Optimizing parameters of freeform surface reconstruction using CMM", Measurement, 64 (2015) 17–28* 13. *K. Duraivelu and S. Karthikeyan. "Engineering Metrology and Measurment", Universities Press (India) Private Limited, 2018.*

Learning Assessment

	Bloom's Level of Thinking	Continuous Learning Assessment (50% weightage)								Final Examination (50% weightage)	
		CLA – 1 (10%)		CLA – 2 (15%)		CLA – 3 (15%)		CLA – 4 (10%)#			
		Theory	Practice	Theory	Practice	Theory	Practice	Theory	Practice	Theory	Practice
Level 1	Remember Understand	40 %	-	30 %	-	30 %	-	30 %	-	30%	-
Level 2	Apply Analyze	40 %	-	40 %	-	40 %	-	40 %	-	40%	-
Level 3	Evaluate Create	20 %	-	30 %	-	30 %	-	30 %	-	30%	-
	Total	100 %		100 %		100 %		100 %		100 %	

CLA – 4 can be from any combination of these: Assignments, Seminars, Tech Talks, Mini-Projects, Case-Studies, Self-Study, MOOCs, Certifications, Conf. Paper etc.,

Course Designers

Experts from Industry	Experts from Higher Technical Institutions	Internal Experts
1. Subburathinam_Shankar@cat.com	*1. Dr. G. Rajamohan, NIFFT, grajamohan.nifft@gov.in*	*1. Mr.Sundar S, SRMIST*
2. Sridhar.narasimhan@hexagon.com	*2. Dr.N.Arunachalam, IIT Madras, chalam@iitm.ac.in*	*2. Dr. A. Vijaya, SRMIST*

Course Code	18MEC207T	Course Name	CAD/CAM	Course Category	C	Professional core	L	T	P	C
							3	0	0	3

Pre-requisite Courses	Nil	Co-requisite Courses	Nil	Progressive Courses	Nil
Course Offering Department	Mechanical Engineering	Data Book / Codes/Standards	-		

Course Learning Rationale (CLR):	*The purpose of learning this course is to:*
CLR-1 :	*Be familiar with the concepts of modeling in 2D and 3D*
CLR-2 :	*Be familiar with he Mathematical Representation of curves and surfaces*
CLR-3 :	*Be familiar with the concepts of Computer Graphics*
CLR-4 :	*Be familiar with the basics of CNC machines and manufacturing systems*
CLR-5 :	*Be familiar with the concepts of Computer aided production planning and control*
CLR-6 :	*Be familiar with the concepts of CAD and CAM*

Course Learning Outcomes (CLO):	*At the end of this course, learners will be able to:*	Learning 1: Level of Thinking (Bloom)	Learning 2: Expected Proficiency (%)	Learning 3: Expected Attainment (%)	PLO 1: Engineering Knowledge	PLO 2: Problem Analysis	PLO 3: Design & Development	PLO 4: Analysis, Design, Research	PLO 5: Modern Tool Usage	PLO 6: Society & Culture	PLO 7: Environment & Sustainability	PLO 8: Ethics	PLO 9: Individual & Team Work	PLO 10: Communication	PLO 11: Project Mgt. & Finance	PLO 12: Life Long Learning	PLO 13: PSO - 1	PLO 14: PSO - 2	PLO 15: PSO – 3
CLO-1 :	*Recognize and analyze the concepts of modeling in 2D and 3D*	3	90	85	H	M	H	L	L	-	-	-	-	L	M	L	H	M	M
CLO-2 :	*Apply the concepts learned in Mathematical Representation of curves and surfaces*	3	90	85	H	M	H	L	L	-	-	-	-	L	M	L	H	M	M
CLO-3 :	*Understand and apply the concepts of Computer Graphics like shading, coloring, clipping, animation and simulation*	3	90	85	H	L	M	H	M	-	-	-	-	L	M	M	H	M	M
CLO-4 :	*Understand and analyze the basics of CNC machines and manufacturing systems*	3	90	85	H	M	L	L	L	-	M	-	-	L	M	H	H	M	H
CLO-5 :	*Apply and evaluate the concepts of Computer aided production planning and control*	3	90	85	H	M	L	L	L	-	M	-	-	L	H	H	H	M	H
CLO-6 :	*Understand, apply and evaluate the concepts of CAD and CAM*	3	90	85	H	M	M	L	L	-	L	-	-	L	M	M	H	M	M

Duration (hour)		9	9	9	9	9
S-1	SLO-1	*Fundamentals of Computer aided design*	*Mathematical representation of lines, circle*	*Cohen Sutherland Clipping Algorithm*	*Fundamentals of CNC machines, Classification, Developments*	*Computer Aided Process Planning (CAPP)*
S-2	SLO-1	*Product Life Cycle*	*Mathematical representation of Hermite curves*	*Shading and its types*	*CNC principles of operation and features*	*Materials Requirement planning with Case study*
S-3	SLO-1	*sequential and concurrent engineering*	*Mathematical representation of Bezier curves, B-spline curves*	*Colouring and its types*	*Machining Centers and its types*	*Management Resource planning with case study*
S-4	SLO-1	*Coordinate Systems, 2D transformations*	*Parametric representation of plane surface and Ruled surface*	*Introduction to Data exchange standards*	*Introduction to Group technology and its types*	*Capacity Planning and Data collection systems*
S-5	SLO-1	*3D transformations*	*parametric representation of Surface of revolution and Tabulated cylinder*	*Data exchange standards: IGES,STEP*	*Part families, coding and classification*	*Shop floor control and monitoring systems*
S-6	SLO-1	*Wire frame modeling and Surface modeling*	*Hidden line removal - Visibility Techniques*	*Data exchange standards: DXF and CALS and GKS*	*Production flow analysis with case study*	*Inventory control and Case study*
S-7	SLO-1	*Solid modeling - Constructive Solid Geometry*	*Priority and Area -oriented Algorithm*	*Animation Types*	*Machine cell design with numerical case study*	*JIT approach and Case study*
S-8	SLO-1	*Solid modeling - Boundary Representation*	*Hidden surface removal algorithms*	*Animation Techniques*	*Introduction to FMS, types, applications and benefits*	*Lean Manufacturing*
S-9	SLO-1	*Feature Entities and Representation*	*Hidden Solid removal algorithms*	*Simulation Technique*	*FMS :components, Layout Configurations and implementation*	*Agile manufacturing*

Learning Resources	1. *Ibrahim Zeid, "Mastering CAD /CAM (Sie)", Tata McGraw-Hill, New Delhi, 2010* 2. *P.N. Rao, "CAD/CAM Principles and Application",3rd Edition, Tata McGraw-Hill, New Delhi, 2012* 3. *Mikell P. Groover, "Automation, Production systems and computer integrated manufacturing", Prentice Hallof India Private Ltd., New Delhi, 2008.* 4. *Mikell P. Groover, Emory W. Zimmers Jr., "CAD/CAM: Computer Aided Design and Manufacturing", Prentice Hall of India Private Ltd., New Delhi, 2008.*

Learning Assessment											
	Bloom's Level of Thinking	Continuous Learning Assessment (50% weightage)								Final Examination (50% weightage)	
		CLA – 1 (10%)		CLA – 2 (15%)		CLA – 3 (15%)		CLA – 4 (10%)#			
		Theory	Practice	Theory	Practice	Theory	Practice	Theory	Practice	Theory	Practice
Level 1	Remember Understand	*40 %*	-	*30 %*	-	*30 %*	-	*30 %*	-	*30%*	-
Level 2	Apply Analyze	*40 %*	-	*40 %*	-	*40 %*	-	*40 %*	-	*40%*	-
Level 3	Evaluate Create	*20 %*	-	*30 %*	-	*30 %*	-	*30 %*	-	*30%*	-
	Total	100 %		100 %		100 %		100 %		100 %	

CLA – 4 can be from any combination of these: Assignments, Seminars, Tech Talks, Mini-Projects, Case-Studies, Self-Study, MOOCs, Certifications, Conf. Paper etc.,

Course Designers		
Experts from Industry	Experts from Higher Technical Institutions	Internal Experts
Dr.R.Kalimuthu,ISRO, Mahendragiri, r_kalimuthu@vssc.gov.in	*Dr. S. Sridhar, PSNA college of Engg. & Tech., Dindigul*	*Mr.J.Daniel Glad Stephen, SRMIST*
Dr.A.Velayutham, DRDO, Avadi, velayudham.a@cvrde.drdo.in	*Mr.V.Selvakumar, vselvakumar86@gmail.com, Ford India, Chennai*	*Dr. P. Nandakumar, SRMIST*

Course Code	18MEC208T	Course Name	MECHANICAL ENGINEERING DESIGN	Course Category	C	Professional core	L	T	P	C
							3	1	0	4

Pre-requisite Courses	18MEC206T	Co-requisite Courses	Nil	Progressive Courses	18MEE401T
Course Offering Department	Mechanical Engineering	Data Book / Codes/Standards	PSG Design Data Book		

Course Learning Rationale (CLR):	*The purpose of learning this course is to:*	Learning			Program Learning Outcomes (PLO)														
		1	2	3	1	2	3	4	5	6	7	8	9	10	11	12	13	14	15
CLR-1 :	*Know fundamental concepts to design the mechanical components.*																		
CLR-2 :	*Be familiar with the concepts to design the shafts, keys and couplings*																		
CLR-3 :	*Know the concepts to design the temporary joints.*																		
CLR-4 :	*Be familiar with the concepts to design the permanent joints.*																		
CLR-5 :	*Know the concepts to design the levers and springs.*																		
CLR-6 :	*Know the fundamental concepts in design of machine elements*																		
Course Learning Outcomes (CLO):	*At the end of this course, learners will be able to:*	Level of Thinking (Bloom)	Expected Proficiency (%)	Expected Attainment (%)	Engineering Knowledge	Problem Analysis	Design & Development	Analysis, Design, Research	Modern Tool Usage	Society & Culture	Environment & Sustainability	Ethics	Individual & Team Work	Communication	Project Mgt. & Finance	Life Long Learning	PSO - 1	PSO - 2	PSO – 3
CLO-1 :	*Design of mechanical components.*	3	85	75	H	H	H	M	L	L	L	L	L	L	L	L	L	H	L
CLO-2 :	*Design of shafts, keys and couplings.*	3	85	75	H	H	H	M	L	L	L	L	L	L	L	L	L	H	L
CLO-3 :	*Design of temporary joints.*	3	85	75	H	H	H	M	L	L	L	L	L	L	L	L	L	H	L
CLO-4 :	*Design of permanent joints.*	3	85	75	H	H	H	M	L	L	L	L	L	L	L	L	L	H	L
CLO-5 :	*Design of levers and springs.*	3	85	75	H	H	H	M	L	L	L	L	L	L	L	L	L	H	L
CLO-6 :	*Design of machine elements*	3	85	75	H	H	H	M	L	L	L	L	L	L	L	L	L	H	L

		FUNDAMENTALS OF MECHANICAL DESIGN	VARIABLE STRESSES ,DESIGN OF SHAFTS,KEYS AND COUPLINGS	DESIGN OF TEMPORARY JOINTS	DESIGN OF PERMANENT JOINTS	DESIGN OF LEVERS AND SPRINGS
Duration (hour)		12	12	12	12	12
S-1	SLO-1	*Introduction to design, types of design.*	*Analysis of variable stresses: Endurance limit.*	*Design of Pin joints- cotter joints , basic concepts and types*	*Riveted joints: Types, materials, arrangement of rivets, terminology of riveted joints*	*Levers: Types, applications and analysis*
	SLO-2	*Criteria for Design based on strength, fatigue, stiffness.*	*Classification of variable stresses, factors influencing the endurance limit and fatigue stress determination.*	*Design of Socket and spigot cotter joint*	*Riveted joints: Types of failures.*	
S-2	SLO-1	*Criteria for Design based on, wear resistance, vibration resistance, heat resistance and reliability.*	*Stress concentration, Methods of reducing stress concentration, Notch sensitivity.theoritical stress concentration factor and fatigue stress concentration factor.*	*Design of Sleeve and cotter joint*	*Strength and efficiency of a riveted joint, Design of riveted joints for non eccentric loads.*	*Design of hand lever,foot lever.*
	SLO-2					
S-3	SLO-1	*Overview of Engineering materials and their properties. Impact stress, Resilience.*	*Variable stresses using Soderberg method, Goodman method.*	*Design of Gib and cotter joint for square rods.*	*Design of riveted joints for pressure vessels.*	*Design of cranked lever, bell crank lever*
	SLO-2	*Principal Stresses and Principal Planes,Application of Principal Stresses in design of machine members.*	*variable stresses using Gerber method.*			
S-4	SLO-1	*Tutorial -Problems on Principal Stresses and Principal Planes.*	*Tutorial -Problems on variable stresses using Soderberg method, Goodman method and Gerber method.*	*Tutorial - problems on cotter joint.*	*Tutorial –Problems on riveted joints for structural applications and pressure vessels.*	*Tutorial – Problems on cranked lever and bell crank lever*
	SLO-2					
S-5	SLO-1	*Theories of failure, Rankine theory, Guests theory, St.Venants theory, Maximum strain energy theory and Distortion energy theory.*	*Types of Shafts, Shafting Materials and working stresses in shafts.*	*Design of Knuckle joint*	*Design of Diamond riveted joint.*	*Design of lever safety valve ,Rocker-Arm*
	SLO-2		*Design of uniform cross sectional Shafts.*			
S-6	SLO-1	*Theories of failure, Rankine theory, Guests theory, St.Venants theory,*	*Design of shaft subjected to combined twisting moment and bending moment.*		*Design of Eccentrically loaded riveted joint.*	*Springs: classification,application,spring materials and their properties.*

	SLO-2	*Maximum strain energy theory and Distortion energy theory.*		*Bolted joints: Design procedure and problems on bolted joints with non eccentric loads,*		Terminology and end conditions of helical compression spring
S-7	SLO-1 SLO-2	*Design of members subjected to combined stresses with eccentric load.*	*Design of shaft subjected to combined twisting moment, bending moment and axial loads.*	*Design of bolted joints for cylinder cover*	*Welded joints: Types and strength calculations*	*Design of circular and non circular wire helical springs for static loadings, Eccentric loading of helical springs,buckling of compression springs*
S-8	SLO-1 SLO-2	*Tutorial –Design of members subjected to combined stresses with eccentric load*	*Tutorial –Problems on Design of shaft.*	*Tutorial –Problems on bolted joints*	*Tutorial - Problems on axially loaded welded joints*	*Tutorial - Problems on helical springs*
S-9	SLO-1	*Eccentric loading in curved beams, crane hooks*	*Design of keys: Types of keys, forces acting on a key*	*Design of bolted joints with eccentric load parallel to axis of bolt and perpendicular to axis of bolt*	*Welded joints subjected to axial loads for unsymmetrical sections*	*Design of concentric helical springs*
	SLO-2		*Couplings: Types of couplings, design of sleeve coupling and clamp coupling.*			*Design of helical springs for fatigue loading*
S-10	SLO-1	*Eccentric loading in frames, clamps*	*Design of Flange coupling*	*Design of bolted joints with eccentric load in the plane containing bolts.*	*Eccentrically loaded linear fillet welded joints.*	*Design of helical torsion springs*
	SLO-2					*Design of Belleville springs*
S-11	SLO-1	*Standardization, interchangeability, fits and tolerances-Terminology of fits and tolerances*	*Design of bushed pin Flexible coupling*	*Design of Power screws; types, working principal and analysis of power screws.*	*Eccentrically loaded circular fillet welded joints.*	*Design of leaf springs, analysis and nipping of leaf springs*
	SLO-2	*Tolerances and their grades, fundamental deviation, Fits and its classifications*			*Welded joint subjected to fatigue loading*	
S-12	SLO-1 SLO-2	*Tutorial –Problems on computation of IT tolerances, fundamental deviations*	*Tutorial – Problems on coupling*	*Tutorial – Problems on bolted joints with eccentric load and Power screws.*	*Tutorial –Problems on eccentrically loaded welded joint.*	*Tutorial –Problems on leaf springs*

Learning Resources	1. *Robert C.Juvinalland Kurt M. Marshek "Fundamentals of Machine Component Design", John wiley& sons, 2017.* 2. *Spotts.M.F, ShoupT.E, "Design of Machine Elements", Prentice Hall of India Eighth Edition, 2006.* 3. *Joseph Edward Shigley and Charles ,R.Mischke, "Mechanical Engineering Design",McGraw-Hill International Editions,10th edition., 2015* 4. *William Orthwein, "Machine Component Design", Vol. I and II, JaicoPublishing house, New Edition, 2006.* 5. *Khurmi, R.S. and Gupta J.K, "Machine design ", S.Chand publishing , 14th Edition, 2014.* 6. *V.B. Bandari, " Design of Machine Elements", McGraw-Hill International Editions, 4th edition., 2016* 7. *P.S.G Tech..,"Design Data Book", KalaikathirAchchagam, 2012*

Learning Assessment											
	Bloom's Level of Thinking	Continuous Learning Assessment (50% weightage)								Final Examination (50% weightage)	
		CLA – 1 (10%)		CLA – 2 (15%)		CLA – 3 (15%)		CLA – 4 (10%)#			
		Theory	Practice	Theory	Practice	Theory	Practice	Theory	Practice	Theory	Practice
Level 1	Remember Understand	*40 %*	-	*30 %*	-	*30 %*	-	*30 %*	-	*30%*	-
Level 2	Apply Analyze	*40 %*	-	*40 %*	-	*40 %*	-	*40 %*	-	*40%*	-
Level 3	Evaluate Create	*20 %*	-	*30 %*	-	*30 %*	-	*30 %*	-	*30%*	-
	Total	100 %		100 %		100 %		100 %		100 %	

CLA – 4 can be from any combination of these: Assignments, Seminars, Tech Talks, Mini-Projects, Case-Studies, Self-Study, MOOCs, Certifications, Conf. Paper etc.,

Course Designers		
Experts from Industry	Experts from Higher Technical Institutions	Internal Experts
Dr.R.Kalimuthu,ISRO, Mahendragiri, r_kalimuthu@vssc.gov.in	*Dr. T.Jeyapoovan jeyapoovan@hindustanuniv.ac.in, Hindustan University,Chennai.*	*Dr.R.Santhana Krishnan., SRM IST,*
Dr.A.Velayutham, DRDO, Avadi, velayudham.a@cvrde.drdo.in	*Mr. V.Sundara Raghavan,sundararaghavanv@bharatpetroleum.in Bharat Petroleum Corporation Limited, Chennai*	*Dr. P. Nandakumar, SRMIST*

Course Code	18MEC209L	Course Name	CAD/CAM LABORATORY	Course Category	C	Professional core	L	T	P	C
							0	0	2	1

Pre-requisite Courses	Nil	Co-requisite Courses	18MEC207T	Progressive Courses	Nil
Course Offering Department	Mechanical Engineering	Data Book / Codes/Standards	Nil		

Course Learning Rationale (CLR):	*The purpose of learning this course is to:*
CLR-1 :	*Learn to Modeling of 3D Mechanical Components*
CLR-2 :	*Prepare assembly drawings of joints, couplings and machine elements*
CLR-3 :	*Design and prepare modelling for Jigs and fixtures of given components*
CLR-4 :	*Familiarize CNC Part programming techniques for Lathe operations and milling operations*
CLR-5 :	*Machining of components using CNC Lathe and CNC milling machine*

Course Learning Outcomes (CLO):	At the end of this course, learners will be able to:	Learning 1: Level of Thinking (Bloom)	Learning 2: Expected Proficiency (%)	Learning 3: Expected Attainment (%)	PLO 1: Engineering Knowledge	PLO 2: Problem Analysis	PLO 3: Design & Development	PLO 4: Analysis, Design, Research	PLO 5: Modern Tool Usage	PLO 6: Society & Culture	PLO 7: Environment & Sustainability	PLO 8: Ethics	PLO 9: Individual & Team Work	PLO 10: Communication	PLO 11: Project Mgt. & Finance	PLO 12: Life Long Learning	PLO 13: PSO - 1	PLO 14: PSO - 2	PLO 15: PSO – 3
CLO-1 :	*Acquire knowledge on Modeling of 3D Mechanical Components*	3	90	85	H	-	H	M	H	-	-	-	M	H	-	-	L	-	L
CLO-2 :	*Understand the concepts of assembly drawings of joints, couplings and machine elements*	3	85	80	H	-	H	M	H	-	-	-	M	H	-	-	M	-	L
CLO-3 :	*Acquire knowledge to design and prepare drawing for Jigs and fixtures of given components*	3	85	80	H	-	H	M	H	-	-	-	M	H	-	-	M	-	M
CLO-4 :	*Understand and generate the NC part programming for Lathe and milling operations.*	3	90	85	H	-	H	L	H	-	-	-	-	-	-	-	L	-	M
CLO-5 :	*Acquire Practical knowledge on machining of components using CNC Lathe, Milling.*	3	90	85	H	-	H	M	H	-	-	-	-	-	-	-	L	-	M

Duration (hour)	Modeling of mechanical components	Machine Tool components	Jigs& Fixtures	CNC LATHE	CNC MILLING
	6	6	6	6	6
S 1-2	*Modeling of Simple Mechanical Components and temporary fasteners, Modeling of components with sweep ,variable sweep ,loft and blend feature*	*Assembly modeling for Machine Vice*	*Assembly modelling for lathe, milling and broaching fixtures types*	*CNC Part Program for Facing, Step turning, Taper and Finish Turning using ordinary cycle*	*CNC Part Program for Linear and Circular Interpolation using Milling operation*
S 3-4	*Assembly Modeling of joints and Couplings*	*Assembly modelling for Lathe tail stock*	*Assembly modelling for plate, latch, channel, box, post, pot drill jigs and automatic drill jigs*	*CNC Part Program for Grooving,Threading and Axial Drilling Using canned cycle*	*CNC Part Program for Drilling, Mirroring and Threading Operation.*
S 5-6	*Assembly modeling of Screw jack*	*Assembly modeling of connecting rod*	*Assembly modelling for Grinding, planning, shaping and welding fixtures*	*Machining of components on Turning operation using CNC Lathe*	*Machining of components on Milling operation using Vertical machining Center*

Note: Course committee will follow any 11 experiment

Learning Resources	
	1.Narayana.K.L, Kanniah.P and VenkataReddy.K, Machine Drawing, New Age International, New Delhi, 2006.
	2.Gopalakrishnan.K.R, Machine Drawing, Subash Publishers, Bangalore, 2000.
	3. Narang, JS, "CNC Machines and automation", Dhanpat Rai & Co. Ltd, 2016.
	4. James Madison, "CNC Machining Hand Book", Industrial Press Inc., New York, 1996.
	5. P.S.G Tech..,"Design Data Book", KalaikathirAchchagam, 2012

Learning Assessment

	Bloom's Level of Thinking	CLA – 1 (10%) Theory	CLA – 1 (10%) Practice	CLA – 2 (15%) Theory	CLA – 2 (15%) Practice	CLA – 3 (15%) Theory	CLA – 3 (15%) Practice	CLA – 4 (10%)# Theory	CLA – 4 (10%)# Practice	Final Examination (50% weightage) Theory	Final Examination (50% weightage) Practice
Level 1	Remember / Understand	-	40 %	-	30 %	-	30 %	-	30 %	-	30%
Level 2	Apply / Analyze	-	40 %	-	40 %	-	40 %	-	40 %	-	40%
Level 3	Evaluate / Create	-	20 %	-	30 %	-	30 %	-	30 %	-	30%
	Total	100 %		100 %		100 %		100 %		100 %	

(CLA columns: Continuous Learning Assessment (50% weightage))

CLA – 4 can be from any combination of these: Assignments, Seminars, Tech Talks, Mini-Projects, Case-Studies, Self-Study, MOOCs, Certifications, Conf. Paper etc.,

Course Designers

Experts from Industry	Experts from Higher Technical Institutions	Internal Experts
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Course Code	18MEC210L	Course Name	AUTOMATION LABORATORY	Course Category	C	Professional core	L	T	P	C
							0	0	2	1

Pre-requisite Courses	Nil	Co-requisite Courses	Nil	Progressive Courses	Nil
Course Offering Department	Mechanical Engineering	Data Book / Codes/Standards	Nil		

Course Learning Rationale (CLR):	*The purpose of learning this course is to:*
CLR-1 :	*Design pneumatic circuits for low cost automation*
CLR-2 :	*Design hydraulic circuits for industrial automation*
CLR-3 :	*Design of Electro pneumatics, servo and stepper motor control circuits*
CLR-4 :	*Design logic circuits and execute using PLC*
CLR-5 :	*Implement photo electric and ultrasonic, positional and velocity sensors, Virtual instrumentation and pick and placerobot.*
CLR-6 :	*Design circuits and simulate hydraulics/ pneumatics/ stepper, servo motors for industrial applications.*

Course Learning Outcomes (CLO):	*At the end of this course, learners will be able to:*	Learning 1: Level of Thinking (Bloom)	Learning 2: Expected Proficiency (%)	Learning 3: Expected Attainment (%)	PLO 1: Engineering Knowledge	PLO 2: Problem Analysis	PLO 3: Design & Development	PLO 4: Analysis, Design, Research	PLO 5: Modern Tool Usage	PLO 6: Society & Culture	PLO 7: Environment & Sustainability	PLO 8: Ethics	PLO 9: Individual & Team Work	PLO 10: Communication	PLO 11: Project Mgt. & Finance	PLO 12: Life Long Learning	PLO 13: PSO - 1	PLO 14: PSO - 2	PLO 15: PSO - 3
CLO-1 :	*Acquire knowledge on designing pneumatic circuits.*	3	90	85	H		H										H	M	M
CLO-2 :	*Acquire knowledge on designing hydraulic circuits.*	3	85	80	M		M										M	M	L
CLO-3 :	*Acquire knowledge on designing electro pneumatic circuits, control of stepper and servo motors for various applications.*	3	85	80	M		L										L	M	L
CLO-4 :	*Do PLC ladder logic programming and execute.*	3	90	85	H		M		H								H	L	L
CLO-5 :	*Use photo electric, ultrasonic, positional, velocity sensors for various applications and virtual instrumentation and pick and place robot.*	3	90	85	M		L		H								M	M	L
CLO-6 :	*Design low cost automation and provide solution for industrial and societal needs*	3	85	80	H		M		H								M	M	H

Duration (hour)	Devising and simulation of pneumatic circuits	Designing and simulation of hydraulic circuits	Electro pneumatics, servo and stepper motor control circuits	PLC based ladder logic circuits	Virtual instrumentation and pick & place robot
	10	4	6	4	6
S 1-2	*Continuous reciprocation of double acting cylinder with speed control circuit.*	*Synchronization circuit for two cylinders*	*Electro Pneumatic circuits: Continuous reciprocation of cylinder (with timer and Counter) and Sequencing of two cylinders*	*PLC Controlled Pneumatic / Hydraulic linear actuator Circuits*	*Process control: Temperature/ force/ pressure/ control using virtual instrumentation*
S 3-4	*Sequencing of two cylinders Circuit*	*Force, velocity calculations in hydraulic linear actuation*	*Speed control of AC Servo Motor using open and closed loop control.*	*PLC application circuits: Basic Trainer kit/ Water Level Controller/ Material Handling system*	*Characteristics of inductive, capacitive and photoelectric proximity sensors*
S 5-6	*Cascading circuit for trapped signal- 2 Cylinder*		*Positional control of a stepper motor*	*Study of SCADA and PAC systems*	*Pick and place operation using industrial robot in Teach pendent method / Manual mode*
S 7-8	*Cascading circuit for trapped signal – 3 Cylinder*				*Study of Image Processing Technique*
S 9-10	*Implementation of logic circuits: AND, OR*				

Note: Course committee will follow any 11 experiment

Learning Resources	*1. Laboratory Manual* *2. Anthony Esposito, "Fluid Power with applications", Pearson Education Inc, 2015.*	*3. FESTO manual, "Fundamentals of Pneumatics", Vol I, II and III.* *4. Joji Parambath "Industrial Hydraulic Systems: Theory and Practice", Universal Publishers, USA, 2016.*

Learning Assessment											
	Bloom's Level of Thinking	Continuous Learning Assessment (50% weightage)								Final Examination (50% weightage)	
		CLA – 1 (10%)		CLA – 2 (15%)		CLA – 3 (15%)		CLA – 4 (10%)#			
		Theory	Practice	Theory	Practice	Theory	Practice	Theory	Practice	Theory	Practice
Level 1	Remember Understand	-	*40 %*	-	*30 %*	-	*30 %*	-	*30 %*	-	*30%*
Level 2	Apply Analyze	-	*40 %*	-	*40 %*	-	*40 %*	-	*40 %*	-	*40%*
Level 3	Evaluate Create	-	*20 %*	-	*30 %*	-	*30 %*	-	*30 %*	-	*30%*
	Total	100 %		100 %		100 %		100 %		100 %	

CLA – 4 can be from any combination of these: Assignments, Seminars, Tech Talks, Mini-Projects, Case-Studies, Self-Study, MOOCs, Certifications, Conf. Paper etc.,

Course Designers		
Experts from Industry	Experts from Higher Technical Institutions	Internal Experts
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Course Code	18MEC211L	Course Name	METROLOGY AND QUALITY CONTROL LABORATORY	Course Category	C	Professional Core	L	T	P	C
							0	0	2	1

Pre-requisite Courses	Nil	Co-requisite Courses	18MEC206TMetrology and Quality Control	Progressive Courses	Nil
Course Offering Department	Department of Mechanical Engineering	Data Book / Codes/Standards	Nil		

Course Learning Rationale (CLR):	*The purpose of learning this course is to:*
CLR-1 :	*Understandvarious standards of measurement (line, end and wavelength standard)*
CLR-2 :	*Perceivethe measurement of Gear, Thread and Form errors*
CLR-3 :	*Acquaintthe calibration of measuring instruments.*
CLR-4 :	*Acquire and explore the use of computer aided measuring techniques*
CLR-5 :	*Interpret and drafting sampling and control charts*
CLR-6 :	*Recognize the various measuring techniques in dimensional, optical and computer aided inspection and its role in SQC*

		Learning			Program Learning Outcomes (PLO)														
		1	2	3	1	2	3	4	5	6	7	8	9	10	11	12	13	14	15
Course Learning Outcomes (CLO):	*At the end of this course, learners will be able to:*	Level of Thinking (Bloom)	Expected Proficiency (%)	Expected Attainment (%)	Engineering Knowledge	Problem Analysis	Design & Development	Analysis, Design, Research	Modern Tool Usage	Society & Culture	Environment & Sustainability	Ethics	Individual & Team Work	Communication	Project Mgt. & Finance	Life Long Learning	PSO - 1	PSO - 2	PSO - 3
CLO-1 :	*demonstrate and practice different standards of measuring instrument (line, end& wavelength)*	*3*	*95*	*90*	*H*	*H*		*L*	*H*			*L*	*M*	*L*			*H*	*M*	*M*
CLO-2 :	*Apply and accomplish the measurement of Gear, Thread and Form errors*	*3*	*95*	*90*	*H*	*H*		*L*	*L*			*M*	*L*	*M*			*L*	*L*	*M*
CLO-3 :	*Exhibit and Perform the caliberation of measuring instruments.*	*3*	*95*	*90*	*H*	*H*		*M*					*L*			*L*	*M*	*M*	*M*
CLO-4 :	*Exemplify and carry measurements using computer aided measuring techniques.*	*3*	*95*	*90*	*H*	*H*		*M*	*H*	*M*		*H*	*M*	*M*		*H*	*H*	*M*	*M*
CLO-5 :	*Exposition and drafting sampling and control charts*	*3*	*95*	*90*			*H*		*M*	*L*		*M*	*H*			*L*	*M*	*L*	*H*

Duration (hour)	*Basic Measuring instruments (end line and light standard)*	*Gear, Thread and Form errors*	*Calibration of Instruments and comparative method of measurement*	*Measurement using computer aided measuring techniques*	*Optical methods & Drafting sampling and control charts*
	6	6	6	6	6
S 1-2	*Linear measurements using Verniercalliper,micrometer, height gauge and slip gauge.*	*Gear tooth measurement using Gear tooth vernier and Parkinson Gear Tester*	*Calibration of Measuring Instruments (Micrometer, Vernier Caliper, Vernier Height gauge and Dial)*	*Various parameter measurement using Computerized profileprojector*	*Attribute Control Charts using Go, No-Go gauges*
S 3-4	*Angle measurements using Sine bar and Sine center*	*Thread parameter measurement using floating carriage*	*Measurement using different comparators (mechanical, electronic and pneumatic)*	*Fundamental measurements including circularity using CMM*	*Demo on Interferometers and measurements using laser*
S 5-6	*Indirect linear and angular measurements using standard balls and rollers*	*Straightness, flatness measurement using autocollimator*	*Surface roughness measurement*	*Measurement using Machine Vision system*	*Tool Angle measurement in tool makers microscope*

Learning Resources	
	1. Laboratory Observation Manual *2. Machine Manuals supplied by supplier/Company*

Learning Assessment

	Bloom's Level of Thinking	Continuous Learning Assessment (50% weightage)								Final Examination (50% weightage)	
		CLA – 1 (10%)		CLA – 2 (15%)		CLA – 3 (15%)		CLA – 4 (10%)#			
		Theory	Practice	Theory	Practice	Theory	Practice	Theory	Practice	Theory	Practice
Level 1	Remember Understand	-	*40 %*	-	*30 %*	-	*30 %*	-	*30 %*	-	*30%*
Level 2	Apply Analyze	-	*40 %*	-	*40 %*	-	*40 %*	-	*40 %*	-	*40%*
Level 3	Evaluate Create	-	*20 %*	-	*30 %*	-	*30 %*	-	*30 %*	-	*30%*
	Total	100 %		100 %		100 %		100 %		100 %	

Course Designers		
Experts from Industry	Experts from Higher Technical Institutions	Internal Experts
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2. Dr. A. Velayutham, DRDO, Avadi, velayudham.a@cvrde.drdo.in	*2. Mr. Ramesh Ramanathan ,rramanathan@outlook.com*	*2. Mr. S. Muralidharan, SRMIST*

Course Code	18MEC350T	Course Name	COMPREHENSION	Course Category	C	Professional Core	L	T	P	C
							0	1	0	1

Pre-requisite Courses	Nil	Co-requisite Courses	Nil	Progressive Courses	Nil
Course Offering Department	Mechanical Engineering	Data Book / Codes/Standards	Nil		

Course Learning Rationale (CLR):	*The purpose of learning this course is to:*
CLR-1 :	*Understand the concepts in design engineering courses*
CLR-2 :	*Understand the concepts in thermal engineering courses*
CLR-3 :	*Understand the concepts in manufacturing engineering courses*
CLR-4 :	*Understand the concepts in engineering that they have learnt so far in the Mechanical Engineering programme*

		Learning			Program Learning Outcomes (PLO)														
		1	2	3	1	2	3	4	5	6	7	8	9	10	11	12	13	14	15
Course Learning Outcomes (CLO):	*At the end of this course, learners will be able to:*	Level of Thinking (Bloom)	Expected Proficiency (%)	Expected Attainment (%)	Engineering Knowledge	Problem Analysis	Design & Development	Analysis, Design, Research	Modern Tool Usage	Society & Culture	Environment & Sustainability	Ethics	Individual & Team Work	Communication	Project Mgt. & Finance	Life Long Learning	PSO - 1	PSO - 2	PSO - 3
CLO-1 :	*Gain the confidence and competence to solve the design engineering problems*	*1,2&3*	*85*	*80*	*H*	*H*	*H*	*L*	*L*	*L*	*L*	*L*	*L*	*L*	*L*	*L*	*M*	*L*	*M*
CLO-2 :	*Gain the confidence and competence to solve the thermal engineering problems*	*1,2&3*	*85*	*80*	*H*	*H*	*M*	*L*	*L*	*L*	*L*	*L*	*L*	*L*	*L*	*L*	*M*	*M*	*M*
CLO-3 :	*Gain the confidence and competence to solve the manufacturing engineering problems*	*1,2&3*	*85*	*80*	*H*	*H*	*M*	*L*	*L*	*L*	*L*	*L*	*L*	*L*	*L*	*L*	*M*	*L*	*M*
CLO-4 :	*Gain the confidence and competence to solve real life engineering problems*	*1,2&3*	*85*	*80*	*H*	*H*	*M*	*L*	*L*	*L*	*L*	*L*	*L*	*L*	*L*	*L*	*M*	*M*	*M*

Duration (hour)		5	5	5
S-1	SLO-1	*Tutorial on Engineering graphics and design*	*Tutorial on Thermodynamics*	*Tutorial on Material technology*
	SLO-2			
S-2	SLO-1	*Tutorial on Engineering Mechanics*	*Tutorial on Fluid mechanics*	*Tutorial on Manufacturing technology*
	SLO-2			
S-3	SLO-1	*Tutorial on Mechanics of solids*	*Tutorial on Applied thermal engineering*	*Tutorial on Metrology and quality control*
	SLO-2			
S-4	SLO-1	*Tutorial on Machines and mechanisms*	*Tutorial on Heat and mass transfer*	*Tutorial on CAD/CAM*
	SLO-2			
S-5	SLO-1	*CLA-1*	*CLA-2*	*CLA-3*
	SLO-2			

Learning Resources	*1. R.S.Khurmi, J.K.Gupta, Mechanical Engineering: Conventional and Objective Types, S.Chand & Co., 2018*	*2. R.K.Jain, Conventional & Objective Type Question & Answers on Mechanical Engineering for Competitions, Khanna Publishers, 2014*

Learning Assessment

	Bloom's Level of Thinking	Continuous Learning Assessment (100% weightage)								Final Examination	
		CLA – 1 (20%)		CLA – 2 (30%)		CLA – 3 (30%)		CLA – 4 (20%)#			
		Theory	Practice	Theory	Practice	Theory	Practice	Theory	Practice	Theory	Practice
Level 1	Remember Understand	-	40%	-	30%	-	30%	-	30%	-	-
Level 2	Apply Analyze	-	40%	-	40%	-	40%	-	40%	-	-
Level 3	Evaluate Create	-	20%	-	30%	-	30%	-	30%	-	-
	Total	100 %		100 %		100 %		100 %		-	

CLA – 4 can be from any combination of these: Assignments, Seminars, Tech Talks, Mini-Projects, Case-Studies, Self-Study, MOOCs, Certifications, Conf. Paper etc.,

Course Designers		
Experts from Industry	Experts from Higher Technical Institutions	Internal Experts
		Dr.M.Kamaraj, SRMIST

ACADEMIC CURRICULA

Professional Core Courses

MECHATRONICS ENGINEERING

Regulations - 2018

SRM
INSTITUTE OF SCIENCE & TECHNOLOGY
(Deemed to be University u/s 3 of UGC Act, 1956)

SRM INSTITUTE OF SCIENCE AND TECHNOLOGY

(Deemed to be University u/s 3 of UGC Act, 1956)

Kattankulathur, Kancheepuram, Tamil Nadu, India

Course Code	18MHC201J	Course Name	LINEAR AND DIGITAL CONTROL SYSTEMS	Course Category	C	Professional Core	L	T	P	C
							3	0	2	4

Pre-requisite Courses	System Dynamics	Co-requisite Courses	Nil	Progressive Courses	Nil
Course Offering Department	Mechatronics Engineering	Data Book / Codes/Standards	Nil		

Course Learning Rationale (CLR):	*The purpose of learning this course is to:*
CLR-1 :	*Learn the significant specifications of control systems*
CLR-2 :	*Understand the design techniques of linear compensators and controllers*
CLR-3 :	*Design state space based controllers and observers*
CLR-4 :	*Practically implement state space and discrete-time controllers*
CLR-5 :	*Simulate of control systems*

Course Learning Outcomes (CLO):	*At the end of this course, learners will be able to:*	Learning 1: Level of Thinking (Bloom)	Learning 2: Expected Proficiency (%)	Learning 3: Expected Attainment (%)	PLO 1: Engineering Knowledge	PLO 2: Problem Analysis	PLO 3: Design & Development	PLO 4: Analysis, Design, Research	PLO 5: Modern Tool Usage	PLO 6: Society & Culture	PLO 7: Environment & Sustainability	PLO 8: Ethics	PLO 9: Individual & Team Work	PLO 10: Communication	PLO 11: Project Mgt. & Finance	PLO 12: Life Long Learning	PLO 13: PSO - 1	PLO 14: PSO - 2	PLO 15: PSO - 3
CLO-1 :	*Mathematically model and design classical compensators and controllers*	2	80	75	H	H	H	H	H	-	-	-	-	-	L	H	H	M	-
CLO-2 :	*Demonstrate modeling and analysis of dynamic systems in state-space*	3	80	75	H	H	H	H	H	-	-	-	M	-	-	H	H	M	-
CLO-3 :	*Design full state feedback controllers and full order observers*	3	75	70	H	H	H	H	H	-	-	-	M	-	M	H	H	M	-
CLO-4 :	*Model, analyze and design control systems in z-domain*	3	75	70	H	H	H	H	H	-	-	-	M	-	M	H	H	M	-
CLO-5 :	*Design and simulate control systems using software tools*	3	75	70	H	H	H	H	H	-	-	-	M	-	M	H	H	M	-

		Classical Compensators Design	PID Controller Design	State Space Modelling and Analysis	Design of State Controllers and Observers	Discrete-time Control System
Duration (hour)		15	15	15	15	15
S-1	SLO-1	*Basic elements of automatic control systems, Classification of controlsystems*	*Introduction to active controllers*	*Concepts of state, state variables and state model*	*Concepts of controllability and observability.*	*Introduction to sampled data systems*
	SLO-2	*Review of time and frequency domain specifications of control system in a design perspective*	*Introduction to On-Off, Proportional, PI, PD and PID controllers*	*Generic state space representations for systems of different types- Linear, Nonlinear, time variant and time invariant*	*Problems and illustrations*	*Sample and holdprocess: Zero order and first order hold.*
S-2	SLO-1	*Effect of adding a pole and zero to dynamic systems*	*Transfer function , time and frequency response of PI controller*	*Derivation of linear state space model for mechanical systems*	*Full state feedback controller design- The pole placement techniques*	*Z-transform analysis of sampled data control systems*
	SLO-2	*Introduction to Compensators and types*	*Transfer function , time and frequency response of PD controller*	*Example problems*	*Examples*	*Problems*
S-3	SLO-1	*Pole zero contributions by lead, lag and lead-lag cascade compensators and their effects on compensated systems*	*Transfer function , time and frequency response of PID controller*	*Derivation of linear state space model for electrical systems*	*Full state feedback controller design using transformation method*	*Transfer function of discrete-time systems*
	SLO-2	*Electrical cascade compensating networks- Transfer function, time and frequency response*	*Effect of each term of PID controller on the response of system*	*Example problems*	*Examples*	*Performance of a sampled-datasecond order system.*
S 4-5	SLO-1 SLO-2	*Lab-1:Generate standard test signals: Impulse, step, ramp,parabolic, exponential and sinusoidal functions.*	*Lab-4:Root locus method: Determination of constant gain K,stability analysis*	*Lab-7:Design of controllers (PI, PD, PID) in time domain and frequency domain*	*Lab-10:Modeling in state-space: Determine state transition matrix, controllability and observability of linear systems*	*Lab-13:Discrete-time control systems: Convert a given transfer functions from analog to digital form, determine performance and stability in Z–domain.*
S-6	SLO-1	*Lead compensator design procedure using root locus- qualitative treatment preferably using software tools*	*Model based design of PI controller*	*Derivation of linear state space model for electrical systems*	*Full state feedback controller design using direct substitution method*	*Stability Analysis of discrete-time systems-Jury's stability criteria*
	SLO-2	*Example problems*	*Example- model based design of PI controller for DC motor speed control*	*Example problems*	*Examples*	*Example problems*
S-7	SLO-1	*Lag compensator design procedure using root locus- qualitative treatment preferably using software tools*	*Model based design of PD controller*	*Computation of state transition matrix, properties of statetransition matrix.*	*Full state feedback controller design using Ackerman's formula*	*Digital controller design-Direct digital design technique and conversion by transformation-introduction*

	SLO-2	*Example problems*	*Example- model based design of PD controller for DC motor position control*	*Importance of state trajectory in chaotic systems*	*Examples*	*Mapping between s-plane and z-plane- different transformation techniques to convert analog controller to digital.*
S-8	SLO-1	*Lead compensator design procedure using Bode plot- qualitative treatment preferably using software tools*	*Model based design of PID controller*	*Solution to state equations*	*Full order and reduced order observers*	*Mapping between s-plane and z-plane- different transformation techniques to convert analog controller to digital.*
	SLO-2	*Example problems*	*Example- model based design of PID controller for DC motor speed as well as position control.*	*Example problems*	*Full order observer design using different methods-Design examples*	*Examples*
S 9-10	SLO-1	*Lab-2: Derive transfer functions of electrical, mechanical and electromechanical systems*	*Lab-5:Frequency response analysis: Determine frequencydomain specifications using Bode plot*	*Lab-8:System Identification with Qube servo*	*Lab-11:Design of full state feedback controllers and full order observers.*	*Lab-14:Implement digital compensators through though transformation technique*
	SLO-2					
S-11	SLO-1	*Lag compensator design procedure using Bode plot- qualitative treatment preferably using software tools)*	*Limitations of Basic PID controller- Sensitive to Noise, Integrator wind-up problem.*	*Conversions of transfer function to state space model and vice versa.*	*Integrated full-state feedback and observer*	*Direct digital compensator design by Root locus technique*
	SLO-2	*Example problems*	*A more practical version of PID controller- it's implementation*	*Example problems*	*Examples*	*Direct digital compensator design by Root locus technique*
S-12	SLO-1	*Introduction to lead-lag compensator*	*Empirical procedure for tuning of PID gains*	*Different Canonical forms of representation of state space models*	*Case study: demonstration of integrated full state feedback & observer in simulation*	*Example problems*
	SLO-2	*Comparison- Lead vs Lag compensators, s-domain vs frequency domain design*	*Zeigler-Nichols method based on open loop and closed loop responses. Cohen-coon method*	*Example Problems*	*A case study- demonstration of integrated full state feedback & observer in simulation*	*Example problems*
S-13	SLO-1	*Limitations of passive compensators*	*Comparison between compensators and active controllers*	*Advantages and disadvantages of state space model representation*	*Introduction to optimal control systems*	*Selection of sampling rate, parameters to meet the desired performance of discrete-time control systems*
	SLO-2	*Need for active controllers*	*Limitations of PID controllers- Need for model based controllers.*	*State space model for discrete-time systems*	*Introduction to optimal control systems*	*Example problems*
S 14-15	SLO-1	*Lab-3:Determine time domain specifications for a givensystem: Transient and steady state.*	*Lab-6:Design compensators (lead, lag etc.,) in time domain and frequency domain.*	*Lab-9:Speed and position control of Qube servo*	*Lab-12: Implement Kalman filter*	*Lab-15: Implement digital compensators by direct digital method*
	SLO-2					

Learning Resources	1. *Richard C Dorf and Robert H Bishop, "Modern Control Systems", 13th edition, Pearson Education, 2016.* 2. *Norman S Nise, "Control Systems Engineering", 7th edition, Wiley, 2015.* 3. *I J Nagrath, M Gopal, "Control Systems Engineering", 5th edition, New Age International, 2007.* 4. *Benjamin C Kuo, FaridGolnaraghi, "Automatic Control Systems", 9th edition, Wiley, 2009.*	5. *K Ogata, "Modern Control Engineering", Prentice Hall, 2010.* 6. *A NagoorKani, "Control systems", RBA, 1998.* 7. *Quanser QNET Practical Control Guide.* 8. *Linear and Digital Control Systems Laboratory Manual, SRMIST.*

Learning Assessment

	Bloom's Level of Thinking	Continuous Learning Assessment (50% weightage)								Final Examination (50% weightage)	
		CLA – 1 (10%)		CLA – 2 (15%)		CLA – 3 (15%)		CLA – 4 (10%)#			
		Theory	Practice	Theory	Practice	Theory	Practice	Theory	Practice	Theory	Practice
Level 1	Remember Understand	20%	20%	15%	15%	15%	15%	15%	15%	15%	15%
Level 2	Apply Analyze	20%	20%	20%	20%	20%	20%	20%	20%	20%	20%
Level 3	Evaluate Create	10%	10%	15%	15%	15%	15%	15%	15%	15%	15%
	Total	100 %		100 %		100 %		100 %		-	

CLA – 4 can be from any combination of these: Assignments, Seminars, Tech Talks, Mini-Projects, Case-Studies, Self-Study, MOOCs, Certifications, Conf. Paper etc.,

Course Designers

Experts from Industry	Experts from Higher Technical Institutions	Internal Experts
1.Mr.Ganesh Ram, Intel Labs ,Bangalore, ganeshram.nandakumar.@intel.com	*1. Dr.R. Thiyagarajan, Visiting faculty, IIT Madras, thiyaguiitm@gmail.com*	*1. Mr.K.Sivanathan, SRMIST*
2. Mr. Mohammed Sagheer ,Wabco Technology Center ,India, mohammedsagheer.musthafa@wabco-auto.com	*2. Dr.PKarthikeyan, MIT,Anna University, pkarthikeyan@annauniv.edu*	*2. Ms.T.Rajalakshmi, SRMIST*

Course Code	18MHC202J	Course Name	SENSORS AND SIGNAL CONDITIONING	Course Category	C	Professional Core	L	T	P	C
							3	0	2	4

Pre-requisite Courses	18MHC103T	Co-requisite Courses	Nil	Progressive Courses	18MHC302J,18MHE402T,18MHE428T
Course Offering Department	Mechatronics Engineering	Data Book / Codes/Standards	Nil		

Course Learning Rationale (CLR):	*The purpose of learning this course is to:*
CLR-1 :	*Expose the applications of OPAMP in signal conditioning circuits*
CLR-2 :	*Perceive the fundamental knowledge of sensors and their characteristics and know the working principle of sensors for measurement of Force, Displacement*
CLR-3 :	*Know the working principle of sensors for measurement of Position, Distance and Acceleration*
CLR-4 :	*Know the working principle of sensors for measurement of Pressure, Flow and Temperature*
CLR-5 :	*Comprehend about data acquisition systems and applications of sensors*
CLR-6 :	Gain knowledge about different sensors for physical system measurement

Course Learning Outcomes (CLO):	*At the end of this course, learners will be able to:*	Learning 1: Level of Thinking (Bloom)	2: Expected Proficiency (%)	3: Expected Attainment (%)	PLO 1: Engineering Knowledge	2: Problem Analysis	3: Design & Development	4: Analysis, Design, Research	5: Modern Tool Usage	6: Society & Culture	7: Environment & Sustainability	8: Ethics	9: Individual & Team Work	10: Communication	11: Project Mgt. & Finance	12: Life Long Learning	13: PSO - 1	14: PSO - 2	15: PSO - 3
CLO-1 :	*Understand the functioning of OPAMP based signal conditioning circuits*	2	90	85	H	M	L	L	M	-	-	-	-	-	-	L	M	-	M
CLO-2 :	*Identify the different types of sensors, their selection criteria and selection of sensors for measurement of Force and Displacement*	3	90	80	H	M	-	L	M	L	-	-	-	-	L	H	M	M	L
CLO-3 :	*Identify and select sensors for measurement of Position, Distance and Acceleration*	3	85	80	H	L	-	L	M	L	-	-	-	-	L	M	M	H	M
CLO-4 :	*Identify and select sensors for measurement of Pressure, Flow and Temperature*	3	80	80	H	L	-	L	M	L	-	-	-	-	L	M	M	H	M
CLO-5 :	*Understand the working of data acquisition system and applications of sensors in various fields*	3	85	80	H	L	L	L	H	L	-	-	-	-	L	M	H	H	H
CLO-6 :	*Prescribe the type of sensor to measure a specific phenomenon and appropriate signal conditioning circuit*	2	85	80	H	L	L	L	M	L	-	-	-	-	L	M	M	H	M

		Signal Conditioning System	Fundamentals of Sensors, Measurement of Force and Displacement	Measurement of Position, Distance and Acceleration	Measurement of Pressure, Flow and Temperature	Data Acquisition System and Case Studies
Duration (hour)		15	15	15	15	15
S-1	SLO-1	*Review of OPAMP*	*Introduction to Sensors and Transducers*	*Working Principle of Eddy Current Sensor*	*Piezoelectric effect*	*Elements of Data Acquisition System*
	SLO-2	*Discussion*	*Classification of Sensors According to Various Physical Quantities*	*Applications of Eddy Current Sensor*	*Working Principle and Applications of Piezoelectric Sensor*	*Elements of Data Acquisition System*
S-2	SLO-1	*Characteristics of Instrumentation Amplifier*	*Working Principle of Strain Gauge*	*Working Principle of Hall Effect Sensor*	*Construction and Working of Bourdon Tubes*	*Multichannel Data Acquisition System*
	SLO-2	*Working of Instrumentation Amplifier*	*Applications of Strain Gauge and Simple Problems*	*Applications of Hall Effect Sensor*	*Types and Applications of Bourdon Tubes*	*Multichannel Data Acquisition System*
S-3	SLO-1	*Design and Analysis of RC Active Low Pass Filter*	*Working Principle and Applications of Load Cell*	*Working Principle and Types of Infra-Red Sensors*	*Working Principle and Applications of Diaphragms*	*Multiplexing*
	SLO-2	*Design and Analysis of Integrator*	*Quarter Bridge, Half Bridge and Full Bridge Configuration of Load Cells*	*Applications of IR Sensors*	*Working Principle and Applications of Bellows*	*DE multiplexing*
S 4-5	SLO-1 SLO-2	*Introduction to the Lab Course Lab 1: Study of Characteristics of Instrumentation Amplifier*	*Lab 4: Study of Characteristics of Load Cell*	*Lab 7: Distance Measurement using IR Sensor*	*Lab 10: Study of Characteristics of Pressure Sensor*	*Lab 13: Introduction to PC Based Data Acquisition System*
S-6	SLO-1	*Design and Analysis of RC Active High Pass Filter*	*Working Principle and Applications of Potentiometer*	*Doppler Effect*	*Working Principle of Flow Sensors*	*Applications of Sensors in Bio Medical Systems*
	SLO-2	*Design and Analysis of Differentiator*	*Working Principle, Types and Applications of Capacitive Sensors*	*Working Principle and Applications of Ultrasonic Sensor*	*Hot Wire Anemometer*	*Discussion*
S-7	SLO-1	*Sampling theorem, Effect of Sampling*	*Working Principle of Magnetic Proximity Switch*	*Working Principle of SONAR*	*Working Principle of Acoustic sensors*	*Applications of Sensors in Aerospace Systems*
	SLO-2	*Quantization, Quantization Error, Digitizing*	*Applications of Magnetic Proximity Switches*	*Working Principle of RADAR*	*Applications of Acoustic sensors*	*Discussion*

S-8	SLO-1	*Aliasing, Sample and Hold Circuit*	*Working Principle of Inductive Proximity Switch*	*Working Principle and Types of Accelerometer*	*Working Principle of Thermocouple*	*Applications of Sensors in Automobile Systems*
	SLO-2	*Simple Problems*	*Applications of Inductive Proximity Switches*	*Applications of Accelerometer*	*Types and Applications of Thermocouple*	*Discussion*
S 9-10	SLO-1 SLO-2	*Lab 2: Study of Characteristics of Active Filters*	*Lab 5: Study of Characteristics of Potentiometer*	*Lab 8: Distance Measurement using Ultrasonic Sensor*	*Lab: 11 Study of Characteristics of Thermocouple and MEMS IC Sensor*	*Lab 14: Repeat Lab Session*
S-11	SLO-1	*ADC: Flash Type*	*Working Principle and Applications of LVDT*	*Inertial Measurement Sensor*	*Working Principle of Thermistor*	*Applications of Sensors in Automobile Systems*
	SLO-2	*ADC: Successive Approximation Type*	*Working Principle and Applications of RVDT*	*Inertial Measurement Sensor*	*Applications of Thermistor*	*Discussion*
S-12	SLO-1	*DAC: Weighted Resistor, R-2R Network*	*Static Characteristics*	*Introduction to Optical Sensors - Photo Diode, Photo Transistor, Opto-Coupler*	*Working Principle of RTD*	*Sensors in Manufacturing*
	SLO-2	*Specifications of ADC and DAC*	*Simple Problems*	*Working Principle of LIDAR*	*Applications of RTD*	*Discussion*
S-13	SLO-1	*Precision Diodes, Half Wave Precision Rectifiers*	*Dynamic Characteristics*	*Working Principle of Optical Encoders*	*Concept of Thermal Mapping*	*Summary of the Course*
	SLO-2	*Full Wave Precision Rectifiers*	*Sensor Calibration*	*Types and Applications of Optical Encoders*	*Applications of Thermal Mapping*	*Discussion*
S 14-15	SLO-1 SLO-2	*Lab 3: Study of Characteristics of Precision Circuits*	*Lab 6: Study of Characteristics of LVDT*	*Lab 9: Position Measurement using Optical Encoders*	*Lab: 12 Study of Characteristics of Thermistor and RTD*	*Lab 15: Model Practical Examination*

Learning Resources	1. *Roy Choudhury.D, Shail. B.Jain, "Linear Integrated Circuits", 4th edition, New Age International Publishers, 2010.* 2. *Pratranabis.D, "Principles of Industrial Instrumentation", 2nd edition, Tata McGraw Hill, 1996.* 3. *Sawhney.A.K., "Course in Mechanical Measurements and Instrumentation", DhanpatRai and Sons, 12thedition, 2001.*	4. *Pratranabis.D, "Principles of Industrial Instrumentation", 2nd edition, Tata McGraw Hill, 1996.* 5. *Paul P.L Regtien, "Sensors for Mechatronics", Elsevier publications, 1st edition, 2012.* 6. *Laboratory Manual for Sensors and Signal Conditioning, SRMIST.*

Learning Assessment

	Bloom's Level of Thinking	Continuous Learning Assessment (50% weightage)								Final Examination (50% weightage)	
		CLA – 1 (10%)		CLA – 2 (15%)		CLA – 3 (15%)		CLA – 4 (10%)			
		Theory	Practice	Theory	Practice	Theory	Practice	Theory	Practice	Theory	Practice
Level 1	Remember Understand	*20%*	*20%*	*15%*	*15%*	*15%*	*15%*	*15%*	*15%*	*15%*	*15%*
Level 2	Apply Analyze	*20%*	*20%*	*20%*	*20%*	*20%*	*20%*	*20%*	*20%*	*20%*	*20%*
Level 3	Evaluate Create	*10%*	*10%*	*15%*	*15%*	*15%*	*15%*	*15%*	*15%*	*15%*	*15%*
	Total	100 %		100 %		100 %		100 %		100%	

CLA – 4 can be from any combination of these: Assignments, Seminars, Tech Talks, Mini-Projects, Case-Studies, Self-Study, MOOCs, Certifications, Conf. Paper etc.,

Course Designers

Experts from Industry	Experts from Higher Technical Institutions	Internal Experts
1. Mr.A.Jegan, Assistant Manager, Renault – Nissan Technology and Business Centre India Private Ltd, jegan.a@rntbci.com	*1. Dr.K. Kalaichelvan, Professor, Department of Ceramic Technology, Anna University, Chennai, kalaichelvan@annauniv.edu*	*1. Ms. G. Madhumitha SRMIST*
2. Mr.R.GovardhanaGiri, Head – Atalon International, giri@atalon.in	*2. Dr. P. Karthikeyan, Assistant Professor, Department of Production Technology, Anna University-MIT Campus, Chennai, pkarthikeyan@mitindia.edu*	*2. Mr. J. Thiyagarajan SRMIST*

Course Code	18MHC203J	Course Name	MACHINE DESIGN	Course Category	C	Professional Core		L	T	P	C
								3	0	2	4

Pre-requisite Courses	18MHC101J	Co-requisite Courses	Nil	Progressive Courses	Nil
Course Offering Department	Mechatronics Engineering	Data Book / Codes/Standards	Approved design data book		

Course Learning Rationale (CLR):	The purpose of learning this course is to:
CLR-1 :	*Analyze stress, strain in mechanical components, quantify failure modes in mechanical parts for various load conditions.*
CLR-2 :	*formulate, design and identify torque elements.*
CLR-3 :	*estimate the life of sliding and rolling contact bearings.*
CLR-4 :	*analyze the gear failure modes, evaluate forces and stresses within a gear system.*
CLR-5 :	*select flexible drive systems and design for light, medium and heavy duty applications.*
CLR-6 :	*design, analyze, and select the suitable components for any particular engineering applications.*

Course Learning Outcomes (CLO):	At the end of this course, learners will be able to:	Learning 1: Level of Thinking (Bloom)	2: Expected Proficiency (%)	3: Expected Attainment (%)	PLO 1: Engineering Knowledge	2: Problem Analysis	3: Design & Development	4: Analysis, Design, Research	5: Modern Tool Usage	6: Society & Culture	7: Environment & Sustainability	8: Ethics	9: Individual & Team Work	10: Communication	11: Project Mgt. & Finance	12: Life Long Learning	13: PSO - 1	14: PSO - 2	15: PSO - 3
CLO-1 :	*design basic mechanical components by considering the stress induced due to different kinds of load.*	3	85	80	H	H	M	M	M	L	M	M	H	M	L	H	M	M	M
CLO-2 :	*select suitable shaft and coupling for the particular engineering applications.*	3	85	80	H	H	H	M	M	L	M	M	H	M	L	H	M	M	M
CLO-3 :	*analyze and select bearing and lubricants for various engineering applications.*	3	85	80	H	H	M	M	M	L	M	M	H	M	L	H	M	M	M
CLO-4 :	*design and analyze various simple gear trains for various power transmission applications.*	3	85	80	H	H	M	M	M	L	M	M	H	M	L	H	M	M	M
CLO-5 :	*design and select suitable flexible drive system for power transmission applications.*	3	85	80	H	H	M	M	M	L	M	M	H	M	L	H	M	M	M
CLO-6 :	*design and analyze the fundamental elements of machine component.*	3	85	80	H	H	H	H	H	L	M	M	H	M	L	H	M	M	M

		Stresses In Machine Parts	Design of Shafts, Springs And Couplings	Design Of Bearings	Design of Gears	Design of Flexible Drives
Duration (hour)		15	15	15	15	15
S-1	SLO-1	*Introduction to the design process, Materials Selection and its Properties, Preferred Numbers, Fits and Tolerances*	*Introduction to Shafts and Types of Transmission Shafts, Shaft materials*	*Introduction to Bearings, Types of Rolling Contact Bearings*	*Introduction to Mechanical Drives, Types of Gears, Gear materials, Gear Nomenclature*	*Types of Flexible Drives, Belt Materials and Constructions*
	SLO-2	*Equilibrium and Free Body Diagram*	*Shaft Layouts and Shaft design for stress*	*Selection of Bearing Type, Static and Dynamic Load Carrying capacity, Equivalent Bearing Load*	*Contact Ratio, Interference, Undercutting and Backlash*	*Mechanics of Belt Drives, Selection of Belt Drives, Belt Tension*
S-2	SLO-1	*Direct, Bending and torsional stresses*	*Practice 11: Problems on Design of Shaft on Strength basis*	*Load –Life Relationship, Selection of Ball Bearing Life*	*Force Analysis-Spur Gear*	*Flat Belt Drive*
	SLO-2	*Practice1: Problems on Bending and Torsional stresses*		*Practice 15: Problems on Single Row Deep Groove Ball Bearing*	*Design of spur gear based on Lewis and Buckingham equations*	*Practice 28: Problems on Design of Flat Belt Drive*
S-3	SLO-1	*Stresses for Various Load Combinations*	*Practice 12 Problems on Design of Shaft on Torsional Rigidity basis*	*Selection of Taper Roller Bearings*	*Practice 22: Problems on Spur Gear Design Based on Lewis and Buckingham Equations*	*V- Belt Drive*
	SLO-2	*Practice 2:Problems on Various Machine Members Subjected to Various Load Combinations*		*Practice 16: Problems on Taper Roller Bearings*		*Practice 29: Problems on Design of V- Belt Drive*
S-4	SLO-1	*Eccentric Loading*	*Design of Hallow Shaft*	*Design for Cyclic Loads and Speeds*	*Practice 23: Problems on Spur Gear Design Based on Lewis and Buckingham Equations*	*Practice 30: Problems on Design of V- Belt Drive*
	SLO-2	*Practice 3:Problems on Various Machine Members Subjected to Eccentric Loading*	*Practice 13: Problems on Design of Hallow Shaft on Strength and Torsional Rigidity basis*	*Practice 17: Design of Ball Bearings subjected to Cyclic Loads and Speeds*		
S-5	SLO-1	*Lab 1: Part Modelling of a Mechanical Component using CAD tool*	*Lab 4: Part Modelling of a Universal Coupling and its Assembly using CAD tool*	*Lab 7: Part Modelling of a Screw Jackand its Assembly using CAD tool*	*Lab 10: Stress Analysis of an Axis-Symmetric Component using ANSYS*	*Lab 13: Convective Heat Transfer Analysis of a 2D Component using ANSYS*
	SLO-2					
S-6	SLO-1	*Factor of safety for Brittle and Ductile Materials*	*Spring Materials,Stresses in Helical Springs*	*Types of Lubrication, Viscosity Index, Petroff's Equation*	*Helical Gear Nomenclature*	*Chain Drive: Types, Failures, Designation*
	SLO-2	*Significance of Factor of Safety in Machine Design*	*Curvature Effect, Deflection, Compression Springs, Stability*	*Stable and Thick-Film Lubrication*	*Force Analysis- Helical Gear*	*Selection of Chain Drive, Chain Lubrication*
S-7	SLO-1	*Theories of failure*	*Helical Compression Spring Design Against Static Load*	*Design Considerations*	*Design of helical gear based on modified Lewis equations*	*Design of Chain Drive*

	SLO-2	Practice 4: Problems on Theory of failure	Practice 14: Problems on Design of Helical Spring Subjected to Static Load	Hydrostatic Step Bearing and its Energy Losses		Practice 31: Problems on Design of Chain Drive to run a Compressor
S-8	SLO-1	Introduction to Fracture Mechanics, and Fatigue in Metals	Helical Compression Spring Design- Trial and Error method	Practice 18: Problems on Hydrostatic Thrust Bearings	Practice 24: Problems onHelical Gear Design Based on Lewis Equations	Practice 32: Problems on Design of Chain Drive Power Transmission Shaft Applications
	SLO-2	S-N Curve, Fatigue Strength and the Endurance Limit	Practice 14: Problems on Design of Helical Spring based on Trial and Error Method			
S-9	SLO-1	Endurance Limit Modifying Factors, Stress Concentration and Notch Sensitivity	Helical Compression Spring Design Against Fatigue Load	Practice 19: Problems on Hydrostatic Step Bearings	Practice 25: Problems onHelical Gear Design Based on Modified Lewis Equations	Practice 33: Problems on Design of Chain Drive for Drilling Machine Applications
	SLO-2	Practice 6: Problems on Stress Concentration Factors	Practice 14: Problems on Design of Helical Spring Subjected to Fatigue Load			
S-10	SLO-1	Lab 2: Part Modelling of a Mechanical Component using CAD tool	Lab 5: Part Modelling of a Plummer Blockand its Assembly using CAD tool	Lab 8: Stress Analysis of Truss using ANSYS	Lab 11: Stress Analysis of Beams (Cantilever, Simply supported, Fixed ends) using ANSYS	Lab 14: Modal analysis of Spring-Mass system using ANSYS
	SLO-2					
S-11	SLO-1	Practice 7: Infinite Life for Machine Member Subjected to Reversed Load	Design of Keys	Hydrodynamic Theory	Bevel Gear and Its Types	Wire Rope - Types, Construction, Lays of Wire Rope
	SLO-2	Practice 8: finite Life for Machine Member Subjected to Reversed Load	Practice 15: Problems on Design of Keys	Sommerfeld Number, Raimondi and Boyd method	Bevel Gear Nomenclature	Failures in Wire Rope
S-12	SLO-1	Soderberg and Goodman lines, Modified Goodman Diagram,	Design of rigidFlange Coupling	Temperature Rise, Bearing Construction, Bearing Materials	Force Analysis- Bevel Gear	Selection of Wire Rope, Stresses in Wire Rope
	SLO-2	Design for Variable Loading	Practice 16: Problems on Flange Coupling	Selection of Lubricants , Bearing failures	Design of bevel gear based on Lewis and Buckingham equations.	Design of a Wire RopeDrive for Crane Applications
S-13	SLO-1	Practice 9: Problems on Infinite Life for Machine Member Subjected to Fluctuating Load	Design of Flexible Flange Coupling	Practice 20: Problems on Hydrodynamic Bearings	Practice 26: Problems on Bevel Gear Design Based on Lewis and Buckingham Equations	Practice 34: Problems on Expected life of Wire Rope under Dynamic Conditions
	SLO-2		Practice 16: Problems on Flexible Bushed Pin Flange Coupling			
S-14	SLO-1	Practice 10: Problems on Finite Life for Machine Member Subjected to Fluctuating Load	Practice 17: Problems on Flexible Bushed Pin Flange Couplings	Practice 21: Problems on Hydrodynamic Bearings	Practice 27: Problems on Bevel Gear Design Based on Lewis and Buckingham Equations	Practice 35: Problems on Factor of Safety of Wire Rope under Static Conditions
	SLO-2					
S-15	SLO-1	Lab 3: Part Modelling of a Flange Coupling and its Assembly using CAD tool	Lab 6: Part Modelling of a Knuckle Joint and its Assembly using CAD tool	Lab 9: Stress Analysis of a Plate with a Circular hole using ANSYS	Lab 12: Conductive Heat Transfer Analysis of 2D Component using ANSYS	Lab 15: Model Practical Exam
	SLO-2					

Learning Resources	1. Bhandari.V.B, "Design of Machine Elements", 3rd ed.,, Tata McGraw-Hill , 2010. 2. Robert L. Norton, "Machine Design: An Integrated Approach", 5th ed., Prentice Hall, 2013. 3. PSG, "Design Data" [Data Book Of Engineers], KalaikathirAchagam, 2016. 4. CAD Laboratory Manual.	5. Merhyle Franklin Spotts, Terry E. Shoup and Hornberger.L.E, "Design of Machine Elements", 8th ed.,, Prentice Hall,2003 6. Joseph Shigley and Charles Mischke, "Standard Handbook of Machine Design", 3rd ed., Tata McGraw Hill, 2004. 7. Richard G.Budynas, J.KeithNisbett, "Shigley's Mechanical Engineering Design", 10th ed., Tata McGraw-Hill , 2015.

Learning Assessment

	Bloom's Level of Thinking	Continuous Learning Assessment (50% weightage)								Final Examination (50% weightage)	
		CLA – 1 (10%)		CLA – 2 (15%)		CLA – 3 (15%)		CLA – 4 (10%)			
		Theory	Practice	Theory	Practice	Theory	Practice	Theory	Practice	Theory	Practice
Level 1	Remember Understand	20%	20%	15%	15%	15%	15%	15%	15%	15%	15%
Level 2	Apply Analyze	20%	20%	20%	20%	20%	20%	20%	20%	20%	20%
Level 3	Evaluate Create	10%	10%	15%	15%	15%	15%	15%	15%	15%	15%
	Total	100 %		100 %		100 %		100 %		100%	

CLA – 4 can be from any combination of these: Assignments, Seminars, Tech Talks, Mini-Projects, Case-Studies, Self-Study, MOOCs, Certifications, Conf. Paper etc.,

Course Designers

Experts from Industry	Experts from Higher Technical Institutions	Internal Experts
1. Mr.Kesavan Raja Ramasamy, Schlumberger, RKRaja@slb.com	1. Dr.L.Ranganathan, Jeppiaar Engineering College, Chennai, ranganathanl1975@gmail.com	1. Mr.M.Chandrasekaran, SRMIST
2. Mr. S.Jagadeeswaran, Renault Nissan Technology and Business Centre, jagadeeswaran.selvamani@rntbci.com	2. Dr.K.Ramanathan, AlagappaChettiar Government college of Engineering and Technology, ramsananthi@gmail.com	2. Mr.S.M.Vignesh, SRMIST

Course Code	18MHC204T	Course Name	POWER ELECTRONICS AND DRIVES	Course Category	C	Professional Core	L	T	P	C
							3	0	0	3

Pre-requisite Courses	18MHC102T, 18MHC103T	Co-requisite Courses	Nil	Progressive Courses	Nil
Course Offering Department	Mechatronics Engineering	Data Book / Codes/Standards	-		

Course Learning Rationale (CLR):	*The purpose of learning this course is to:*
CLR-1 :	*Identify different power semiconductor devices and utilize them in different converter circuits*
CLR-2 :	*Utilise single phase and three phase converters and Choppers*
CLR-3 :	*Utilise single phase and three phase inverters, AC Voltage regulators and cycloconverters*
CLR-4 :	*Apply converters and choppers to drive DC motors*
CLR-5 :	*Apply Inverters, voltage Regulators and cycloconverters to drive AC motors*
CLR-6 :	*Utilise Power Semiconductor devices for converter circuits, operate DC and AC drives using converters*

Course Learning Outcomes (CLO):	*At the end of this course, learners will be able to:*	Learning 1: Level of Thinking (Bloom)	Learning 2: Expected Proficiency (%)	Learning 3: Expected Attainment (%)	PLO 1: Engineering Knowledge	PLO 2: Problem Analysis	PLO 3: Design & Development	PLO 4: Analysis, Design, Research	PLO 5: Modern Tool Usage	PLO 6: Society & Culture	PLO 7: Environment & Sustainability	PLO 8: Ethics	PLO 9: Individual & Team Work	PLO 10: Communication	PLO 11: Project Mgt. & Finance	PLO 12: Life Long Learning	PLO 13: PSO - 1	PLO 14: PSO - 2	PLO 15: PSO - 3
CLO-1 :	*Analyze various power semiconductor devices used in Power converters*	3	75	70	H	-	H	L	M	-	M	M	M	M	-	M	-	-	-
CLO-2 :	*Identify working principle of controlled Rectifiers and Choppers*	3	75	70	H	M	H	H	M	-	M	M	M	M	-	M	-	-	-
CLO-3 :	*Identify working principle of Inverters and Cycloconverters*	3	75	70	H	M	H	H	M	-	M	M	M	M	-	M	-	-	-
CLO-4 :	*Operate DC drives using controlled rectifiers and choppers*	3	75	70	H	-	M	H	M	-	M	M	M	M	-	M	-	-	-
CLO-5 :	*Operate AC drives using Inverters and Cycloconverters*	3	75	70	H	-	M	H	M	-	M	M	M	M	-	M	-	-	-
CLO-6 :	*Identify power semiconductor devices, controlled rectifiers, choppers, inverters, cycloconverters for operating electric drives.*	3	75	70	-	-	M	M	M	-	M	M	M	M	-	M	-	-	-

		Semiconductor Devices	Controlled Rectifiers and Choppers	Inverters and AC Chopper	DC Drives	AC Drives
Duration (hour)		9	9	9	9	9
S-1	SLO-1	*Introduction to power semiconductor devices.*	*Introduction to controlled rectifiers*	*Introduction to inverters*	*Drives: Introduction*	*Induction motor fundamentals*
	SLO-2	*Basic structure and operation of power diode, Types of power diode*	*Types of controlled rectifiers*	*Types of inverters.*	*Electric Drives: Classification*	*Types of Induction motor*
S-2	SLO-1	*Basic structure and operation of power transistor*	*Operation of single phase fully controlled rectifier with R load*	*Operation of 1- phase voltage source inverter.*	*Classes of Duty*	*Speed control of Induction motor : Types*
	SLO-2	*Basic structure and operation of SCR*	*Operation of single phase fully controlled rectifier with RL load*		*Fundamentals of DC motor*	*Stator voltage control.*
S-3	SLO-1	*Characteristics and applications of SCR*	*Operation of single phase fully controlled rectifier with RLE load*	*Operation of 3 - phase voltage source inverter:180° mode VSI*	*Speed control of DC motor : Armature control*	*Variable frequency control.*
	SLO-2	*Basic structure and operation of GTO*	*Operation of single phase half controlled rectifier with RLE load*		*Speed control of DC motor: Field control.*	*VSI fed Induction motor drive*
S-4	SLO-1	*Basic structure and operation of TRIAC.*	*Operation of three phase half wave controlled rectifier with R load for continuous current.*	*Operation of 3 - phase voltage source inverter: 120° mode*	*Operation of Ward Leonard drives.*	*Rotor resistance control.*
	SLO-2	*Characteristics and applications of TRIAC.*	*Operation of three phase fully controlled rectifier with R load for continuous current.*	*Operation of 3 - phase current source inverter*		*Static Rotor resistance control*
S-5	SLO-1	*Basic structure and operation of MOSFET*	*Operation of three phase fully controlled rectifier with RL load for continuous current.*	*Types of ac voltage control: Phase control.*	*Converter fed DC drive: Types, Quadrant operation*	*Slip power recovery scheme:StaticKramers Scheme*
	SLO-2	*Characteristics and applications of MOSFET*	*Dual Converter*	*Types of ac voltage control: Integrated cycle control.*	*Fully controlled converter fed drive*	*StaticScherbius Scheme*
S-6	SLO-1	*Basic structure and operation of IGBT*	*Operation of choppers. Classification of choppers*	*Operation of 1- phase voltage regulator .*	*Semi-converter controlled converter fed drive*	*Fundamentals of synchronous motor*
	SLO-2	*Characteristics and applications of IGBT*	*Control strategies: Methods and Operation*		*Speed torque characteristics*	*Types of synchronous motor*

S-7	SLO-1	*Triggering methods for SCR*	*Operation of A, B types of chopper.*	*Operation of 3 - phase AC voltage controls: With anti parallel SCR configuration, with R load operation.*	*Chopper fed DC drive: types*	*Open loop control.*
	SLO-2		*Operation of C type of chopper.*		*Chopper fed DC drive: operation*	*Closed loop control.*
S-8	SLO-1	*Commutation techniques for SCR.*	*Operation of D type of chopper.*	*1-phase cyclo–converters: Introduction*	*Four quadrant operation of dc drive*	*Variable frequency control: Methods*
	SLO-2		*E type of chopper.*	*1-phase cyclo–converters: Types*		
S-9	SLO-1	*Firing circuits of SCR: R,RC and UJT Firing circuits*	*Multiphase chopper*	*1-phase step up cyclo-converters*	*Closed loop control*	*Voltage source fed synchronous motor.*
	SLO-2		*Applications of choppers.*	*1-phase step down cyclo-converters*		*Current source fed synchronous motor.*

Learning Resources	1. *Bhimbra. Dr.P.S., "Power Electronics", Khanna Publishers, 2012.* 2. *Dubey.G.K., "Fundamentals of Electrical Drives", Narosa publishing house 2001.* 3. *Muhammad H. Rashid, "Power Electronics - Circuits, Devices and Applications", Prentice Hall of India, New Delhi, 2003.* 4. *Singh. M.D and Khanchandani. K.B., "Power Electronics", Tata McGraw Hill Publishing Co. Ltd., New Delhi, 2000.*	5. *Pillai.S.K., "A first course on Electrical Drives", New Age International (P)Ltd., 2012.* 6. *Dubey.G.K., "Power Semiconductor Controlled Drives", Narosa publishing house, 1995.* 7. *Dubey. G.K., "Thyristorised Power Controllers", New Age International (P) Publishers Ltd., 2002.*

Learning Assessment											
	Bloom's Level of Thinking	Continuous Learning Assessment (50% weightage)								Final Examination (50% weightage)	
		CLA – 1 (10%)		CLA – 2 (15%)		CLA – 3 (15%)		CLA – 4 (10%)			
		Theory	Practice	Theory	Practice	Theory	Practice	Theory	Practice	Theory	Practice
Level 1	Remember Understand	*40%*	-	*30%*	-	*30%*	-	*30%*	-	*30%*	-
Level 2	Apply Analyze	*40%*	-	*40%*	-	*40%*	-	*40%*	-	*40%*	-
Level 3	Evaluate Create	*20%*	-	*30%*	-	*30%*	-	*30%*	-	*30%*	-
	Total	100 %		100 %		100 %		100 %		100%	

CLA – 4 can be from any combination of these: Assignments, Seminars, Tech Talks, Mini-Projects, Case-Studies, Self-Study, MOOCs, Certifications, Conf. Paper etc.,

Course Designers		
Experts from Industry	Experts from Higher Technical Institutions	Internal Experts
1.Mr. D.Gokulakrishnan, Planning Engineer, ABB India Ltd, Oman, gokul@tlsoman.com	*1. Dr.S.S Dash, Government College of Engineering Kednhhar, Orisha, munu_dash_2k@yahoo.com*	*1. Dr.M.Santhosh Rani, SRMIST*
2. Mrs.T.Priya,Sr.Design Engineer, Electrical&Instrumentation,Kavin Engineering and Services Pvt Ltd, priya@kavinengg.com	*2. Dr.M.Jagadeeshkumar,,Sri SaiRam Institute of Technology, jagadeeshkumar.eee@sairamit.edu.in*	*2. Mrs.V.Krithika, SRMIST*

Course Code	18MHC205J	Course Name	MICROCONTROLLERS AND EMBEDDED SYSTEMS	Course Category	C	Professional Core	L	T	P	C
							3	0	2	4

Pre-requisite Courses	18MHC108J	Co-requisite Courses	Nil	Progressive Courses	Nil
Course Offering Department	Mechatronics Engineering	Data Book / Codes/Standards	Nil		

Course Learning Rationale (CLR):	The purpose of learning this course is to:
CLR-1 :	*Familiarize with the functionality of microcontrollers.*
CLR-2 :	*Understand the concepts of microcontroller and its applications to mechatronics systems.*
CLR-3 :	*Understand the fundamentals of embedded systems design with real time system.*
CLR-4 :	*Develop programming skill to design in embedded C.*
CLR-5 :	*Apply knowledge to real-world application.*
CLR-6 :	*To impart knowledge of embedded system and microcontroller programming.*

Course Learning Outcomes (CLO):	At the end of this course, learners will be able to:	Learning			Program Learning Outcomes (PLO)														
		1	2	3	1	2	3	4	5	6	7	8	9	10	11	12	13	14	15
		Level of Thinking (Bloom)	Expected Proficiency (%)	Expected Attainment (%)	Engineering Knowledge	Problem Analysis	Design & Development	Analysis, Design, Research	Modern Tool Usage	Society & Culture	Environment & Sustainability	Ethics	Individual & Team Work	Communication	Project Mgt. & Finance	Life Long Learning	PSO - 1	PSO - 2	PSO - 3
CLO-1 :	*Demonstrate an understanding with the functionality of microcontrollers*	2	85	80	H	-	-	M	-	-	-	-	H	-	-	H	-	-	-
CLO-2 :	*Apply the concepts of microcontroller and its applications to mechatronics systems*	1	85	80	H	-	-	M	-	-	-	-	H	-	-	H	-	-	-
CLO-3 :	*Apply the fundamentals of embedded systems design with real time system.*	1	85	80	H	H	H	H	-	-	-	-	H	-	-	-	-	-	-
CLO-4 :	*Able to program and design using embedded C*	2	85	80	H	-	H	H	M	-	-	-	H	-	-	-	-	-	-
CLO-5 :	*Demonstrate the application of knowledge to real world application*	2	85	80	H	-	H	H	M	-	-	-	H	-	-	-	-	-	-
CLO-6 :	*Demonstrate an understanding on the concept of embedded system and microcontroller programming*	2	85	80	H	H	H	H	M	L	M	L	H	L	M	H	-	-	-

		Microcontroller 8051	ARM7 Controller	Introduction to Embedded Systems	Computing Platform and Design Analysis	Real Time Operating System
Duration (hour)		15	15	15	15	15
S-1	SLO-1	*Microcontroller 8051*	*ARM7 Controller*	*Definition, Key Elements Of An Embedded System.*	*DebuggingTechniques/ Challenges*	*Arbitration Schemes*
	SLO-2	*Architecture*	*Architecture*	*Design Metric Challenges*		*Software Architectures*
S-2	SLO-1	*Pin Description*	*Functional Description*	*Cpu Buses*	*Program Design And Analysis*	*Round Robin*
	SLO-2	*FunctionalDescription*		*Memory Devices, I/O Device*	*Components For Embedded Programs*	*Round Robin With Interrupt*
S-3	SLO-1	*Instruction Set Of 8051 Microcontroller.*	*ARM State Instruction*	*Component Interfacing*	*Model Of Programs*	*Function Queue Scheduling, Limitations Of Non-RTOS Embedded Systems*
	SLO-2	*Arithmetic Group*	*Data Transfer Instruction*	*Design With Microprocessors*	*DFG, CDFG*	*Introduction To RTOS And Its Features*
S 4-5	SLO-1	*Arithmetic Operations Using 8051*	*Arithmetic Operations Using ARM7*	*Stepper Motor Interface Using Microcontroller.*	*Keyboard Display Interface Using Microcontroller*	*Traffic Light Control Interface Using Microcontroller*
	SLO-2					
S-6	SLO-1	*Logical Group*	*Data Processing Instruction*	*Processor Technology*	*Assembly, Linking And Loading*	*Shared Data Problems*
	SLO-2	*Data Transfer Group*	*Thumb State Instruction*	*General Purpose Processors*	*Basic Compilation Techniques*	*IssuesIn SDP*
S-7	SLO-1	*Boolean Group*	*Data Transfer Instruction*	*Custom Single Purpose Processors*	*Program Optimization*	*SolutionsOf Shared Data Problem*
	SLO-2	*Branching Group*	*Data Processing Instruction*	*Application Specific Integrated Circuits*		*Semaphores – Introduction*
S-8	SLO-1	*Addressing Modes*	*Addressing Modes*	*IC Technology*	*Performance Analysis - System Level & Program Level*	*Multiple Semaphores; Reentrancy*
	SLO-2		*ARM Operating Modes*	*PLD*		*Semaphore Problems*
S 9-10	SLO-1	*Counting Odd And Even Numbers Using 8051 Microcontroller*	*Code Conversion Using ARM7*	*ADC Interfacing Using Microcontroller*	*PWM Interfacing UsingMicrocontroller*	*Repeat Session*
	SLO-2					
S-11	SLO-1	*Assembly Language Programming*	*Branch, SWI, PSR Instructions*	*VLSI*	*Optimization- Performance, Energy*	*Semaphores & Shared Data Problem*
	SLO-2	*Mnemonics, Op Code*	*Loading Constants, Conditional Execution*	*FPGA*	*Optimization – Power, Program Size*	*Semaphores As A Signaling Device*
S-12	SLO-1	*Programming Of 8051 Using Assembly Language*	*Programming Of ARM7Using Assembly Language*	*Design Technology*	*Program Validation*	*Operating System Services*
	SLO-2			*Hardware / Software Co-Design*	*TestingOf Program*	*Queues , Mailbox*
S-13	SLO-1	*Programming Of 8051 Using Assembly Language*	*Programming Of ARM7 Using Assembly Language*	*Integrated Development Environments*	*Interrupts*	*Pipes , Timer Functions*
	SLO-2			*Tool Chains*	*Interrupt Latency*	*Events*
S 14-15	SLO-1	*Timer/Counter Programs Using 8051 Microcontroller*	*Timer/Counter Programs Using ARM7Controller*	*DAC Interfacing Using Microcontroller*	*LED Display Using Microcontroller*	*Repeat Session*
	SLO-2					

Learning Resources	1. *Frank Vahid and Tony Givargis, "Embedded system design: A unified hardware/ software approach", Pearson Education Asia, 3rd edition, 2009.* 2. *Wayne Wolf, "Computers as components - Principles of Embedded computing system design", 2nd edition, MK Publishers.* 3. *Mazidi and Mazidi , "Intel 8051 Microcontrollers", Pearson education, India, 2006.*	4. *Steve Furber, "ARM System-on-chip Architecture", Pearson education, India, 2000.* 5. *David E.Simon , "An Embedded Software Primer", Pearson Education Asia 2001* 6. *Joseph Yiu, "The Definitive Guide to ARM Cortex Processors", 3rd edition, Newnes Publication* 7. *Microcontroller And Embedded Systems Laboratory Manual.*

Learning Assessment											
	Bloom's Level of Thinking	Continuous Learning Assessment (50% weightage)								Final Examination (50% weightage)	
		CLA – 1 (10%)		CLA – 2 (15%)		CLA – 3 (15%)		CLA – 4 (10%)			
		Theory	Practice	Theory	Practice	Theory	Practice	Theory	Practice	Theory	Practice
Level 1	Remember Understand	*20%*	*20%*	*15%*	*15%*	*15%*	*15%*	*15%*	*15%*	*15%*	*15%*
Level 2	Apply Analyze	*20%*	*20%*	*20%*	*20%*	*20%*	*20%*	*20%*	*20%*	*20%*	*20%*
Level 3	Evaluate Create	*10%*	*10%*	*15%*	*15%*	*15%*	*15%*	*15%*	*15%*	*15%*	*15%*
	Total	100 %		100 %		100 %		100 %		100%	

CLA – 4 can be from any combination of these: Assignments, Seminars, Tech Talks, Mini-Projects, Case-Studies, Self-Study, MOOCs, Certifications, Conf. Paper etc.,

Course Designers		
Experts from Industry	Experts from Higher Technical Institutions	Internal Experts
1. Mr.A.Rajasekar, CCG-RVP,rajasekar.a@intel.com	*1. Dr.BamaSrinivasan, Anna University, Guindy, Chennai, bama@annauniv.edu*	*1. Mrs.T.S.Rajalakshmi, SRMIST*
2. Mr. Reuben Fernandes, ATOM 360, India, wenisch@atom360.io	*2. Dr.K.Rahimunnisa, EashwariEngineering College, Chennai, krahimunnisa@gmail.com*	*2. Ms.Cross T AshaWise SRMIST*

Course code	18MHC301J	Course name	MANUFACTURING PROCESSES	Course category	P	Professional core	L	T	P	C
							3	0	2	4

Pre-requisite courses	Nil	Co-requisite courses	Nil	Progressive courses	Nil
Course offering department	Mechatronics engineering	Data book / codes/standards	Nil		

Course Learning Rationale (CLR):	*The purpose of learning this course is to:*
CLR-1 :	*understand the principle and process of different metal forming process*
CLR-2 :	*Impart knowledge on types and approaches of metal cutting process.*
CLR-3 :	*Gain knowledge in concept of computerized machine tool for metal cutting process.*
CLR-4 :	*Understand the concept of additive manufacturing process.*
CLR-5 :	*familiar in manufacturing metrology*
CLR-6 :	*implement knowledge of manufacturing processes and manufacturing metrology*

Course Learning Outcomes (CLO):	*At the end of this course, learners will be able to:*	Learning 1 Level of Thinking (Bloom)	2 Expected Proficiency (%)	3 Expected Attainment (%)	Program Learning Outcomes (PLO) 1 Engineering Knowledge	2 Problem Analysis	3 Design & Development	4 Analysis, Design, Research	5 Modern Tool Usage	6 Society & Culture	7 Environment & Sustainability	8 Ethics	9 Individual & Team Work	10 Communication	11 Project Mgt. & Finance	12 Life Long Learning	13 PSO - 1	14 PSO - 2	15 PSO - 3
CLO-1 :	*Explain the process of different metal forming process.*	1	85	80	H	H	-	-	-	-	-	-	-	-	-	-	-	-	-
CLO-2 :	*Distinguish the types and approaches of metal cutting process.*	1	85	80	H	H	-	-	-	-	-	-	-	-	-	-	-	-	-
CLO-3 :	*Implement the concept of computerized machine tool for metal cutting process.*	1	85	80	H	-	H	_	H	-	-	-	-	-	-	-	-	-	-
CLO-4 :	*Understand the concept of additive manufacturing process.*	2	85	80	H	-	-	H	-	-	H	-	-	-	-	-	-	-	-
CLO-5 :	*acquire knowledge on manufacturing metrology*	2	85	80	H	H	-	H	-	-	_	-	-	-	-	-	-	-	-
CLO-6 :	*impart knowledge of manufacturing processes and manufacturing metrology*	2	85	80	H	H	H	H	-	-	H	-	-	-	-	-	-	-	-

Duration (hour)		15	15	15	15	15
S-1	SLO-1	*Casting process: introduction*	*Introduction to metal cutting processes*	*CNC machine tools*	*Additive manufacturing: concept, types.*	*Introduction to manufacturing metrology*
	SLO-2	*Classification of casting process.*	*Cutting tools*	*NC machines*	*Fused deposition method: working principle,*	*Laser metrology and precision instruments*
S-2	SLO-1	*Mould and its types.*	*Classification: single point cutting tool nomenclature*	*DNC machines*	*Advantages, limitations, applications.*	*Types of lasers – laser in engineering metrology*
	SLO-2	*Pattern: types of pattern*	*Multi point cutting tool nomenclature*	*CNC machines: introduction*	*Selective laser sintering process*	*Metrological laser methods for applications in machine systems*
S-3	SLO-1	*Special casting techniques*	*Tool wear*	*Classification of CNC machines.*	*Working principle, advantages, limitations,*	*Interferometry applications – speckle interferometry*
	SLO-2	*Expandable mould casting*	*Tool life, Prediction of tool life*	*Constructional feature of CNC turning centre and*	*Applications.*	*Laser interferometers in manufacturing and machine tool alignment testing*
S 4-5	SLO-1 SLO-2	*Lab – 1: Machining of spur gear using universal milling machine.*	*Lab – 4: Manufacturing a single point cutting tool using tool and cutter grinder.*	*Lab - 6 :Multiple turning with grooving and thread cutting by applying canned cycle using CNC turning centre*	*Lab – 9: Profile cutting by applying Mirroring operation using CNC vertical machining centre.*	*Lab – 11: Profile cutting using Wire cut Electrical Discharge Machine (WEDM).*
S-6	SLO-1	*Investment casting , Shell mould casting,*	*Orthogonal and oblique cutting*	*CNCmachining centre.*	*Stereo lithography process: working principle,.*	*Introduction to co-ordinate measuring system*
	SLO-2	*Permanent mould casting.*	*Mechanics of orthogonal cutting using single point cutting tool*	*Open loopCNC systems, closed loop CNC systems*	*Advantages, limitations, applications*	*Co-ordinate metrology*
S-7	SLO-1	*Die casting and its types*	*Cutting forces in orthogonal cutting, merchant circle analysis.*	*CNC controllers.*	*3d printing technique: working process,*	*CMM configurations , hardware components – software*
	SLO-2	*Centrifugal casting and its types*	*Calculation of various forces involved during orthogonal cutting.*	*Structural members of CNC machines: slide ways, linear motion*	*Advantages, limitations, applications.*	*Probe sensors – displacement devices –*
S-8	SLO-1	*Defects in casting.*	*Problem solving*	*Bearings, ball screws*	*PCB manufacturing process: silicon wafer production process*	*Performance evaluations, applications*
	SLO-2	*Mechanical working of metals*	*Methods to gear generation:*	*Work holding, tool holding devices,*	*Diffusion, masking.*	*Roll of CMM in reverse engineering*

S 9-10	SLO-1 SLO-2	*Lab – 2: Machining of helical gear using gear hobbing machine.*	*Gear shaping*	*Lab – 7: Step turning using CNC turning centre.*	*Lab – 10: Drilling and peck drilling using CNC vertical machining centre.*	*Lab – 12: Pocketing of Linear and Circular profile using CNC vertical machining centre.*
S-11	SLO-1	*Rolling process, Mechanism, types and defects of rolling.*	*Milling*	*Automatic tool changer.*	*Photolithography technique.*	*Opto electronic devices*
	SLO-2	*Joining Process- Welding techniques- Conventional and special Techniques*	*Hobbing process.*	*Feedback devices used in machining centre*	*Etching, cleaning,*	*Ccd, on-line and in-process monitoring in production*
S-12	SLO-1	*Joining Process- Soldering and Brazing*	*Grinding: cylindrical, surface*	*fundamentals of part programming,*	*. Types of pcb: single sided, double sided,*	*Applications.*
	SLO-2	*Forging: mechanism Types, machine used for forging, defects.*	*Centreless grinding process.*	*G and m codes.*	*Multilayer pcb board*	*Image analysis and computer vision*
S-13	SLO-1	*Extrusion: mechanism, classification, defects.*	*Super finishing: lapping.*	*. Types of programming: manual part programming,*	*flexible PCB board*	*image analysis techniques*
	SLO-2	*Drawing: mechanism, tube drawing, deep drawing, defects.*	*Honing, buffing.*	*Canned cycle and subroutines.*	*Inspection of PCB boards.*	*Comparison laser scanning with vision system*
S 14-15	SLO-1 SLO-2	*Lab - 3 : Facing, turning and thread cutting using conventional lathe*	*Lab - 5 :Finishing operation using cylindrical and surface grinding process.*	*Lab – 8 :Multiple turning by applying canned cycle using CNC turning centre.*	*Lab – 13: Extra practice session.*	*Lab – 14 :Model Examination*

Learning Resources	1. Sharma.P.C, "A textbook of Production Technology", Vol I and II, S. Chand And Company Ltd., New Delhi, 2007. 2. SeropeKalpakjian and Steven Schmid, "Manufacturing Engineering and Technology", Pearson Education, 7th edition, 2014. 3. Radhakrishnan.P, "CNC Machines", New Central Book Agency, 2000. 4. Pandey and H.S.Shah, "Modern Machining Process", Tata McGraw Hill Publishing Co., New Delhi, 2008. 5. Chua C.K., Leong K.F., and Lim C.S., "Rapid prototyping: Principles and applications", 3rd edition, World Scientific Publishers, 2010. 6. R. S. Khandpur"Printed Circuit Boards: Design, Fabrication, and Assembly" Tata McGraw Hill Publishing Co., New Delhi,2010.	7. S.K. HajraChoudry, S.K.Bose, A.K. HajraChoudry , "Elements of Workshop Technology Vol II: Machine tools", Media promoters and Publishers Pvt Ltd, 2002. 8. Chapman.W.A.J, "Workshop Technology" Vol. I and II, Arnold Publisher, 1996. 9. Elanchezhian.C, VijayaRamnath.B and Sunder Selwyn, T., Engineering Metrology, Eswar Press, Chennai, 2004. 10. John A. Bosch, Giddings and Lewis Dayton, Co-ordinate Measuring Machines and Systems, Marcel Dekker, Inc, 1999 11. ZuechNello, Understanding and Applying Machine Vision, Marcel Dekker, Inc, 2000

Learning Assessment

	Bloom's Level of Thinking	Continuous Learning Assessment (50% weightage)								Final Examination (50% weightage)	
		CLA – 1 (10%)		CLA – 2 (15%)		CLA – 3 (15%)		CLA – 4 (10%)#			
		Theory	Practice	Theory	Practice	Theory	Practice	Theory	Practice	Theory	Practice
Level 1	Remember Understand	*20%*	*20%*	*15%*	*15%*	*15%*	*15%*	*15%*	*15%*	*15%*	*15%*
Level 2	Apply Analyze	*20%*	*20%*	*20%*	*20%*	*20%*	*20%*	*20%*	*20%*	*20%*	*20%*
Level 3	Evaluate Create	*10%*	*10%*	*15%*	*15%*	*15%*	*15%*	*15%*	*15%*	*15%*	*15%*
	Total	100 %		100 %		100 %		100 %		100 %	

CLA – 4 can be from any combination of these: Assignments, Seminars, Tech Talks, Mini-Projects, Case-Studies, Self-Study, MOOCs, Certifications, Conf. Paper etc.,

Course Designers

Experts from Industry	Experts from Higher Technical Institutions	Internal Experts
1. Mr.K.Balaguru, Deputy manager, Hindustan Aeronautics limited, Structural Design, gurubala07@gmail.com	*1. Dr.v. Senthilkumar , NIT Tiruchirappalli, Production department, vskumar@nitt.edu*	*1. Dr.B.K. Vinayagam, SRMIST*
2. Mr. HariPrabhu, Junior Engineer, Indian Railways, Egmore, hpvijay5894@gmail.com	*2. Dr. R. Sarala,AlagappaChettiar college of Engineering and Technology, Manufacturing department, r.sarala@accetedu.in, karaikudi.*	*2. Mr. J.Arivarasan, SRMIST*

Course Code	15MH302J	Course Name	DESIGN OF MECHATRONICS SYSTEMS	Course Category	C	Professional Core	L	T	P	C
							3	0	2	4

Pre-requisite Courses	Nil	Co-requisite Courses	Nil	Progressive Courses	Nil
Course Offering Department	Mechatronics Engineering	Data Book / Codes/Standards	Nil		

Course Learning Rationale (CLR):	The purpose of learning this course is to:
CLR-1 :	*Understand the design challenges involved in multidisciplinary modern machines*
CLR-2 :	*Familiarize the mechatronics approach design process and its benefit*
CLR-3 :	*Understand the various simulation methods and its importance*
CLR-4 :	*Understand the importance of modeling and model based design*
CLR-5 :	*Understand and apply the mechatronics design approach for various real systems*

Course Learning Outcomes (CLO):	At the end of this course, learners will be able to:	Learning 1: Level of Thinking (Bloom)	Learning 2: Expected Proficiency (%)	Learning 3: Expected Attainment (%)	PLO 1: Engineering Knowledge	PLO 2: Problem Analysis	PLO 3: Design & Development	PLO 4: Analysis, Design, Research	PLO 5: Modern Tool Usage	PLO 6: Society & Culture	PLO 7: Environment & Sustainability	PLO 8: Ethics	PLO 9: Individual & Team Work	PLO 10: Communication	PLO 11: Project Mgt. & Finance	PLO 12: Life Long Learning	PLO 13: PSO - 1	PLO 14: PSO - 2	PLO 15: PSO - 3
CLO-1 :	*Familiarize with design challenges, integrated design issues associated with the multidisciplinary modern machines and systems*	2	80	75	H	H	H	H	H	-	-	-	-	-	L	H	H	M	-
CLO-2 :	*Learn the mechatronics concepts, design processes and benefits*	3	80	75	H	H	H	H	H	-	-	-	M	-	-	H	H	M	-
CLO-3 :	*Understand and apply MIL, SIL simulations and virtual prototyping*	3	75	70	H	H	H	H	H	-	-	-	M	-	M	H	H	M	-
CLO-4 :	*Learn the fundamentals of system modeling and its importance*	3	75	70	H	H	H	H	H	-	-	-	M	-	M	H	H	M	-
CLO-5 :	*Apply mechatronics design approaches in some common products development*	3	75	70	H	H	H	H	H	-	-	-	M	-	M	H	H	M	-

		Introduction to mechatronic system design	Mechatronics design concepts	Model based system engineering	Case Study-1	Case Study-2
Duration (hour)		15	15	15	15	15
S-1	SLO-1	*Definition of mechatronics*	*Significance of modeling*	*Motivation for model based system engineering (MBSE)*	*Need of model based design for the system under consideration*	*Need of model based design for the system under consideration*
	SLO-2	*Evolution of mechatronics systems*	*Example*	*System engineering process*	*Benefits of model based design*	*Benefits of model based design*
S-2	SLO-1	*Multidisciplinary nature of modern machines and their design challenges*	*Model-In-Loop(MIL) simulation*	*System lifecycle*	*Understanding the system under consideration*	*Understanding the system under consideration*
	SLO-2	*Example*	*Example*	*Types of systems*	*Mechanical and electronics description*	*Mechanical and electronics description*
S-3	SLO-1	*Traditional vs mechatronics approaches*	*Software-In-Loop(SIL) simulations*	*Modeling ,analysis and management of system requirements*	*Mathematical description of the model*	*Mathematical description of the model*
	SLO-2	*Example*	*Example*	*Modeling ,analysis and management of system requirements*	*Mathematical modeling- derivation*	*Mathematical modeling- derivation*
S 4-5	SLO-1 SLO-2	*Lab 1*	*Lab 4*	*Lab 7*	*Lab 10*	*Lab 13*
S-6	SLO-1	*Mechatronics design process*	*Virtual Prototyping- a critical aspect of mechatronics approach*	*Structural modeling using SysML*	*Detailed modelling procedures and simulation parameters.*	*Detailed modelling procedures and simulation parameters.*
	SLO-2	*Need of design tools integration*	*Example*	*Structural modeling using SysML*	*Simulation methods*	*Simulation methods*
S-7	SLO-1	*Review of key elements of mechatronics systems from integration perspective*	*Real-time simulations (xPC)*	*Behavioral modeling using SysML*	*Key integration issues specific to the system under consideration*	*Key integration issues specific to the system under consideration*
	SLO-2	*Example*	*Example*	*Behavioral modeling using SysML*	*Key integration issues specific to the system under consideration*	*Key integration issues specific to the system under consideration*
S-8	SLO-1	*Role of mechatronics engineer.*	*concurrent development of subsystems*	*Identifying complexities through different levels of abstractions and refinement*	*System integration*	*System integration*
	SLO-2	*Various steps for design*	*Example*	*Identifying complexities through different levels of abstractions and refinement*	*System integration*	*System integration*
S 9-10	SLO-1 SLO-2	*Lab 2*	*Lab 5*	*Lab 8*	*Lab 11*	*Lab 14*

S-11	SLO-1	Types of design (mecahtronics approach)	Real-time Hardware-In-Loop simulation (HIL)	Adding constraints	Control techniques adopted	Control techniques adopted
	SLO-2	Example	Example	Interaction diagrams	Related Control theory	Related Control theory
S-12	SLO-1	integrated product design	Running the controller model and plant model on real-time target	Automatic approach for synergistic verification and validation	Selection of hardware components based on the model based design	Selection of hardware components based on the model based design
	SLO-2	load conditions on mechanisms	V&V using HIL RT model.	Automatic approach for synergistic verification and validation	Selection of hardware components based on the model based design	Selection of hardware components based on the model based design
S-13	SLO-1	Structure and systems	Rapid prototyping of mechatronic products- introduction to precision engineering	Performance analysis	System performance evaluation techniques	System performance evaluation techniques
	SLO-2	Man Machine Interface (MMI).	Example	Performance analysis	System performance evaluation techniques	System performance evaluation techniques
S 14-15	SLO-1 SLO-2	Lab 3	Lab 6	Lab 9	Lab 12	Lab 15: Model Practical Examination

Note: ** List of plants/systems for case study 1,2 and 3 is listed below in the table. Faculty may choose any one plant/system from the list given and continue the same system/plant for the entire case study module

** List of experiments for the lab slots is listed below in the table for mechatronics as well as mechatronics with robotics specialization. Faculty in-charge may choose from the list of experiments to be provided for the various lab slots

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LIST OF PLANTS/SYSTEMS FOR CASE STUDIES		
CASE STUDY 1	CASE STUDY 2	CASE STUDY 3
Rotary Inverted pendulum	Hybrid Electric Vehicle	Six Degree of freedom serial manipulator
Inverted pendulum on a cart with rotary actuator	Electronic Stability Control (ABS, EBD and ESP)	Six Degree of freedom parallel manipulator
Inverted pendulum with Linear Actuator	Active Suspension	Collision avoidance in mobile robotic systems
Double inverted pendulum	Engine Control System	Multi-rotor aerial vehicles
Ball and Plate Control Systems	Systems for Passenger Safety and Convenience	Haptics based teleoperation of manipulators
Two wheeled Self Balancing Mobile Robot	Cruise control	Cooperative manipulators
Magnetically levitated Systems		Underwater vehicles

LIST OF EXPERIMENTS FOR LABORATORY EXERCISE FOR MECHATRONICS AND MECHATRONICS WITH ROBOTICS SPECILAIZATION	
MECHATRONICS	MECHATRONICS WITH ROBOTICS SPECILAIZATION
Quadrature decoding of incremental encoder	Quadrature Encoder Decoding for Position and Velocity Estimation of a DC Servo Motor
Closed loop position control of DC motor	Mathematical modeling and control of physical system
Open loop control of mobile robot	Physical Modelling of a Differential Drive Robot
Closed loop control of mobile robot with wheel encoders	Closed Loop Control of a Differential Drive Robot with Wheel Encoder and Acoustic Ranging
Mathematical modeling and control of physical system.	Localization and Global Path Planning for a differential drive robot in a occupancy grid
Introduction to physical modeling	Closed loop control of pneumatics
Creating requirements models of systems using SysML in different context and views	Closed control of pneumatics with PLC
MBSE approach for elevator	Introduction to hardware in loop simulation
Localization and Global Path Planning for a differential drive robot in a occupancy grid	Introduction to forward and inverse Kinematics of a serial Manipulator
Introduction to hardware in loop simulation	Introduction to velocity Kinematics of a Serial Manipulator
One degree of freedom pitch control (VTOL).	Trajectory Planning in Joint Space for Serial Manipulator
Control of rotary inverted pendulum	Trajectory Planning in Cartesian Space for Serial Manipulator
Closed loop control of pneumatics	Position Control of Serial Manipulator – Application task
Closed control of pneumatics with PLC	Force/Position Control of Serial Manipulator- Application task

Learning Resources	1. Devdasshetty, Richard A.Kolk “Mechatronics Systems Design”, Cengage Learning, 2011. 2. D A Bradley and et al,"Mechatronics-Electronics in Products and Processes",Springerscience+business media 3. Ni_mechatronics_machine_design_guide from ni.com. 4. Advanced model based systems design courseware from mathworks.com. 5. Quanser QNET Practical Control Guide (available in Mechatronics Laboratory).	6. Quanser QNET VTOL Laboratory manual (available in Mechatronics Laboratory). 7. Quanser QNET Rotary Inverted Pendulum manual (available in Mechatronics Laboratory). 8. Laboratory manual for Mechatronics Laboratory, SRMIST 9. Dennis M.Buede& William D.Miller., "The Engineering Design of Systems Models and Methods" 3rd Edition, Wiley, 2016

Learning Assessment											
	Bloom's Level of Thinking	Continuous Learning Assessment (50% weightage)								Final Examination (50% weightage)	
		CLA – 1 (10%)		CLA – 2 (15%)		CLA – 3 (15%)		CLA – 4 (10%)#			
		Theory	Practice	Theory	Practice	Theory	Practice	Theory	Practice	Theory	Practice
Level 1	Remember Understand	*20%*	*20%*	*15%*	*15%*	*15%*	*15%*	*15%*	*15%*	*15%*	*15%*
Level 2	Apply Analyze	*20%*	*20%*	*20%*	*20%*	*20%*	*20%*	*20%*	*20%*	*20%*	*20%*
Level 3	Evaluate Create	*10%*	*10%*	*15%*	*15%*	*15%*	*15%*	*15%*	*15%*	*15%*	*15%*
	Total	100 %		100 %		100 %		100 %		100 %	

CLA – 4 can be from any combination of these: Assignments, Seminars, Tech Talks, Mini-Projects, Case-Studies, Self-Study, MOOCs, Certifications, Conf. Paper etc.,

Course Designers		
Experts from Industry	Experts from Higher Technical Institutions	Internal Experts
1.Mr.Ganesh Ram, Intel Labs ,Bangalore, ganeshram.nandakumar.@intel.com	*1. Dr., R. Thiyagarajan, Visiting faculty, IIT Madras, thiyaguiitm@gmail.com*	*1. Mr.KSivanathan, SRMIST*
2. Mr. Mohammed Sagheer ,Wabco Technology Center ,India, mohammedsagheer.musthafa@wabco-auto.com	*2. Dr., P Karthikeyan, MIT,Anna University, pkarthikeyan@annauniv.edu*	*2. Mr.Ranjith Pillai R, SRMIST*

Course Code	18MHC350T	Course Name	COMPREHENSION	Course Category	C	Professional Core	L	T	P	C
							0	1	0	1

Pre-requisite Courses	Nil	Co-requisite Courses	Nil	Progressive Courses	Nil
Course Offering Department	Mechatronics Engineering	Data Book / Codes/Standards	Nil		

Course Learning Rationale (CLR):	*The purpose of learning this course is to:*
CLR-1 :	*Acquire skills to solve real world problems in Engineering Graphics Design, Engineering Mechanics and Mechanics of Solids*
CLR-2 :	*Acquire skills to solve real world problems in Machines and Mechanisms, Thermodynamics and Fluid Mechanics*
CLR-3 :	*Solve problems in Manufacturing Technology, Material Technology, Applied Thermal Engineering for Automotive Engineers*
CLR-4 :	*Solve problems in Automotive Engines, Vehicular Structures, Driveline Systems and Automotive Electrical and Electronics Systems*
CLR-5 :	*Acquire skills to solve real world problems in Design of Automotive components and CAD Analysis for Automotive Engineers*
CLR-6 :	*Acquire skills to solve real world problems for competitive examinations in Automobile and Mechanical Engineering*

Course Learning Outcomes (CLO):	*At the end of this course, learners will be able to:*	Learning 1: Level of Thinking (Bloom)	2: Expected Proficiency (%)	3: Expected Attainment (%)	PLO 1: Engineering Knowledge	2: Problem Analysis	3: Design & Development	4: Analysis, Design, Research	5: Modern Tool Usage	6: Society & Culture	7: Environment & Sustainability	8: Ethics	9: Individual & Team Work	10: Communication	11: Project Mgt. & Finance	12: Life Long Learning	13: PSO - 1	14: PSO - 2	15: PSO - 3
CLO-1 :	*Practice and gain confidence, competence to solve problems in Engineering Graphics Design, Engineering Mechanics, Mechanics of Solids*	3	85	80	H	H	H	L	L	L	L	L	L	L	L	L	M	L	M
CLO-2 :	*Practice and gain confidence and competence to solve problems in Machines and Mechanisms, Thermodynamics and Fluid Mechanics*	3	85	80	H	H	M	L	L	L	L	L	L	L	L	L	M	M	M
CLO-3 :	*Solve problems in Manufacturing Technology, Material Technology and Applied Thermal Engineering for Automotive Engineers*	3	85	80	H	H	M	L	L	L	L	L	L	L	L	L	M	L	M
CLO-4 :	*Solve problems in Automotive Engines, Vehicular Structures and Driveline Systems and Automotive Electrical and Electronics Systems*	3	85	80	H	H	M	L	L	L	L	L	L	L	L	L	M	M	M
CLO-5 :	*Practice and gain confidence,competence to solve problems in Design of Automotive components, CAD Analysis for Automotive Engineers*	3	85	80	H	H	H	L	L	L	L	L	L	L	L	L	M	L	M
CLO-6 :	*Practice and gain confidence and competence to solve problems in the broad domain of Automobile and Mechanical Engineering*	3	85	80	H	H	M	L	L	L	L	L	L	L	L	L	M	M	M

Duration (hour)		3	3	3	3	3
S-1	SLO-1	*Tutorial on Engineering graphics and design*	*Tutorial on Machines and Mechanisms*	*Tutorial on Manufacturing Technology for Automotive Engineers*	*Tutorial on Automotive Engines*	*Tutorial on Design of Automotive components*
	SLO-2	*Problem Solving*	*Problem Solving*	*Problem Solving*	*Problem Solving*	*Problem Solving*
S-2	SLO-1	*Tutorial on Engineering Mechanics*	*Tutorial on Thermodynamics*	*Tutorial on Material Technology*	*Tutorial on Vehicular Structures and Driveline Systems*	*Tutorial on CAD Analysis for Automotive Engineers*
	SLO-2	*Problem Solving*	*Problem Solving*	*Problem Solving*	*Problem Solving*	*Problem Solving*
S-3	SLO-1	*Tutorial on Mechanics of Solids*	*Tutorial on Fluid mechanics*	*Tutorial on Applied Thermal Engineering for Automotive Engineers*	*Tutorial on Automotive Electrical and Electronics Systems*	*Problem Solving*
	SLO-2	*Problem Solving*	*Problem Solving*	*Problem Solving*	*Problem Solving*	*Problem Solving*

Learning Resources	1. *R.S.Khurmi, J.K.Gupta, Mechanical Engineering: Conventional and Objective Types, S.Chand& Co., 2018*	2. *R.K.Jain, Conventional & Objective Type Question & Answers on Mechanical Engineering for Competitions, Khanna Publishers, 2014*

Learning Assessment

	Bloom's Level of Thinking	Continuous Learning Assessment (100% weightage)								Final Examination	
		CLA – 1 (20%)		CLA – 2 (30%)		CLA – 3 (30%)		CLA – 4 (20%)#			
		Theory	Practice	Theory	Practice	Theory	Practice	Theory	Practice	Theory	Practice
Level 1	Remember Understand	-	*40%*	-	*30%*	-	*30%*	-	*30%*	-	-
Level 2	Apply Analyze	-	*40%*	-	*40%*	-	*40%*	-	*40%*	-	-
Level 3	Evaluate Create	-	*20%*	-	*30%*	-	*30%*	-	*30%*	-	-
	Total	100 %		100 %		100 %		100 %		-	

CLA – 4 can be from any combination of these: Assignments, Seminars, Tech Talks, Mini-Projects, Case-Studies, Self-Study, MOOCs, Certifications, Conf. Paper etc.,

Course Designers		
Experts from Industry	Experts from Higher Technical Institutions	Internal Experts
1.Mr.Ganesh Ram, Intel Labs ,Bangalore, ganeshram.nandakumar.@intel.com	*1. Dr., R. Thiyagarajan, Visiting faculty, IIT Madras, thiyaguiitm@gmail.com*	*1. Mr.KSivanathan, SRMIST*
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ACADEMIC CURRICULA

Professional Core Courses

NANOTECHNOLOGY

Regulations - 2018

SRM INSTITUTE OF SCIENCE & TECHNOLOGY
(Deemed to be University u/s 3 of UGC Act, 1956)

SRM INSTITUTE OF SCIENCE AND TECHNOLOGY

(Deemed to be University u/s 3 of UGC Act, 1956)

Kattankulathur, Kancheepuram, Tamil Nadu, India

Course Code	18NTC201T	Course Name	NANOPHOTONICS	Course Category	C	Professional Core	L	T	P	C
							3	0	0	3

Pre-requisite Courses	Nil	Co-requisite Courses	Nil	Progressive Courses	Nil
Course Offering Department	Nanotechnology	Data Book / Codes/Standards	Nil		

Course Learning Rationale (CLR):	The purpose of learning this course is to:
CLR-1 :	*Understand the fundamentals of light interaction with nanoscale materials*
CLR-2 :	*Learn the basic concepts of quantum confined materials*
CLR-3 :	*Understand the principles of photonic crystals*
CLR-4 :	*Enrich their knowledge on plasmonics and near field optics*
CLR-5 :	*Familiarize themselves with nanophotonic fabrication*
CLR-6 :	*Understand the various aspects of nanobiophotonics*

Course Learning Outcomes (CLO):	At the end of this course, learners will be able to:	Learning			Program Learning Outcomes (PLO)														
		1	2	3	1	2	3	4	5	6	7	8	9	10	11	12	13	14	15
		Level of Thinking (Bloom)	Expected Proficiency (%)	Expected Attainment (%)	Engineering Knowledge	Problem Analysis	Design & Development	Analysis, Design, Research	Modern Tool Usage	Society & Culture	Environment & Sustainability	Ethics	Individual & Team Work	Communication	Project Mgt. & Finance	Life Long Learning	PSO - 1	PSO - 2	PSO - 3
CLO-1 :	*Apply the principles of Quantum confinement effects to understand Nanoscale interaction dynamics*	2	80	75	H	M	H	H	H	M	M	H	H	H	M	H	H	H	H
CLO-2 :	*Utilize the photonic crystals in various applications*	2	80	70	H	M	M	H	M	M	M	H	M	H	M	H	M	M	M
CLO-3 :	*Explore the principles of plasmonics to study Near field scanning optical microscopy*	2	75	70	H	M	H	H	H	H	H	M	H	H	H	H	H	H	H
CLO-4 :	*Utilize the Near field scanning optical microscopy in data storage applications*	2	80	75	M	H	H	M	H	H	H	H	H	H	M	H	H	H	H
CLO-5 :	*Apply fundamental principles of Near field optical chemical vapor deposition technique for fabrication of nanophotonic materials*	2	80	70	H	M	H	H	H	M	M	H	M	H	M	H	H	H	H
CLO-6 :	*Utilize the Fluorescence contrast mechanism concepts to analyze the properties of organic materials*	2	80	75	H	M	M	H	H	M	M	H	H	H	M	H	H	M	H

Duration (hour)		9	9	9	9	9
S-1	SLO-1	*Photons and electrons*	*Quantum confined materials*	*Plasmonics*	*Nanophotonic Fabrication*	*Biophotonics*
	SLO-2	*Similarities and differences*	*Inorganic quantum confined structures*	*Internal reflection*	*Adiabatic nanofabrication*	*Nanobiophotonics*
S-2	SLO-1	*Free space propagation*	*Manifestation of quantum confinement*	*Evanescent waves*	*Non adiabatic nanofabrications*	*The cell and scale*
	SLO-2	*Confinement of photons and electrons*	*Quantum confined Stark effect*	*Plasmons and surface plasmon resonance*	*Conditions for non-adiabatic nanofabrications*	*The cell and constituents*
S-3	SLO-1	*Propagation through a classically forbidden zone - Electrons*	*Dielectric confinement effect*	*Attenuated total reflection*	*Near field optical Chemical Vapour Deposition NFO CVD - Philosophy*	*Origin of contrast mechanisms*
	SLO-2	*Propagation through a classically forbidden zone - Photons*	*Super lattices*	*Grating SPR coupling*	*Near field optical Chemical Vapour Deposition – Design and technique*	*Optical contrast mechanisms*
S-4	SLO-1	*Tunneling Localization under a periodic potential - Electrons*	*Core-shell quantum dots*	*Optical waveguide SPR coupling*	*Near field photolithography - Philosophy*	*Classical contrast mechanisms*
	SLO-2	*Tunneling Localization under a periodic potential - Photons*	*Quantum wells*	*SPR dependencies and materials*	*Near field photolithography design and technique*	*Bright field and dark field contrast*
S-5	SLO-1	*Band gap and cooperative effects of photons*	*Quantum confined structures as lasing media*	*Plasmonics and nanoparticles*	*Self-assembling method*	*Phase contrast*
	SLO-2	*Band gap and cooperative effects of electrons*	*Organic quantum confined structures*	*Near-Field Optics*	*Self-assembling method via optical near field interactions*	*Inter ferrometric contrast*
S-6	SLO-1	*Nanoscale optical interactions*	*Photonic crystals*	*Aperture less near field optics*	*Regulating the size of Nanoparticles*	*Fluorescence contrast mechanism*
	SLO-2	*Axial and lateral nanoscopic localization*	*Important features of photonic crystals*	*Near field scanning optical microscopy (NSOM or SNOM) - Principle*	*Size dependent resonance*	*Confocal Microscopy*
S-7	SLO-1	*Nanoscale confinement of photonic interactions*	*Applications of Photonic crystals*	*Near field scanning optical microscopy design and technique*	*Controlling size of Nanoparticles*	*Nonlinear microscopy based on second harmonic generation*
	SLO-2	*Nanoscale confinement of electronic interactions*	*Dielectric mirrors*	*SNOM Applications*	*Alignment of Size controlled Nanoparticles*	*Coherent anti-stokes Raman scattering (CARS)*

S-8	SLO-1	*Quantum confinement effects*	*Interference filters*	*SNOM based visualization of waveguide structures*	*Controlling position of Nanoparticles*	*Reduction of the observation volume*
	SLO-2	*Nanoscale interaction dynamics*	*Photonic crystal laser, Photonic crystal sensing*	*SNOM based energy transport*	*Alignment of position controlled Nanoparticles*	*Far field method - 4Pi microscopy*
S-9	SLO-1	*Nanoscale electronic energy transfer*	*Photonic crystal fibers (PCFs)*	*SNOM based optical data storage*	*Separation of Nanoparticles*	*Microscopy on a mirror*
	SLO-2	*Cooperative emissions*	*Introduction to Metamaterials*	*SNOM based optical data recovery*	*Alignment of Separated and controlled Nanoparticles*	*Stimulated emission depletion (STED)*

Learning Resources	1. *M.Ohtsu,K.Kobayashi,T.Kawazoe and T.Yatsui, Principals of Nanophotonics (Optics and Optoelectronics),CRC press,2003* 2. *H.Masuhara,SKawata and F Tokunga, NanoBiophotoics, Elsevier Science, 2007*	3. *BEA Saleh and AC Teich, Fundamentals of Photonics, John Wiley and Sons,1993* 4. *Y. V. G.S. Murthy and C. Vijayan, Essentials of Nonlinear Optics, Wiley, 1st edition, 2014*

Learning Assessment

	Bloom's Level of Thinking	Continuous Learning Assessment (50% weightage)								Final Examination (50% weightage)	
		CLA – 1 (10%)		CLA – 2 (15%)		CLA – 3 (15%)		CLA – 4 (10%)#			
		Theory	Practice	Theory	Practice	Theory	Practice	Theory	Practice	Theory	Practice
Level 1	Remember Understand	*30 %*	-	*30 %*	-	*30 %*	-	*30 %*	-	*30%*	-
Level 2	Apply Analyze	*40 %*	-	*40 %*	-	*40 %*	-	*40 %*	-	*40%*	-
Level 3	Evaluate Create	*30 %*	-	*30 %*	-	*30 %*	-	*30 %*	-	*30%*	-
	Total	100 %		100 %		100 %		100 %		100 %	

CLA – 4 can be from any combination of these: Assignments, Seminars, Tech Talks, Mini-Projects, Case-Studies, Self-Study, MOOCs, Certifications, Conf. Paper etc.,

Course Designers

Experts from Industry	Experts from Higher Technical Institutions	Internal Experts
1. Mr. Sameer Sharda, New Age Instruments & Materials Pvt. Ltd., Gurgaon, sameer@newagein.com	*1. Prof. C. Vijayan, IIT Madras, cvijayan@iitm.ac.in*	*1. Dr. D. John Thiruvadigal,SRMIST*
2. Mr. Muhammed Shafi, Holmarc Opto-Mechatronics Pvt. Ltd, Cochin, optics@holmarc.com	*2. Prof. S. Balakumar, Univ. of Madras, balakumar@unom.ac.in*	*2. Dr. Junaid Masud Laskar, SRMIST*

ourse Code	18NTC202J	Course Name	NANOBIOTECHNOLOGY	Course Category	C	Professional Core	L	T	P	C
							3	0	2	4

Pre-requisite Courses	Nil	Co-requisite Courses	Nil	Progressive Courses	Nil
Course Offering Department	Nanotechnology	Data Book / Codes/Standards	Nil		

Course Learning Rationale (CLR):	The purpose of learning this course is to:
CLR-1 :	*Understand the interaction of nanomaterials with biological systems*
CLR-2 :	*Know about the properties of biomaterials*
CLR-3 :	*Learn various applications of nanotechnology in biology*
CLR-4 :	*Apply the nanoscience concepts in biotechnology*
CLR-5 :	*Utilize various biological techniques to understand nano bio interactions*
CLR-6 :	*Demonstrate skills in nanobiotechnology experimental techniques*

Course Learning Outcomes (CLO):	At the end of this course, learners will be able to:	Learning 1: Level of Thinking (Bloom)	Learning 2: Expected Proficiency (%)	Learning 3: Expected Attainment (%)
CLO-1 :	*Choose appropriate biomaterial for biological application*	1	80	75
CLO-2 :	*Explain the concept of biocompatibility*	1	80	70
CLO-3 :	*Perform experiments like Electrophoresis, Protein estimation and Drug loading*	2	75	70
CLO-4 :	*Describe about various biological molecules.*	2	80	75
CLO-5 :	*Analyze the interaction of nanomaterials with biomolecules*	2	80	80
CLO-6 :	Demonstrate skills required for application of nanotechnology in biology	2	80	80

Program Learning Outcomes (PLO)

	1 Engineering Knowledge	2 Problem Analysis	3 Design & Development	4 Analysis, Design, Research	5 Modern Tool Usage	6 Society & Culture	7 Environment & Sustainability	8 Ethics	9 Individual & Team Work	10 Communication	11 Project Mgt. & Finance	12 Life Long Learning	13 PSO - 1	14 PSO - 2	15 PSO - 3
CLO-1	H	M	H	H	H	H	H	H	M	H	L	H	H	H	H
CLO-2	H	M	H	H	M	M	M	H	M	H	M	H	M	M	M
CLO-3	H	H	H	H	H	H	H	H	M	H	L	H	H	H	H
CLO-4	H	H	H	H	H	H	H	H	M	H	M	H	H	H	H
CLO-5	H	H	H	H	H	H	H	H	M	H	L	H	H	H	H
CLO-6	H	H	H	H	H	H	H	H	M	H	M	H	H	H	H

Duration (hour)		15	15	15	15	15
S-1	SLO-1	*Biomaterials*	*Structure of membranes*	*Nanodiagnosis*	*Drug delivery systems*	*Biosensor*
	SLO-2	*Surface and bulk properties of bio materials*	*Lipid bilayer*	*Detection of tumors*	*Traditional drug delivery*	*Nanobiosensors design*
S-2	SLO-1	*Nanoceramics*	*Traffic across membranes*	*Detection of plaque*	*Controlled drug delivery*	*optical biosensors based on nanoplasmonics*
	SLO-2	*Polymeric nanoparticles*	*Endocytosis*	*Genetic defects*	*Nanoparticle based drug delivery*	*Nanoimmuno sensors*
S-3	SLO-1	*Hydroxyapatite: Structures, Chemical composition*	*Exocytosis*	*Nano medical devices.*	*Targeted drug delivery to cancer*	*Immuno Fluorescent Biomarker Imaging*
	SLO-2	*Applications of hydroxyapatite*	*Receptor mediated transport*	*In vivo imaging*	*Types of drug targeting*	*Iron Oxide Nanoparticles in Magnetic Resonance Imaging*
S 4-5	SLO-1 SLO-2	*Lab 1:Introduction to Nanobiotechnology laboratory*	*Lab 4: Analysis of antimicrobial activity of nanoparticles*	*Lab 7: Hemocompatability analysis of nanoparticles*	*Lab 10: Fabrication of nanoparticles incorporated scaffolds for tissue engineering*	*Lab 13: Determination of controlled drug release from controlled drug delivery system*
S-6	SLO-1	*Surface modification of biomaterials*	*Active transport*	*Nanotechnology in gene therapy*	*Surface Modified Nanoparticles*	*Nanotechnology in food processing*
	SLO-2	*Surface immobilized biomolecules*	*Passive transport*	*Stem cells*	*Peptide/DNA Coupled Nanoparticles for drug delivery and targeting*	*Food preservation*
S-7	SLO-1	*Interaction of biomaterials with cells*	*Membrane transporters*	*Polymerase chain reaction*	*Lipid Nanoparticles For Drug Delivery and targeting*	*Nanomaterials for food packing*
	SLO-2	*Immune response to biomaterials*	*Membrane proteins and Pumps*	*Enzyme-linked immunosorbent assay(ELISA)*	*Inorganic Nanoparticles For Drug Delivery*	*Delivery of nutraceuticals*
S-8	SLO-1	*Biocompatibility*	*Antibodies*	*DNA profiling*	*Metal/Metal Oxide Nanoparticles for antibacterial/anti-fungal/anti-viral activity*	*Delivery of functional foods*
	SLO-2	*In vitro analysis*	*Monoclonal antibodies*	*Nanoprobes*	*Hyperthermia treatment*	*Nanosensors for food Pathogen Detection*
S 9-10	SLO-1 SLO-2	*Lab 2: Preparation of media, slants and plates for bacterial growth*	*Lab 5: Isolation of Genomic DNA*	*Lab 8: Amplification of DNA by PCR*	*Lab 11: Quantitation estimation of biomolecules*	*Lab 14: Fluorescent imaging of nano-bio interaction*

S-11	SLO-1	*In vivo analysis*	*Nanoimmuno assay*	*Blotting techniques*	*Dental implants*	*Nanotechnology in agriculture*
	SLO-2	*Tissue compatibility*	*Blood-Biomaterial Interactions*	*Western Blotting*	*Regenerative medicine*	*Nanoformulation For The Control Of Plant Disease*
S-12	SLO-1	*Biomolecular motors*	*Interactions with Proteins*	*Surface plasmon Resonance*	*Tissue engineering*	*Nanomaterials for PEST control in PLANTS*
	SLO-2	*Linear motors*	*Cell Adhesion*	*Surface enhanced Raman scattering*	*Nanoparticles and polymeric nanofibers in tissue engineering*	*Nanotechnology and Agricultural Sustainable Development*
S-13	SLO-1	*Rotary motors*	*Biocompatibility*	*Analysis of biomolecular structure by AFM*	*Scaffold design and fabrication*	*Toxicity of nanomaterials*
	SLO-2	*Actin and myocin*	*Safety Testing of Biomaterials*	*Analysis of biomolecular structure by molecular pulling force spectroscopy*	*Controlled release strategies in tissue engineering*	*Environmental risks of nanomaterials*
S 14-15	SLO-1 SLO-2	*Lab 3: Growth of Bacteria by pour plate, spread plate and streak plate techniques*	*Lab 6: DNA fragmentation analysis by Agarose gel electrophoresis*	*Lab 9: Repeat/Revision of the experiments*	*Lab 12: Estimation of drug loading percentage*	*Lab 15: Protein separation by SDS PAGE analysis*

Learning Resources	1. *Niemeyer, C.M. and Mirkin, C.A., Nanobiotechnology: Concepts, Applications and Perspectives, Wiley-VCH, 2004.* 2. *Madhuri Sharon, Maheshwar Sharon, Sunil Pandey and Goldie Oza, Bio-Nanotechnology_ Concepts and applications. Ane Books Pvt Ltd, 1 edition 2012.*	3. *Goodsell, D.S., Bionanotechnology, John Wiley and Sons, Inc., 2004.*

Learning Assessment											
	Bloom's Level of Thinking	Continuous Learning Assessment (50% weightage)								Final Examination (50% weightage)	
		CLA – 1 (10%)		CLA – 2 (15%)		CLA – 3 (15%)		CLA – 4 (10%)#			
		Theory	Practice	Theory	Practice	Theory	Practice	Theory	Practice	Theory	Practice
Level 1	Remember Understand	*20%*	*20%*	*15%*	*15%*	*15%*	*15%*	*15%*	*15%*	*15%*	*15%*
Level 2	Apply Analyze	*20%*	*20%*	*20%*	*20%*	*20%*	*20%*	*20%*	*20%*	*20%*	*20%*
Level 3	Evaluate Create	*10%*	*10%*	*15%*	*15%*	*15%*	*15%*	*15%*	*15%*	*15%*	*15%*
	Total	100 %		100 %		100 %		100 %		1000%	

CLA – 4 can be from any combination of these: Assignments, Seminars, Tech Talks, Mini-Projects, Case-Studies, Self-Study, MOOCs, Certifications, Conf. Paper etc.,

Course Designers		
Experts from Industry	Experts from Higher Technical Institutions	Internal Experts
1. Mr. K. Chandru Trivitron Healthcare Pvt. Ltd. Chennai, chandru.k@trivitron.com	*1. Dr. Mukesh Doble, IIT M, mukeshd@iitm.ac*	*1. Dr. G. Devanand Venkatasubbu, SRMIST*
2. Dr. Asifkhan Shanavas, INST Mohali, asifkhan@inst.ac.in	*2. Dr. T. Prakash, UOM, thanigaiprakash@gmail.com*	*2.Dr. N. Selvamurugan,, SRMIST*

Course Code	18NTC203T	Course Name	NANOTOXICOLOGY	Course Category	C	Professional Core	L	T	P	C
							3	0	0	3

Pre-requisite Courses	Nil	Co-requisite Courses	Nil	Progressive Courses	Nil
Course Offering Department	Nanotechnology	Data Book / Codes/Standards	Nil		

Course Learning Rationale (CLR):	The purpose of learning this course is to:
CLR-1 :	*Understand the concept of toxicity*
CLR-2 :	*Acquire knowledge on physical properties of nanostructured materials on toxicity*
CLR-3 :	*Learn about nanoparticle interaction with cells*
CLR-4 :	*Know about various methods of toxicity assessment*
CLR-5 :	*Learn various in vivo toxicity methods*
CLR-6 :	*Gain knowledge about the toxic nanomaterials and their properties*

Course Learning Outcomes (CLO):	At the end of this course, learners will be able to:	Learning 1: Level of Thinking (Bloom)	2: Expected Proficiency (%)	3: Expected Attainment (%)	PLO 1: Engineering Knowledge	2: Problem Analysis	3: Design & Development	4: Analysis, Design, Research	5: Modern Tool Usage	6: Society & Culture	7: Environment & Sustainability	8: Ethics	9: Individual & Team Work	10: Communication	11: Project Mgt. & Finance	12: Life Long Learning	13: PSO - 1	14: PSO - 2	15: PSO - 3
CLO-1 :	*Aware about toxicity caused by nanomaterials*	1	80	75	H	M	H	H	H	H	H	H	M	H	M	H	H	H	H
CLO-2 :	*Relate the physical properties of nanostructured materials to its toxicity*	1	80	70	H	M	H	H	M	M	M	H	M	H	M	H	M	M	M
CLO-3 :	*Analyze the various symptoms caused due to toxicity of nanoparticles*	2	75	70	H	H	H	H	H	H	H	H	M	H	M	H	H	H	H
CLO-4 :	*Apply the various methods of toxicity assessment*	2	80	75	M	H	H	M	H	H	H	H	M	H	M	H	H	H	H
CLO-5 :	*Analyze the in vivo toxicity data*	2	80	80	M	H	H	M	H	M	H	H	M	H	M	M	H	H	H
CLO-6 :	*Demonstrate skills required for application of nanotechnology in toxicity studies*	2	80	80	M	H	H	M	H	M	H	H	M	H	M	M	H	H	H

Duration (hour)		9	9	9	9	9
S-1	SLO-1	*Introduction to toxicity*	*Nanoparticles vs. micron-size particle*	*Interaction of nanoparticles with lipid bilayers*	*Methods for toxicity assessment*	*In vivo Analysis*
	SLO-2	*Size-specific behavior of nanomaterials*	*Nanoparticle toxicity*	*Cell-level studies*	*LADMET hypothesis*	*species and strains of animals used in toxicity studies*
S-2	SLO-1	*Challenges in Nanotoxicology*	*Comparison to larger counterparts*	*Nanoparticle-induced membrane permeability*	*Effects of Nanoparticle on the Cardiovascular System*	*Dosing profile for animal models*
	SLO-2	*Entry Routes into the Human Body*	*Requirement for appropriate model*	*Internalization of cation nanoparticles into cells*	*Thrombosis*	*Studies on toxicology*
S-3	SLO-1	*Importance of size and shape of Nano particle*	*Exposure assessment*	*Placental Barrier*	*Cardiac ischemia*	*Histopathology studies*
	SLO-2	*Physicochemical properties of nanomaterials*	*Types of exposure pathways*	*Biological barrier model evaluation of nanoparticle transfer*	*Fibrinolysis*	*metabolism in mouse and rat*
S-4	SLO-1	*Mediators of nano toxicity*	*Significance of Exposure assessment*	*Transport across placental barrier*	*Coagulation*	*Predicting Penetration of nanomaterials*
	SLO-2	*physicochemical properties of Nanomaterials related to toxicity*	*Occurrence of exposure pathways*	*Assessment of placental Transfer*	*Endothelial Dysfunction*	*Fate of Nanoparticles in the Body*
S-5	SLO-1	*Characterization of administered nanomaterials*	*Nature of exposures*	*Biological mechanism of nanoparticle disposition*	*Effect of Nanoparticles on Nervous system*	*Toxicity Mechanisms*
	SLO-2	*Toxicity studies*	*Documentation of toxicity*	*Outline of gene*	*Effect of Nanoparticles on Genotoxicity*	*Mechanisms for Radical Species Production*
S-6	SLO-1	*Nanomaterial characterization after administration*	*Bio-distribution of nanoparticles*	*Cellular interactions*	*Effect of Nanoparticles on carcinogenicity*	*Genotoxicity Mechanisms*
	SLO-2	*Source and types of Nanoparticles-*	*Localization of particles in tissues*	*Nano Biointeractions*	*Mechanism of carcinogenecity*	*Detection of Genotoxicity*
S-7	SLO-1	*Particles due to airpollution*	*Nanoparticles in the environment*	*Toxicity based on route of entry*	*Toxicity caused to Organ by Nanoparticles*	*Characterization of Genotoxicity*
	SLO-2	*Biotoxicity of metal oxide Nanoparticles*	*Nanoparticles in mammalian system*	*Nature of toxicity*	*Effect of nanoparticles on Respiratory system*	*Inflammation analysis*

S-8	SLO-1	*Carbon nanotubes in practice*	*Health threats due to Nanoparticles*	*Toxicodynamics*	*Dermal toxicity analysis*	*Biocompatibility studies*
	SLO-2	*Postproduction processing of carbon nanotubes*	*Nanoparticle translocation in mammalian system*	*Dose vs Toxicity Relationships*	*Hepato toxicity analysis*	*Laws and Regulations Governing Animal Care and Use in Research*
S-9	SLO-1	*Toxicity of Carbon nano tubes*	*Direct vascular effects in mammalian system*	*Toxicokinetics*	*Nephrotoxicity studies*	*Factors Affecting Exposure to Nanomaterials*
	SLO-2	*Body Distribution;Nanoparticles and Cellular Uptake*	*Role of Nanoparticles in Mediating the Adverse Pulmonary Effects*	*Absorption, distribution, metabolism excretion studies (ADME)*	*Assessment of oxidative stress and antioxidant status*	*Elements of a Risk Management Program*

Learning Resources	1. *Niemeyer, C.M. and Mirkin, C.A., "Nanobiotechnology: Concepts, Applications and Yuliang Zhao, Hari Singh Nalwa, "Nanotoxicology: interactions of nanomaterials with biological systems", American Scientific Publishers, 2007.* 2. *Lynn Goldman, Christine Coussens, "Implications of nanotechnology for environmental health research", National Academic Press, Washington, 2007.*	3. *Approaches to safe nanotechnology: Managing the health and safety concerns associated with Engineered Nanomaterials", DHHS (NIOSH) publishers, 2009*

Learning Assessment

	Bloom's Level of Thinking	Continuous Learning Assessment (50% weightage)								Final Examination (50% weightage)	
		CLA – 1 (10%)		CLA – 2 (15%)		CLA – 3 (15%)		CLA – 4 (10%)#			
		Theory	Practice	Theory	Practice	Theory	Practice	Theory	Practice	Theory	Practice
Level 1	Remember Understand	*40%*	-	*30%*	-	*30%*	-	*30%*	-	*30%*	-
Level 2	Apply Analyze	*40%*	-	*40%*	-	*40%*	-	*40%*	-	*40%*	-
Level 3	Evaluate Create	*20%*	-	*30%*	-	*30%*	-	*30%*	-	*30%*	-
	Total	100 %		100 %		100 %		100 %		100%	

CLA – 4 can be from any combination of these: Assignments, Seminars, Tech Talks, Mini-Projects, Case-Studies, Self-Study, MOOCs, Certifications, Conf. Paper etc.,

Course Designers

Experts from Industry	Experts from Higher Technical Institutions	Internal Experts
1. Mr. K. Chandru Trivitron Healthcare Pvt. Ltd. Chennai, chandru.k@trivitron.com	*1. Dr. Asifkhan Shanavas, INST Mohali, asifkhan@inst.ac.in*	*1. Dr. G. Devanand Venkatasubbu, SRMIST*
2. Dr. Achuth Padmanaban, Baylor College of Medicine, USA, achuthz@gmail.com	*2. Dr. Dayanand Reddy, CRIS Chennai, dayanand01@gmail.com*	*2. Dr. Selvamurugan, SRMIST*

Course Code	18NTC204J	Course Name	NANOELECTRONICS	Course Category	C	Professional Core	L	T	P	C
							3	0	2	4

Pre-requisite Courses	Nil	Co-requisite Courses	Nil	Progressive Courses	Nil
Course Offering Department	Nanotechnology	Data Book / Codes/Standards	Nil		

Course Learning Rationale (CLR):	*The purpose of learning this course is to:*
CLR-1 :	*Acquire knowledge on quantum confinement and low-dimensional nanostructures for use in nanoelectronics*
CLR-2 :	*Understand the key aspects of electron tunneling and its application in the operation of nanodevices.*
CLR-3 :	*Understand the functioning of tunnel junctions in single electron devices*
CLR-4 :	*Understand the concept of molecular electronics for realization of device miniaturization*
CLR-5 :	*Acquire knowledge on the fabrication, characterization and modeling of nanodevices*
CLR-6 :	*Acquire knowledge on designing and fabrication process which is Essential for simulation of nanoelectronic devices.*

Course Learning Outcomes (CLO):	*At the end of this course, learners will be able to:*	Learning 1: Level of Thinking (Bloom)	Learning 2: Expected Proficiency (%)	Learning 3: Expected Attainment (%)	PLO 1: Engineering Knowledge	PLO 2: Problem Analysis	PLO 3: Design & Development	PLO 4: Analysis, Design, Research	PLO 5: Modern Tool Usage	PLO 6: Society & Culture	PLO 7: Environment & Sustainability	PLO 8: Ethics	PLO 9: Individual & Team Work	PLO 10: Communication	PLO 11: Project Mgt. & Finance	PLO 12: Life Long Learning	PLO 13: PSO - 1	PLO 14: PSO - 2	PLO 15: PSO - 3
CLO-1 :	*Acquaint with the fundamentals of nanoelectronics*	1	80	75	H	H	M	M	M	M	H	H	H	H	M	H	H	H	H
CLO-2 :	*Utilize their knowledge on the electron tunneling phenomena in semiconductor nanodevices*	1	80	70	H	H	M	M	M	M	H	H	H	H	M	H	H	H	H
CLO-3 :	*Apply the knowledge on the operation and application perspectives of various tunnel devices*	2	75	70	H	H	H	H	H	H	H	H	M	H	M	H	H	H	H
CLO-4 :	*Analyze the concept of molecular electronics*	2	80	75	M	H	M	M	H	H	H	H	M	H	L	H	M	M	M
CLO-5 :	*Apply their knowledge on the fabrication and modeling of nanodevices*	2	80	80	H	H	H	H	H	H	H	H	H	H	L	H	H	H	H
CLO-6 :	*Demonstrate skills required for using advanced experimental techniques*	2	80	75	H	M	M	H	M	M	M	H	H	H	M	H	H	M	H

Duration (hour)		15	15	15	15	15
S-1	SLO-1	*Introduction to nanoelectronics*	*Tunnel effect and tunneling elements*	*Classical and semi-classical transport*	*Introduction to molecular electronics*	*Introduction to computational methods*
	SLO-2	*Review of basic quantum physics*	*Nanoelectronics in tunneling devices*	*Ballistic transport in nanostructures*	*Atomic-scale junctions: an overview*	*Necessity of computational methods*
S-2	SLO-1	*Moore's law and its consequences*	*Tunneling of electrons through a potential barrier*	*Coulomb blockade - an overview*	*Schrodinger equation*	*Molecular wire*
	SLO-2	*Silicon electronics - limitations*	*Electron tunneling–key points*	*Single electron tunneling and Coulomb blockade*	*Self-consistent field*	*Molecular wire conductance*
S-3	SLO-1	*International technology roadmap characteristics (ITRC)*	*Potential energy profiles for material interfaces*	*Coulomb blockade in a quantum dot circuit*	*Molecular functionalities*	*Theoretical aspects on molecular conductance*
	SLO-2	*ITRC and Nanoscale importance*	*Metal-semiconductor and metal-insulator junctions*	*Coulomb blockade in a nano-capacitor*	*Metal-molecule interfaces*	*Computational aspects on molecular conductance*
S 4-5	SLO-1 SLO-2	*Lab 1: Determination of electron concentration versus temperature using MATLAB*	*Lab 4: Four probe resistivity measurement*	*Lab 7: PSpice simulation of FET and its I-V characteristics*	*Lab 10: PSpice simulation of MOSFETs using a simple DC circuit and a CMOS inverter with DC sweep analysis*	*Lab 13: Simulation of diode using TCAD and its characterization*
S-6	SLO-1	*Need for new concepts in electronics*	*Metal-insulator-metal junctions*	*Ballistic transport and the Landauerformula*	*Molecular band Structure*	*Various modeling techniques*
	SLO-2	*Challenges in micro to Nano conversion*	*Metal work function and electron affinity*	*Quantized Conductance*	*Level broadening*	*Monte Carlo method*
S-7	SLO-1	*Dimensionality in materials*	*Tunneling applications*	*Working principle of Single Electron Transistor (SET)*	*Atomistic view of electrical resistance*	*Ab initio simulations*
	SLO-2	*Density of states of materials at nanoscale*	*Field electron emission*	*A single-electron pump and turnstile*	*Conductance of atomic-scale contacts*	*Ab initio simulations: examples and problems*
S-8	SLO-1	*Effect of band gap of material at different dimensions*	*Double barrier tunneling*	*Quantum dot*	*Coherent transport through molecular junctions*	*Multiscale modeling*
	SLO-2	*Length scales of charge scattering*	*Resonant tunneling diodes*	*Quantum-dot cellular automata*	*Non-coherent transport in molecular electronics devices*	*Modeling of nanodevices and applications*

S 9-10	SLO-1	Lab 2: Determination of electron (μn) and hole (μp) mobilities versus doping concentration in semiconductor using MATLAB	Lab 5: PSpice simulation of diode and its I-V characteristics with smoke analysis	Lab 8: Hall effect of semiconductors	Lab 11: PSpice simulation of Zener Diode model and its I-V characteristics	Lab 14: Designing of 2D MOSFET using TCAD
	SLO-2					
S-11	SLO-1	Special dimensionality case of carbon	Tunneling in MOS Transistors	Electron transport in quantum dots	Molecular diodes	TCAD
	SLO-2	Introduction to 0D, 1D, 2D and 3D carbon forms	nel transistor	Electron transport in quantum wires	Conducting mechanism of single-molecule junctions	TCAD: examples and problems
S-12	SLO-1	Nanocomputing	Hot electron effects in MOSFETs	Introduction to spintronics	Single-molecule transistors	NEH DFT
	SLO-2	Device simulation software at nanoscale	Gate-oxide tunneling	Giant magneto resistance	Elastic and inelastic co-tunneling	NEH DFT: examples and problems
S-13	SLO-1	Future Prospects of Nanoelectronic Devices	Principles of scanning tunneling microscopy (STM)	Tunnel magneto resistance	Molecular devices and logic switches	Materials studio
	SLO-2	Progress in Nanoelectronic Architectures	Applications of STM in nanotechnology	Spintronic devices and applications	Interface engineering issues	Future of nanoscale modeling
S 14-15	SLO-1	Lab 3: Determination of Fermi function for different temperature using MATLAB	Lab 6: PSpice simulation of BJT and its I-V characteristics	Lab 9: Repeat/Revision of the experiments	Lab 12: PSpice simulation of a Phototransistor	Lab 15: Repeat/Revision of the experiments
	SLO-2					

Learning Resources	1. G. W. Hanson, Fundamentals of Nanoelectronics, Pearson Education; 1 edition (2009) 2. V. V. Mitin, V. A. Kochelap, M. A. Stroscio, Introduction to Nanoelectronics, Cambridge University Press; 1 edition (2007) 3. E. Scheer and J. C. Cuevas, Molecular Electronics: An Introduction to Theory and Experiment, World Scientific Pub Co Inc; 1 edition (2010) 4. K. I. Ramachandran, Computational Chemistry and Molecular Modeling, Springer, 2008 5. Nanoelectronics simulation laboratory course manual, 2016	6. Sarhan. M. Musa, Computational Nanotechnology: Modeling and Applications with MATLAB", CRC Press, 2011 7. John O. Attia, Electronics and Circuit Analysis using Matlab, CRC Press, 2001 8. Mitchell A. Thornton, PSpice for Circuit Theory and Electronic Devices,Morgan& Claypool Publishers series 9. Simon Li and Yue Fu, 3D TCAD Simulation for Semiconductor Processes,Devices and Optoelectronics, Springer,2012

Learning Assessment

	Bloom's Level of Thinking	Continuous Learning Assessment (50% weightage)								Final Examination (50% weightage)	
		CLA – 1 (10%)		CLA – 2 (15%)		CLA – 3 (15%)		CLA – 4 (10%)#			
		Theory	Practice	Theory	Practice	Theory	Practice	Theory	Practice	Theory	Practice
Level 1	Remember Understand	20%	20%	15%	15%	15%	15%	15%	15%	15%	15%
Level 2	Apply Analyze	20%	20%	20%	20%	20%	20%	20%	20%	20%	20%
Level 3	Evaluate Create	10%	10%	15%	15%	15%	15%	15%	15%	15%	15%
	Total	100 %		100 %		100 %		100 %		50%	50%

CLA – 4 can be from any combination of these: Assignments, Seminars, Tech Talks, Mini-Projects, Case-Studies, Self-Study, MOOCs, Certifications, Conf. Paper etc.,

Course Designers

Experts from Industry	Experts from Higher Technical Institutions	Internal Experts
1. Dr. Krishna Surendra Muvvala, Saint Gobain Research India, India, Krishna.muvvala@saintgobain.com	1. Prof.. V. Subramaniam IIT M, manianvs@iitm.ac.in	1. Dr. D. John Thiruvadigal, SRMIST
2. Dr. Hemant Dixit, Global Foundaries,USA, aplahemant@gmail.com	2. Prof. C. Venkateswaran, Univ. of Madras, cvenkateswaran@unom.ac.in	2. Dr.Arijith Sen, SRMIST

Course Code	18NTC205J	Course Name	MICRO AND NANOFABRICATION	Course Category	C	Professional Core	L	T	P	C
							3	0	1	4

Pre-requisite Courses	SOLID STATE ENGINEERING	Co-requisite Courses	Nil	Progressive Courses	Nil
Course Offering Department	Nanotechnology	Data Book / Codes/Standards	Nil		

Course Learning Rationale (CLR):	*The purpose of learning this course is to:*
CLR-1 :	*Overview the techniques and processes to organize nanoscale materials in device form*
CLR-2 :	*Understand methodology of lithography and etching to pattern materials*
CLR-3 :	*Acquire knowledge of different deposition techniques and ion implantation*
CLR-4 :	*Get acquainted with CMOS fabrication rules*
CLR-5 :	*Introduce next generation printed electronics technology*
CLR-6 :	*Make aware of VLSI technology*

Course Learning Outcomes (CLO):	*At the end of this course, learners will be able to:*	Learning 1 Level of Thinking (Bloom)	2 Expected Proficiency (%)	3 Expected Attainment (%)	PLO 1 Engineering Knowledge	2 Problem Analysis	3 Design & Development	4 Analysis, Design, Research	5 Modern Tool Usage	6 Society & Culture	7 Environment & Sustainability	8 Ethics	9 Individual & Team Work	10 Communication	11 Project Mgt. & Finance	12 Life Long Learning	13 PSO - 1	14 PSO - 2	15 PSO - 3
CLO-1 :	*Realizing the technology of Si wafer manufacturing*	2	80	75	H	M	H	H	H	M	M	H	H	H	M	H	H	H	H
CLO-2 :	*Pattern diverse materials using lithography techniques to enhance the device density on chip*	2	80	70	H	M	M	H	M	M	M	H	M	H	M	H	M	M	M
CLO-3 :	*Applying basic diffusion processes importance in semiconductor technology*	2	75	70	H	M	H	H	H	H	H	M	H	H	H	H	H	H	H
CLO-4 :	*Fabricate small-scale devices and chip level device space management*	2	80	75	M	H	H	M	H	H	H	H	H	H	M	H	H	H	H
CLO-5 :	*Envision low cost production of electronic devices using printed technology*	2	80	70	H	M	H	H	H	M	M	H	M	H	M	H	H	H	H
CLO-6 :	*Imagining importance of nanoscale devices*	2	80	75	H	M	M	H	H	M	M	H	H	H	M	H	H	M	H

Duration (hour)		9	9	9	9	9
S-1	SLO-1	*Importance of micro and nanofabrication techniques in IC: front and back plane*	*Need and basics of lithography*	*Classification of material deposition techniques*	*History of complementary metal-oxide-semiconductor (CMOS)*	*Overview of printing processes*
	SLO-2	*Over view of crystal and lattices*	*Optical lithography*	*Overview of physical and chemical deposition technique*	*Requirements of device isolation*	*Advantages of printing*
S-2	SLO-1	*Classification of grades of silicon*	*Optical lithography controls and mask making*	*Physical vapour deposition*	*Types of isolation*	*Requirements of printing*
	SLO-2	*Production of electronic grade silicon*	*Working concept and controls of e-beam lithography*	*Resistive heating evaporation*	*Local Oxidation of Silicon (LOCOS) and shallow trench isolation (STI) processes for local isolation*	*Printing tools*
S-3	SLO-1	*Czochralski growth technique*	*Resolution of electron beam lithography*	*Electron beam heating evaporation*	*Concept of self-alignment*	*Types of fluids for ink*
	SLO-2	*float zone growth technique*	*X-ray lithography*	*Pulsed laser evaporation*	*MOS fabrication with self-alignment*	*Properties of fluids in printing processes*
S-4,5	SLO-1 SLO-2	*Lab 1:Introduction to the basics of laboratory*	*Lab 4: To perform patterning by photolithography process*	*Lab 7: To deposit Al thin film on the oxidized silicon surface by thermal evaporation*	*Lab 10:To form local anodic oxidation pattern by scanning probe microscopy*	*Lab 13:To perform contact angle measurement of solvents used in printing process*
S-6	SLO-1	*Silicon wafer shaping*	*Stamp based lithography*	*Basics of sputtering*	*Requirement of planarization*	*Working principle of flexographic printing (FP)*
	SLO-2	*Wafer manufacturing steps and inspection*	*Nanoimprint lithography and applications*	*DC and magnetron sources for sputtering*	*Local and global planarization using chemical-mechanical polishing*	*Advantages and disadvantages of FP*
S-7	SLO-1	*Overview of types of epitaxy*	*Etching of silicon*	*Introduction to atomic layer deposition*	*Importance of MOS devices*	*Working principle of gravure printing (GP)*
	SLO-2	*Definition-epitaxy*	*Wet etching mechanism and disadvantages*	*Working principle of atomic layer deposition*	*Concept of well formation with p and n doping*	*Advantages and disadvantages of GP*
S-8	SLO-1	*Comparison of vapour phase epitaxy (VPE), liquid phase epitaxy (LPE) and molecular beam epitaxy (MBE)*	*Types of dry etching*	*Concepts of diffusion*	*Working principle of integrated CMOS inverter*	*Working principle of screen printing (SP)*

	SLO-2	*Working of MBE process*	*Ways of plasma generation for etching processes, Sputter etching*	*Using Fick's diffusion in semiconductor doping*	*Fabrication process of CMOS inverter*	*Advantages and disadvantages of SP*
S-9,10	SLO-1	*Lab 2: To perform wafer cleaning processes followed for VLSI applications*	*Lab 5: To perform wet chemical etching of silicon dioxide*	*Lab 8: To deposit Al thin film on the oxidized silicon surface by e-beam evaporation*	*Lab 11: To design MOS capacitor design layout using 'layout editor'*	*Lab 14: To measure gauge factor of flexible strain gauge*
	SLO-2					
S-11	SLO-1	*General epitaxy growth mechanism*	*Capacitively coupled plasma*	*Process of ion implantation*	*Usage of isolation and biasing of inverter*	*Working principle of inkjet printing (IP)*
	SLO-2	*Epitaxy growth kinetics and examples*	*Inductively coupled plasma*	*Ion implantation tool*	*'Latch up' concept for inverter*	*Advantages and disadvantages of IP*
S-12	SLO-1	*Understanding silicon oxide properties*	*Classification of plasma using its density*	*Fundamentals of ion energy loss and stopping*	*Design rules for CMOS*	*Examples of printed devices*
	SLO-2	*Thermal oxidation furnace*	*High density plasma*	*Damage due to implantation*	*MOSIS specifics for inverter*	*Comparison of printed devices with lithographically fabricated devices*
S-13	SLO-1	*Silicon oxide growth kinetics*	*Reactive ion etching*	*Ion distribution, junction control*	*Introduction to silicon-on-insulator (SOI)*	*Concept of hybrid printed electronics*
	SLO-2	*Thin oxide growth and process of oxidizing polysilicon*	*Deep reactive ion etching and bosh process*	*Carrier recovery using annealing process*	*On chip fabrication processes of passive components*	*Future of printed low-cost electronics*
S-14,15	SLO-1	*Lab 3: To oxidize silicon under O_2 ambient using temperature controlled furnace*	*Lab 6: To perform wet chemical etching of metal films*	*Lab 9: To perform ion beam implantation process and defect analysis using SRIM software*	*Lab 12: To fabricate MOS capacitor and study its I-V characteristics*	*Lab 15: Repeating of experiments*
	SLO-2					

Learning Resources	1. *Hans H. Gatzen, Volker Saile, Jürg Leuthold, "Micro and Nano Fabrication", Springer 2015* 2. *S. M. Sze, and S. Lee, "Semiconductor Devices Physics and Technology", Wiley, 2012*	3. *Giovanni Nisato, Donald Lupo, Simone Ganz, "Organic and Printed Electronics", CRC Press, 2016.* 4. *Sorab K. Gandhi, "VLSI Fabrication and Principles", McGraw Hill, 2005*

Learning Assessment

	Bloom's Level of Thinking	Continuous Learning Assessment (50% weightage)								Final Examination (50% weightage)	
		CLA – 1 (10%)		CLA – 2 (15%)		CLA – 3 (15%)		CLA – 4 (10%)#			
		Theory	Practice	Theory	Practice	Theory	Practice	Theory	Practice	Theory	Practice
Level 1	Remember Understand	*20%*	*20%*	*15%*	*15%*	*15%*	*15%*	*15%*	*15%*	*15%*	*15%*
Level 2	Apply Analyze	*20%*	*20%*	*20%*	*20%*	*20%*	*20%*	*20%*	*20%*	*20%*	*20%*
Level 3	Evaluate Create	*10%*	*10%*	*15%*	*15%*	*15%*	*15%*	*15%*	*15%*	*15%*	*15%*
	Total	100 %		100 %		100 %		100 %		100 %	

CLA – 4 can be from any combination of these: Assignments, Seminars, Tech Talks, Mini-Projects, Case-Studies, Self-Study, MOOCs, Certifications, Conf. Paper etc.,

Course Designers

Experts from Industry	Experts from Higher Technical Institutions	Internal Experts
1. Dr. Hemant Dixit, GlobalFoundaries,USA, aplahemant@gmail.com	*1. Dr. A. Subrahmanyam, IIT Madras, manu@iitm.ac.in*	*1. Dr. Abhay Sagade, SRMIST*
2. Dr. Krishna Surendra Muvvala, Saint Gobain Research India, India, Krishna.muvvala@saintgobain.com	*2. Dr. N. N. Murthy, IIT Tirupati, nnmurty@iittp.ac.in*	*2. Dr. P. Malar, SRMIST*

Course Code	18NTC301J	Course Name	POLYMER AND NANOCOMPOSITES	Course Category	C	Professional Core Course	L	T	P	C
							3	0	2	4

Pre-requisite Courses	Nil	Co-requisite Courses	Nil	Progressive Courses	Nil
Course Offering Department	Nanotechnology	Data Book / Codes/Standards	Nil		

Course Learning Rationale (CLR):	*The purpose of learning this course is to:*
CLR-1 :	*Acquire knowledge about fundamentals of polymers*
CLR-2 :	*Understand basics concepts about polymerization reactions*
CLR-3 :	*Gain insight into the importance of polymers in nanotechnology*
CLR-4 :	*Understand the physical and mechanical properties of polymer*
CLR-5 :	*Gain knowledge about the preparation and properties of nanocomposites*
CLR-6 :	*Understand the significance of nanosize on polymer and composites*

Course Learning Outcomes (CLO):	*At the end of this course, learners will be able to:*	Learning 1: Level of Thinking (Bloom)	2: Expected Proficiency (%)	3: Expected Attainment (%)	PLO 1: Engineering Knowledge	2: Problem Analysis	3: Design & Development	4: Analysis, Design, Research	5: Modern Tool Usage	6: Society & Culture	7: Environment & Sustainability	8: Ethics	9: Individual & Team Work	10: Communication	11: Project Mgt. & Finance	12: Life Long Learning	13: PSO - 1	14: PSO - 2	15: PSO - 3
CLO-1 :	*Apply the chemical concepts to understand the configuration and conformation of polymers*	1	80	75	H	M	H	H	H	H	M	H	M	H	M	H	H	H	H
CLO-2 :	*Analyze the mechanical behavior of polymers by studying its properties*	1	80	70	H	M	H	H	M	M	M	H	M	H	L	H	M	M	M
CLO-3 :	*Utilize the basic principles about polymerization to synthesize polymers using monomers*	2	75	70	H	H	H	H	H	M	H	H	M	H	L	H	H	H	H
CLO-4 :	*Apply the knowledge about fibers and matrix materials in making nanocomposites*	2	80	75	H	H	H	H	H	H	H	H	H	H	M	H	H	H	H
CLO-5 :	*Analyze the types of matrix and reinforcements available for the preparation of nanocomposites*	2	80	80	H	H	H	H	H	H	H	H	H	H	M	H	H	H	H
CLO-6 :	*Utilize the knowledge about polymers towards environmental and biomedical applications*	2	80	80	H	H	H	H	H	H	H	H	H	H	H	H	H	H	H

Duration (hour)		15	15	15	15	15
S-1	SLO-1	*Importance of polymers: basic concepts*	*Conducting polymers*	*Introduction and additives of composites*	*Metal – Polymer Nanocomposites*	*Metal Matrix Nanocomposites*
	SLO-2	*Classification of polymers on the basis of microstructures & macrostructures*	*Discovery*	*Characteristics of composites*	*Physical and chemical properties of Nanosized metal particles*	*Introduction to metal matrix composites*
S-2	SLO-1	*polymer classifications based on-occurrence, types, process and applications*	*Structural characteristics*	*Classification- particulate, fibrous*	*Metal containing polymers: cryochemical synthesis, structure and physio-chemical properties*	*Reinforcement and matrix materials*
	SLO-2	*Chain structure, configuration and conformation*	*Intrinsic and extrinsic conduction in polymers*	*Laminated and hybrid composites*	*Nanostructured polymer nanoreactors for metal particle formation*	*Mechanism of reinforcement*
S-3	SLO-1	*Homo and heteropolymers - copolymers*	*Charge carriers and conducting mechanism*	*Additives for Composites*	*Metal-polymer nanocomposite synthesis, Ex-situ, In-situ*	*Long fiber, short fiber and particulate*
	SLO-2	*Chemistry of polymerization*	*Chemical and electrochemical methods of synthesis of conducting polymers*	*Catalysts*	*Optically anisotropic metal polymer nanocomposites*	*Interlayer in metal matrix composites*
S 4-5	SLO-1 SLO-2	*Lab 1:Introduction to the basics of Polymer science*	*Lab 4: Preparation of poly vinyl alcohol nanofibers by electro spinning technique*	*Lab 7: Fabrication of polymer thin film composites using phase inversion techniques*	*Lab 10: Preparation of ceramic based nanocomposites*	*Lab 13: Synthesis of particulate reinforced composites*
Coupling Agents	SLO-1	*Molecular solution, Melt and elastomer*	*Synthesis method of polyaniline*	*Accelerators*	*Polymer- Clay Nanocomposites*	*Characterization and relevance to material properties*
	SLO-2	*Crystalline nature of polymers*	*Polypyrrole*		*Synthesis of Nylon 6-clay hybrid (NCH) composites and characterization*	*Ceramic Matrix Nanocomposites*
S-7	SLO-1	*Factors affecting crystallization phenomenon*	*Characterization using UV-Visible and FTIR spectrometer*	*Fillers*	*Crystal structure of NCH and properties of NCH*	*Fibrous monolithic ceramic, fiber reinforced ceramic composites*
	SLO-2	*Glass transition temperature (Tg)*	*Morphological study using SEM and TEM*	*Toughening Agents*	*Polypropylene layered silicate Nanocomposites*	*Whisker reinforced ceramic matrix composite*

S-8	SLO-1	*Melting temperature(Tm)*	*Applications of conducting polymers in corrosion protection*	*Reinforcement Materials*	*Epoxy Nanocomposite*	*Particulate reinforced, graded and layered ceramic composite*
	SLO-2	*Factors affecting Tg and Tm*	*Sensors*	*Fibre Reinforcements*	*Layered silicate Nanocomposites*	*Nanophase ceramic composites*
S 9-10	SLO-1 SLO-2	*Lab 2: Polymerization of Urea-formaldehyde resin*	*Lab 5: Characterization of the fibers prepared using SEM and wettability test*	*Lab 8: Preparation of metal-polymer nanocomposites*	*Lab 11: Morphological characterization of prepared composites using SEM*	*Lab 14: Synthesis of hydrogel using cellulose acetate polymer*
S-11	SLO-1	*Importance of Tg*	*Conducting adhesives*	*Woven and Non-Woven Fabrics*	*Structure, properties and characterization*	*Metal reinforced ceramic matrix nanocomposites*
	SLO-2	*Molecular weight distribution*	*Electro conducting polymers*	*Carbon , Aramid Fibre and Boron Fibres*	*Poly(ethyl acrylate)/bentonite nanocomposites*	*Refractory and special ceramic composites*
S-12	SLO-1	*Degree of polymerization*	*Polymer batteries and electrets*	*Natural Fibres – Cellulose*	*Poly(butylene terephthlate) based Nanocomposites*	*Non-oxide ceramic composites*
	SLO-2	*Reaction kinetics of polymerization*	*Polymers with piezoelectric property*	*Testing of Composites*	*Polymer/calcium carbonate Nanocomposites*	*Machinable Nanocomposite ceramics-Silicon nitride and silicon carbide based ceramics*
S-13	SLO-1	*Dielectric constant*	*Pyroelectric and ferroelectric property*	*Tensile, Impact strength, Compression and Flexural Strength*	*Functional applications of polymer-clay Nanocomposites*	*Functionally graded ceramics- clay Nanocomposites*
	SLO-2	*Polarization; Dissipation factor*	*Photo conducting polymers.*	*Applications of composites*	*Biodegradable polymer categories, properties and drawback*	*Applications of ceramic matric Nanocomposites*
S 14-15	SLO-1 SLO-2	*Lab 3: Interfacial Polymerization of polyamide from Diamine and Diacid Chloride.*	*Lab 6: Fabrication of polymer membrane using phase inversion techniques*	*Lab 9: Repeat/Revision of the experiments*	*Lab 12: Synthesis of Nylon-6 polymer*	*Lab 15: Study of glass transition, melting and crystallization temperature of given materials*

Learning Resources	1. *Gowariker V.R., Viswanathan N.V., Sreedhar J., Polymer Science, New age International publications, 2005* 2. *Luigi Nicolais, Gianfranco Carotenuto,Metal–polymerNanocomposites,Wiley-Interscience,2005* 3. *BorZ.Jang, Advanced Polymer composites, ASM International, USA, 1994.*	4. *Alfred rudin , The elements of polymer science and engineering, 2nd edition, Academic press publication, 1999* 5. *Low I. M., Ceramic matrix composites: Microstructure, properties and applications, Woodhead Publishing Limited, 2006*

Learning Assessment

	Bloom's Level of Thinking	Continuous Learning Assessment (50% weightage)								Final Examination (50% weightage)	
		CLA – 1 (10%)		CLA – 2 (15%)		CLA – 3 (15%)		CLA – 4 (10%)#			
		Theory	Practice	Theory	Practice	Theory	Practice	Theory	Practice	Theory	Practice
Level 1	Remember Understand	20%	20%	15%	15%	15%	15%	15%	15%	15%	15%
Level 2	Apply Analyze	20%	20%	20%	20%	20%	20%	20%	20%	20%	20%
Level 3	Evaluate Create	10%	10%	15%	15%	15%	15%	15%	15%	15%	15%
	Total	100 %		100 %		100 %		100 %		-	

CLA – 4 can be from any combination of these: Assignments, Seminars, Tech Talks, Mini-Projects, Case-Studies, Self-Study, MOOCs, Certifications, Conf. Paper etc.,

Course Designers

Experts from Industry	Experts from Higher Technical Institutions	Internal Experts
1. Dr. P. Sudhakara, CLRI – CSIR, Jalandhar, sudhakarp@clri.res.in	*1. Dr. Kothandaraman Ramanujam, IITM Chennai, rkraman@iitm.ac.in*	*1. Dr. N. Angeline Little Flower. SRMIST*
2. Dr. Sudhakar Selvakumar, CSIR-Central Electrochemical Research Institute, ssudhakar79@gmail.com	*2. Dr.Arthanreeswaran, NIT, Trichy,arthanareeg@nitt.edu*	*2. Dr. C. Siva, SRMIST*

Course Code	18NTC350T	Course Name	COMPREHENSION	Course Category	C	Professional Core	L	T	P	C
							0	1	0	1

Pre-requisite Courses	Nil	Co-requisite Courses	Nil	Progressive Courses	Nil
Course Offering Department	Nanotechnologu	Data Book / Codes/Standards	Nil		

Course Learning Rationale (CLR):	The purpose of learning this course is to:
CLR-1 :	*Acquire skills to develop knowledge in nanotechnology principles*
CLR-2 :	*Acquire skills to understand quantum mechanical concepts of free electron and band theory of solids*
CLR-3 :	*Acquire skills in size effects and reaction kinetics at nanoscale*
CLR-4 :	*Acquire skills in various imaging techniques related to the field of nanotechnology*
CLR-5 :	*Acquire skills in chemistry of biological molecules*
CLR-6 :	*Acquire skills in knowing the electronic property of materials in mesoscopic level*

Course Learning Outcomes (CLO):	At the end of this course, learners will be able to:	Learning 1: Level of Thinking (Bloom)	2: Expected Proficiency (%)	3: Expected Attainment (%)	PLO 1: Engineering Knowledge	2: Problem Analysis	3: Design & Development	4: Analysis, Design, Research	5: Modern Tool Usage	6: Society & Culture	7: Environment & Sustainability	8: Ethics	9: Individual & Team Work	10: Communication	11: Project Mgt. & Finance	12: Life Long Learning	13: PSO - 1	14: PSO - 2	15: PSO - 3
CLO-1 :	*Practice and gain confidence and competence to solve problems in statistical mechanics & thermodynamics*	3	85	80	H	H	H	L	L	L	L	L	L	L	L	L	M	L	M
CLO-2 :	*Practice and gain confidence and competence to solve many body problems using various quantum phenomenon & assumptions*	3	85	80	H	H	M	L	L	L	L	L	L	L	L	L	M	M	M
CLO-3 :	*Practice and gain confidence and competence to solve problems in biophysical principles and dynamics involved in biological systems*	3	85	80	H	H	M	L	L	L	L	L	L	L	L	L	M	L	M
CLO-4 :	*Practice and gain confidence and competence to solve problems & simulation process involved in nanoelectronics devices*	3	85	80	H	H	M	L	L	L	L	L	L	L	L	L	M	M	M
CLO-5 :	*Practice and gain confidence and competence to solve problems using spectroscopic techniques*	3	85	80	H	H	H	L	L	L	L	L	L	L	L	L	M	L	M
CLO-6 :	*Solve problems in the broad domain of Naotechnology and competitive examinations in Nanoscience & NT*	3	85	80	H	H	M	L	L	L	L	L	L	L	L	L	M	M	M

Duration (hour)		3	3	3	3	3
S-1	SLO-1	*Tutorial on Solid State Physics*	*Tutorial on Synthesis Methods of Nanomaterials*	*Tutorial on Nanomagnetism*	*Tutorial on Nanocomposite Materials*	*Tutorial on Nanotoxicology*
	SLO-2	*Problem Solving*	*Problem Solving*	*Problem Solving*	*Problem Solving*	*Problem Solving*
S-2	SLO-1	*Tutorial on Thermodynamics & Statistical Mechanics*	*Tutorial on Nanophotonics*	*Tutorial on Nanoelectronics*	*Tutorial on Nanobiotechnology*	*Tutorial on Environmental Nanoscience*
	SLO-2	*Problem Solving*	*Problem Solving*	*Problem Solving*	*Problem Solving*	*Problem Solving*
S-3	SLO-1	*Tutorial on Biological Principles*	*Tutorial on Micro and Nanofabrication*	*Tutorial on Polymer Technology*	*Tutorial on Quantum Mechanics*	*Tutorial on Industrial Nanotechnology*
	SLO-2	*Problem Solving*	*Problem Solving*	*Problem Solving*	*Problem Solving*	*Problem Solving*

Learning Resources	1. *Sulabha K. Kulkarni, Nanotechnology: Principles and Practices, 3rd Edition, Springer, 2015*

Learning Assessment

	Bloom's Level of Thinking	Continuous Learning Assessment (100% weightage)								Final Examination	
		CLA – 1 (20%)		CLA – 2 (30%)		CLA – 3 (30%)		CLA – 4 (20%)#			
		Theory	Practice	Theory	Practice	Theory	Practice	Theory	Practice	Theory	Practice
Level 1	Remember Understand	-	40%	-	30%	-	30%	-	30%	-	-
Level 2	Apply Analyze	-	40%	-	40%	-	40%	-	40%	-	-
Level 3	Evaluate Create	-	20%	-	30%	-	30%	-	30%	-	-
	Total	100 %		100 %		100 %		100 %		-	

CLA – 4 can be from any combination of these: Assignments, Seminars, Tech Talks, Mini-Projects, Case-Studies, Self-Study, MOOCs, Certifications, Conf. Paper etc.,

Course Designers		
Experts from Industry	Experts from Higher Technical Institutions	Internal Experts
1. Dr. M. Krishna Surendra, Saint-Gobain Research, Chennai, krishna.muvvala@saint-gobain.com	*1. Prof. S. Balakumar, University of Madras, balakumar@unom.ac.in*	*1. Dr. Angeline Littleflower, SRMIST*
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ACADEMIC CURRICULA

Professional Elective Courses

Regulations - 2018

SRM INSTITUTE OF SCIENCE AND TECHNOLOGY

(Deemed to be University u/s 3 of UGC Act, 1956)

Kattankulathur, Kancheepuram, Tamil Nadu, India

ACADEMIC CURRICULA

Professional Elective Courses

AEROSPACE ENGINEERING

Regulations - 2018

SRM INSTITUTE OF SCIENCE AND TECHNOLOGY

(Deemed to be University u/s 3 of UGC Act, 1956)

Kattankulathur, Kancheepuram, Tamil Nadu, India

Course Code	18ASE201T	Course Name	INDUSTRIAL AERODYNAMICS	Course Category	E	Professional Elective	L	T	P	C
							3	0	0	3

Pre-requisite Courses	18ASC202J	Co-requisite Courses	Nil	Progressive Courses	Nil
Course Offering Department	Aerospace Engineering	Data Book / Codes/Standards	Nil		

Course Learning Rationale (CLR):	*The purpose of learning this course is to:*
CLR-1 :	*Understand the application of aerodynamics in fields other than Aerospace*
CLR-2 :	*understand effect of terrain types on the wind flows*
CLR-3 :	*understand the concepts on wind energy and wind turbine aerodynamics*
CLR-4 :	*Understand how buildings are affected by wind flows and how to mitigate the unwanted aerodynamic forces*
CLR-5 :	*Understand how aerodynamics plays a major role in streamlining and drag reduction of automobiles*
CLR-6 :	*Understand the role of aerodynamics in sports balls and vortex induced vibrations*

Course Learning Outcomes (CLO):	*At the end of this course, learners will be able to:*	Learning 1 Level of Thinking (Bloom)	2 Expected Proficiency (%)	3 Expected Attainment (%)	PLO 1 Engineering Knowledge	2 Problem Analysis	3 Design & Development	4 Analysis, Design, Research	5 Modern Tool Usage	6 Society & Culture	7 Environment & Sustainability	8 Ethics	9 Individual & Team Work	10 Communication	11 Project Mgt. & Finance	12 Life Long Learning	13 PSO - 1	14 PSO - 2	15 PSO – 3
CLO-1 :	*Understand different aspects of atmosphere and atmospheric boundary layer*	2	80	70	H	M	L	L	-	-	M	-	-	-	-	-	-	M	L
CLO-2 :	*Acquire knowledge on Atmospheric boundary layer in a wind tunnel*	2	80	70	H	M	M	L	-	-	M	-	-	-	-	-	H	M	M
CLO-3 :	*Learn the working principles of wind turbines*	2	80	70	H	L	L	L	-	-	H	-	-	-	-	-	-	M	M
CLO-4 :	*Appreciate the usefulness of drag reduction devices*	2	80	70	H	L	L	L	-	-	-	-	-	-	-	-	H	H	H
CLO-5 :	*Gain knowledge on building aerodynamics*	2	80	70	H	L	M	L	-	-	M	-	-	-	-	-	M	M	M
CLO-6 :	*Acquire comprehensive understanding on sports aerodynamics*	2	80	70	H	M	L	L	-	-	-	-	-	-	-	-	M	M	M

Duration (hour)		9	9	9	9	9
S-1	SLO-1	*Aerodynamics / Aviation Aerodynamics / Non-Aviation Aerodynamics*	*Need for renewable energy sources*	*Rolling resistance Vs Air resistance*	*Aerodynamics of race cars*	*Introduction to building aerodynamics*
	SLO-2	*Introduction to Industrial Aerodynamics*	*Wind energy and its importance*	*Need for automotive aerodynamics*	*Ground effects*	*Environmental winds in city blocks*
S-2	SLO-1	*Need for Industrial Aerodynamics*	*Wind turbine and its parts*	*History of Automotive Aerodynamics*	*Down force generation*	*Low-rise buildings (LRB)*
	SLO-2	*Branches of Industrial Aerodynamics*	*Classification of wind turbines*	*Evolution of Automobile styling*	*Frontal and rear wings*	*Roof suction effects*
S-3	SLO-1	*Atmospheric layers*	*Horizontal axis wind turbine (HAWT)*	*Classification of cars*	*Aerodynamic braking - Spoilers*	*High-rise buildings (HRB)*
	SLO-2	*Atmospheric circulations*	*Advantages and disadvantages of HAWT*	*Pressure distribution over cars*	*Aerodynamics of wheels*	*Dynamic loads*
S-4	SLO-1	*Local winds*	*Vertical axis wind turbine (VAWT)*	*Aerodynamic forces on Automobiles*	*Introduction to sports aerodynamics*	*Aerodynamic load mitigation techniques for LRB*
	SLO-2	*Terrain types*	*Advantages and disadvantages of VAWT*	*Lift, Drag and Moments*	*Aerodynamics of Cricket ball*	*Aerodynamic load mitigation techniques for HRB*
S-5	SLO-1	*Atmospheric Boundary Layer (ABL)*	*Wind power, Power coefficient*	*Sources of vortices in automobiles*	*Swing and Spin*	*Flow over a simplified building*
	SLO-2	*Aerodynamic Roughness length*	*Tip speed ratio, Solidity ratio*	*Flow separation and wake dynamics*	*Effect of dimples on golf ball*	*Pressure distribution*
S-6	SLO-1	*Mean velocity profiles*	*1-D Momentum theory*	*Aerodynamic Improvements*	*Vortex shedding*	*Wind loads – TVL Formula*
	SLO-2	*Power-law and Logarithmic law*	*Betz limit*	*Aerodynamics Vs Styling - Limitations*	*Strouhal number*	*Funneling effect*
S-7	SLO-1	*Variation of wind velocity with height in ABL for different terrain types*	*Power losses*	*Aerodynamics of motor bikes*	*Flow induced vibrations*	*Ventilation*
	SLO-2	*Turbulence Intensity and its variation in ABL*	*Energy density of different rotors*	*Aerodynamics of roofless vehicles*	*Fluid-structure interactions*	*HVAC*
S-8	SLO-1	*Need for ABL simulation*	*Aerodynamic power control*	*Aerodynamics of Trucks and Buses*	*Effect of Reynolds number on wake*	*Architectural Aerodynamics*
	SLO-2	*Boundary layer tunnels*	*Methods for power control*	*Aerodynamics of Trains*	*Aerodynamic flutter*	*Wind catchers*
S-9	SLO-1	*Simulation of ABL in a wind tunnel*	*Blade sections - Airfoils*	*Ahmed body – Generic automobile shape*	*Wake galloping*	*Building codes*
	SLO-2	*Methods to produce ABL*	*Wind turbine siting*	*Wind tunnel experiments and simulations*	*Vortex shedding control methods*	*Loads on launch vehicles subjected to winds*

Learning Resources	1. *Tom Lawson, Building aerodynamics: Imperial College Press, 2001.* 2. *Joseph Katz, Automotive Aerodynamics, John Wiley & Sons, 2016.* 3. *Joseph Katz, Race Car Aerodynamics, Robert Bentley, 1995* 4. *Erich Hau,. Wind turbines: fundamentals, technologies, application, economics. Springer Science & Business Media, 2013.*	5. *Martin OL Hansen, Aerodynamics of wind turbines. Routledge, 2015.* 6. *Robert D Blevins, Flow-induced vibration. Van Nostrand Reinhold Co., 1977.* 7. *Helge Nørstrud, Sport aerodynamics. Springer Science & Business Media, 2009.*

Learning Assessment

	Bloom's Level of Thinking	Continuous Learning Assessment (50% weightage)								Final Examination (50% weightage)	
		CLA – 1 (10%)		CLA – 2 (15%)		CLA – 3 (15%)		CLA – 4 (10%)#			
		Theory	Practice	Theory	Practice	Theory	Practice	Theory	Practice	Theory	Practice
Level 1	Remember Understand	*40 %*	-	*30 %*	-	*30 %*	-	*30 %*	-	*30%*	-
Level 2	Apply Analyze	*40 %*	-	*40 %*	-	*40 %*	-	*40 %*	-	*40%*	-
Level 3	Evaluate Create	*20 %*	-	*30 %*	-	*30 %*	-	*30 %*	-	*30%*	-
	Total	100 %		100 %		100 %		100 %		100 %	

CLA – 4 can be from any combination of these: Assignments, Seminars, Tech Talks, Mini-Projects, Case-Studies, Self-Study, MOOCs, Certifications, Conf. Paper etc.,

Course Designers

Experts from Industry	Experts from Higher Technical Institutions	Internal Experts
Dr. C. Palani Kumar, CFD Application Expert, DJAIR, Korea. Email: kumar@djair.co.kr	*1. Dr .Arun Kumar Perumal, Mechanical Eng, IIT Jammu, arun.perumal@iitjammu.ac.in*	*1. Dr. Bharadwaj K K, SRMIST* *2. Dr. Kannan B T, SRMIST*

Course Code	18ASE202T	Course Name	APPLIED STRUCTURAL MECHANICS	Course Category	E	Professional Elective	L	T	P	C
							3	0	0	3

Pre-requisite Courses	18ASC201J	Co-requisite Courses	Nil	Progressive Courses	Nil
Course Offering Department	Aerospace Engineering	Data Book / Codes/Standards	Nil		

Course Learning Rationale (CLR):	*The purpose of learning this course is to:*
CLR-1 :	*To familiarize the concept of external load acting on a rigid airplane.*
CLR-2 :	*To familiarize the concept of statically indeterminate beams.*
CLR-3 :	*To familiarize with various energy methods.*
CLR-4 :	*To familiarize with the columns.*
CLR-5 :	*To study the concepts of failure theories.*
CLR-6 :	*Utilize the concepts in better understanding of various structural elements dealing with loads.*

		Learning			Program Learning Outcomes (PLO)														
		1	2	3	1	2	3	4	5	6	7	8	9	10	11	12	13	14	15
Course Learning Outcomes (CLO):	*At the end of this course, learners will be able to:*	Level of Thinking (Bloom)	Expected Proficiency (%)	Expected Attainment (%)	Engineering Knowledge	Problem Analysis	Design & Development	Analysis, Design, Research	Modern Tool Usage	Society & Culture	Environment & Sustainability	Ethics	Individual & Team Work	Communication	Project Mgt. & Finance	Life Long Learning	PSO - 1	PSO - 2	PSO – 3
CLO-1 :	*Determine the forces or loads acting on an accelerated airplane.*	2	80	70	H	H	H	H	-	-	-	-	-	-	-	M	M	M	M
CLO-2 :	*Determine the fixed end moments and plot shear force and bending moment diagram.*	2	85	75	H	H	H	H	-	-	-	-	-	-	-	M	M	M	M
CLO-3 :	*Determine the deflection of various structures by different energy methods.*	2	75	70	H	H	H	H	-	-	-	-	-	-	-	M	M	M	M
CLO-4 :	*Determine the buckling load of a column under various end conditions.*	2	85	80	H	H	H	H	-	-	-	-	-	-	-	M	M	M	M
CLO-5 :	*Application of theorem of three moments to solve for statically indeterminate beams.*	2	85	75	H	H	H	H	-	-	-	-	-	-	-	M	M	M	M
CLO-6 :	*Apply the concepts of theories of failure to determine the safe design.*	3	80	70	H	H	H	H	-	-	-	-	-	-	-	M	M	M	M

Duration (hour)		9	9	9	9	9
S-1	SLO-1	*Introduction to limit loads, design loads and factor of safety.*	*Continuous beam concept. Derivation of Clapeyron's equation of three moments.*	*Derivation of Strain Energy stored due to axial, bending and Torsional loads.*	*Introduction to columns and its classification. Buckling load, factor of safety.*	*Introduction to failure theories.*
	SLO-2	*Broad classification of external loads on a conventional aircraft.*	*Application of Clapeyron's equation of three moments to continuous beam with simply supported ends.*	*Strain Energy stored due to shear loads, The theorem of Complementary Energy and Castigliano' s Theorem.*	*Failure of a short and long column, Euler's theory for long columns.*	*Discussion about different materials and its properties*
S-2	SLO-1	*Problems involving accelerated motion of rigid airplane.*	*Problem solving*	*Derivation of Castigliano's theorem I and II, Maxwell's Reciprocal theorem*	*Assumptions followed in Euler's theory for long columns. Different end conditions of a column, concept of buckling stress.*	*Maximum Principal stress theory: Derivation.*
	SLO-2		*Application of Clapeyron's equation of three moments to continuous beam with fixed end supports.*	*Application of Castigliano's theorem – I to find deflection of beams.*	*Derivation of Euler's formula for crippling load when both ends are hinged*	*Maximum Principal stress theory: Problem solving*
S-3	SLO-1	*Landing Gear Structure*	*Problem solving*	*Problem solving*	*Derivation of Euler's formula for crippling load when both ends are fixed*	*Maximum Principal strain theory Derivation.*
	SLO-2	*Problems of Calculating Reactions andLoads on Members of Landing Gear Units*	*Application of Clapeyron's equation of three moments to continuous over-hanging beam.*	*Problem solving*	*Derivation of Euler's formula for crippling load when one end fixed and the other hinged end.*	*Maximum Principal strain theory: Problem solving*
S-4	SLO-1	*Problem solving*	*Problem solving*	*Differences between statically determinate and statically indeterminate structures with examples*	*Derivation of Euler's formula for crippling load when one end fixed and the other I free.*	*Maximum Shear stress theory: Derivation.*
	SLO-2	*Torque link*	*Application of Clapeyron's equation of three moments to continuous beam with one end fixed and other one simply supported end.*	*Application of Castigliano's theorem – II to find deflection of trusses.*	*Limitations of Euler's formula, slenderness ratio and equivalent length of a column.*	*Maximum Shear stress theory: Problem solving*
S-5	SLO-1	*Main forces on the airplane in an accelerated flight condition.*	*Problem solving*	*Problem solving*	*Problems to solve for crippling load using Euler's formula*	*Maximum Strain energy theory : Derivation.*

	SLO-2	*Loads on structural components*	*Derivation for Moment distribution method, stiffness factor, Distribution factor, carry over factor.*	*Problem solving*	*Problems to solve for crippling load using Euler's formula*	*Maximum Strain energy theory : Problem solving*
S-6	SLO-1	*Function of structural components*	*Application of Moment distribution method to continuous beam with simply supported ends.*	*Strain energy methods to find deflection in simply supported beams*	*Derivation: Column with initial curvature*	*Maximum Shear Strain energy theory: Derivation.*
	SLO-2	*Fabrication of structural components*	*Problem solving*	*Strain energy methods to find deflection in cantilever beams*	*Derivation: Column with an Eccentric loading.*	*Maximum Shear Strain energy theory: Problem solving*
S-7	SLO-1	*Safe life and fail-safe structures*	*Application of Moment distribution method to continuous beam with fixed end supports.*	*Unit load method to find member forces in a single redundant trusses/frames.*	*Problem solving*	*Important points from theories of failures used in design*
	SLO-2	*Aircraft inertia loads - Problems*	*Problem solving*	*Problem solving*	*Rankine's formula for columns and associated problems.*	*Problems on thin cylindrical shells on design criterion*
S-8	SLO-1	*Fixed and continuous beam – Introduction, Bending moment diagram for fixed beams*	*Application of Moment distribution method to continuous beam with one end fixed and other one simply supported end.*	*Problem solving*	*Long and short columns - Modes of failure*	*Problems on thick cylindrical shells on design criterion*
	SLO-2	*Slope and deflection for a fixed beam carrying point load at the middle*	*Problem solving*	*Unit load method to find member forces in double redundant trusses/frames.*	*Introduction to Beam columns and its applications*	*Graphical représentation of Maximum Principal stress and strain theory*
S-9	SLO-1	*Slope and deflection for a fixed beam carrying an eccentric point load.*	*Application of Moment distribution method to continuous over-hanging beam.*	*Problem solving*	*Member subjected to combined axial and transverse loads – Point load at the middle and an eccentric load*	*Graphical représentation of Maximum Shear stress and strain energy theory*
	SLO-2	*Slope and deflection for a fixed beam carrying uniformly distributed load over the entire length.*	*Problem solving*	*Problem solving*	*Member subjected to combined axial and transverse loads – Uniformly Distributed Load.*	*Graphical représentation of Maximum Shear strain energy theory*

Learning Resources	1 *Rajput R. K., "Strength of Materials", S.Chand publications, Sixth Edition, 2015.* 2. *John Case, and A.H.Chilver, "Strength of Materials and structures", Edward Arnold Publishers Ltd., 2016.*	3. *E. F. Bruhn, "Analysis and Design of Flight Vehicle Structures", Tri-State Offset Company (U.S.A),1973*

Learning Assessment

	Bloom's Level of Thinking	Continuous Learning Assessment (50% weightage)								Final Examination (50% weightage)	
		CLA – 1 (10%)		CLA – 2 (15%)		CLA – 3 (15%)		CLA – 4 (10%)#			
		Theory	Practice	Theory	Practice	Theory	Practice	Theory	Practice	Theory	Practice
Level 1	Remember Understand	*40%*	-	*30%*	-	*30%*	-	*30%*	-	*30%*	-
Level 2	Apply Analyze	*40%*	-	*40%*	-	*40%*	-	*40%*	-	*40%*	-
Level 3	Evaluate Create	*40%*	-	*30%*	-	*30%*	-	*30%*	-	*30%*	-
	Total	100 %		100 %		100 %		100 %		100 %	

CLA – 4 can be from any combination of these: Assignments, Seminars, Tech Talks, Mini-Projects, Case-Studies, Self-Study, MOOCs, Certifications, Conf. Paper etc.,

Course Designers

Experts from Industry	Experts from Higher Technical Institutions	Internal Experts
1. Dr. G.Balamurugan, National Aerospace Laboratories, Bangalore, gbala@nal.res.in	*1. Dr. V.Arumugam, Madras Institute of Technology, Chennai, arumugam.mitaero@gmail.com*	*Dr.L.R.Ganapathy Subramanian,SRMIST*
2. Dr.A. Sakthivel, CEMILAC, Bangalore, asakthironika@gmail.com	*2. Dr. R.Velmurugan, Indian Institute of Technology Madras, rvel@ae.iitm.ac.in*	*Dr.T.Selvakumaran,SRMIST*

Course Code	18ASE203T	Course Name	EXPERIMENTAL STRESS ANALYSIS	Course Category	E	Professional Elective	L	T	P	C
							3	0	0	3

Pre-requisite Courses	18PYB101J, 18ASC201J	Co-requisite Courses	Nil	Progressive Courses	Nil
Course Offering Department	Aerospace Engineering	Data Book / Codes/Standards	Nil		

Course Learning Rationale (CLR):	*The purpose of learning this course is to:*
CLR-1 :	*Understand the various aspects of measurements*
CLR-2 :	*Understand the different physical principles of strain measuring instruments.*
CLR-3 :	*Identify the different materials for resistance type strain gages*
CLR-4 :	*Know the various circuits for strain measuring purpose.*
CLR-5 :	*Know the principles and materials in photo elastic concepts.*
CLR-6 :	*Understand the various non-destructive testing methods.*

		Learning			Program Learning Outcomes (PLO)														
		1	2	3	1	2	3	4	5	6	7	8	9	10	11	12	13	14	15
Course Learning Outcomes (CLO):	*At the end of this course, learners will be able to:*	Level of Thinking (Bloom)	Expected Proficiency (%)	Expected Attainment (%)	Engineering Knowledge	Problem Analysis	Design & Development	Analysis, Design, Research	Modern Tool Usage	Society & Culture	Environment & Sustainability	Ethics	Individual & Team Work	Communication	Project Mgt. & Finance	Life Long Learning	PSO - 1	PSO - 2	PSO – 3
CLO-1 :	*Describe the measuring process of various instruments*	2	85	75	H	-	H	H	L	H	H	H	-	-	-	M	M	M	M
CLO-2 :	*Describe about the various strain measuring devices*	2	85	75	H	H	H	H	-	H	H	H	-	-	-	M	M	M	M
CLO-3 :	*Explain the physical principle and circuits used in resistance type strain gages*	2	85	75	H	-	H	H	-	H	H	H	-	-	-	M	M	M	M
CLO-4 :	*Explain the rosette analysis*	2	85	75	H	H	-	H	-	H	H	H	-	-	-	M	M	M	M
CLO-5 :	*Describe the various photo elastic concepts of stress measurements*	2	85	75	H	-	H	H	-	H	H	H	-	-	-	M	M	M	M
CLO-6 :	*Explain the various non destructive methods of flaw detection*	2	85	75	H	H	H	H	-	H	H	H	-	-	-	M	M	M	M

Duration (hour)		9	9	9	9	9
S-1	SLO-1	*Introduction-Stress and strain*	*Properties of strain gage system*	*Introduction to resistance strain gage*	*Introduction to photoelasticity*	*NDT method-Introduction*
	SLO-2	*Introduction- Relation between stresses and strains for different materials*	*Basic characteristics of strain gage*	*Principle of operation of the resistance strain gage, Strain sensitivity*	*wave plates, polarized light*	*Classification of flaws, Steps in NDT*
S-2	SLO-1	*Principles of measurements*	*Huggenberger tensometer*	*Materials for resistance strain gage, Advance alloy, Isoelastic alloy, Karma alloy and other materials*	*Stress optic law*	*Fluorescent penetrant technique*
	SLO-2	*Aspects of measurements*	*Advantages and disadvantages, limitations*	*Types of electrical resistance strain gages-Unbonded wire strain gage, Bonded wire strain gage*	*Strain optic law*	*Magnetic particle inspection*
S-3	SLO-1	*Fundamental methods of measurements*	*Diffraction strain gage*	*Types of resistance strain gage-Bonded foil strain gage, Weldable strain gage*	*Plane polariscope , Derivation of intensity of light in circular polariscope*	*Eddy current testing*
	SLO-2	*Generalized measuring system*	*Advantages and disadvantages*	*Strain gage adhesives, Selection, Properties and types*	*Effect of stressed model in plane polariscope*	*Radiography*
S-4	SLO-1	*Accuracy and Precision*	*Interferometric strain gage*	*Mounting methods-Gage installation, Curing*	*Circular polariscope*	*Ultrasonic inspection*
	SLO-2	*Repeatability and Reproducibility*	*Advantages and disadvantages*	*Temperature compensation, Gage sensitivity, Gage factor*	*Derivation of intensity of light in circular polariscope*	*A scan, B scan and C scan*
S-5	SLO-1	*Tolerance and Range*	*Tuckerman strain gage*	*Strain gage circuits, Potentiometer circuit*	*Effect of stressed model in a circular polariscope*	*Thermography*
	SLO-2	*Bias and Linearity*	*Advantages and disadvantages*	*Temperature compensation ,sensitivity and range in potentiometer circuit*	*Explanation of fringe patterns*	*Holography*
S-6	SLO-1	*Sensitivity explanation*	*Capacitance strain gage*	*Wheatstone bridge circuit*	*Compensation techniques- Babinet soleil method of compensation*	*Acoustic emission technique*
	SLO-2	*Numerical solving*	*Advantages and disadvantages*	*Derivation of output voltage*	*Tardy method of compensation*	*Moire method of strain analysis*
S-7	SLO-1	*Hysteresis*	*Inductance strain gage*	*Circuit sensitivity and different arrangements in wheat stone bridge circuit*	*Fringe separation methods-Shear difference method, Interferometer method*	*Methods*

	SLO-2	*Dead space, Threshold and Resolution*	*Advantages and disadvantages*	*Rosette analysis, Different conditions of strain measurements*	*Electrical analogy method, Oblique-incidence method*	*Moire fringe pattern*
S-8	SLO-1	*Error Analysis- Classification*	*Semiconductor strain gage*	*Three element rectangular rosette*	*Fringe multiplication method*	*Physical explanation of moiré fringe pattern*
	SLO-2	*Error analysis- Sources*	*Advantages and disadvantages*	*Delta rosette*	*Explanation of fringe multiplication*	*Brittle coating methods*
S-9	SLO-1	*Error analysis numerical*	*Acoustical strain gage*	*Four element rectangular rosette*	*Properties of photoelastic materials*	*Types of brittle coating methods*
	SLO-2	*Calibration*	*Advantages and disadvantages*	*Tee delta rosette*	*Explanation of different photoelastic materials*	*Advantages and disadvantages of brittle coating methods*

Learning Resources	1. *Dally, J.W., and Riley, W.F., Experimental Stress Analysis, McGraw Hill Inc., New York, 1978* 2. *Hetyenyi, M., Hand Book of Experimental Stress Analysis, John Wiley and Sons Inc., New York, 1972*	3. *Srinath, L.S., Raghava, M.R., Lingaiah, K.Gargesha, G.Pant B., and Ramachandra, K., Experimental Stress Analysis, Tata McGraw Hill, New Delhi, 1984* 4. *Pollock, A.A., Acoustic Emission in Acousticsand Vibrations Progress, ed. By StephensR.W.B., Chapman and Hall, 1983*

Learning Assessment

	Bloom's Level of Thinking	Continuous Learning Assessment (50% weightage)								Final Examination (50% weightage)	
		CLA – 1 (10%)		CLA – 2 (15%)		CLA – 3 (15%)		CLA – 4 (10%)#			
		Theory	Practice	Theory	Practice	Theory	Practice	Theory	Practice	Theory	Practice
Level 1	Remember Understand	*40 %*	-	*30 %*	-	*30 %*	-	*30 %*	-	*30%*	-
Level 2	Apply Analyze	*40 %*	-	*40 %*	-	*40 %*	-	*40 %*	-	*40%*	-
Level 3	Evaluate Create	*20 %*	-	*30 %*	-	*30 %*	-	*30 %*	-	*30%*	-
	Total	100 %		100 %		100 %		100 %		100 %	

CLA – 4 can be from any combination of these: Assignments, Seminars, Tech Talks, Mini-Projects, Case-Studies, Self-Study, MOOCs, Certifications, Conf. Paper etc.,

Course Designers

Experts from Industry	Experts from Higher Technical Institutions	Internal Experts
1. Dr. G.Balamurugan, National Aerospace Laboratories, Bangalore, gbala@nal.res.in	*1. Dr. V.Arumugam, Madras Institute of Technology, Chennai, arumugam.mitaero@gmail.com*	*1. Dr. L.R. Ganapathi Subramanian, SRMIST*
2. Dr.A. Sakthivel, CEMILAC, Bangalore, asakthironika@gmail.com	*2. Dr. R.Velmurugan, Indian Institute of Technology Madras, rvel@ae.iitm.ac.in*	*2. Mr. S. Chandra Sekhar, SRMIST*

Course Code	18ASE204T	Course Name	COMPOSITE MATERIALS AND STRUCTURES	Course Category	E	Professional Elective	L	T	P	C
							3	0	0	3

Pre-requisite Courses	18ASC201J	Co-requisite Courses	Nil	Progressive Courses	Nil
Course Offering Department	Aerospace Engineering	Data Book / Codes/Standards	Nil		

Course Learning Rationale (CLR):	*The purpose of learning this course is to:*
CLR-1 :	*Identify Composite materials*
CLR-2 :	*Understand the mechanical behavior of composite materials*
CLR-3 :	*Understand the existing production technologies*
CLR-4 :	*Identifying the selection of materials*
CLR-5 :	*Identify material's Application*
CLR-6 :	*Understand the application of various composites*

Course Learning Outcomes (CLO):	*At the end of this course, learners will be able to:*	Learning 1: Level of Thinking (Bloom)	Learning 2: Expected Proficiency (%)	Learning 3: Expected Attainment (%)	PLO 1: Engineering Knowledge	PLO 2: Problem Analysis	PLO 3: Design & Development	PLO 4: Analysis, Design, Research	PLO 5: Modern Tool Usage	PLO 6: Society & Culture	PLO 7: Environment & Sustainability	PLO 8: Ethics	PLO 9: Individual & Team Work	PLO 10: Communication	PLO 11: Project Mgt. & Finance	PLO 12: Life Long Learning	PLO 13: PSO - 1	PLO 14: PSO - 2	PLO 15: PSO – 3
CLO-1 :	*Aware of the composite materials and it properties*	*2*	*80*	*70*	*H*	*H*	-	-	-	-	-	-	-	-	-	*M*	*M*	*M*	*M*
CLO-2 :	*Understands application of composite materials in different aircraft components*	*2*	*85*	*75*	*H*	*H*	-	-	*H*	-	-	-	-	-	-	*M*	*M*	*M*	*M*
CLO-3 :	*Identify different treatments to strengthen materials*	*2*	*75*	*70*	*H*	-	*H*	*H*	-	-	-	-	-	-	-	*M*	*M*	*M*	*M*
CLO-4 :	*Understand molding techniques*	*2*	*85*	*80*	*H*	*H*	-	-	*H*	-	-	-	-	-	-	*M*	*M*	*M*	*M*
CLO-5 :	*Understand Various terminologies used in composite Materials*	*2*	*85*	*75*	*H*	-	*H*	-	-	-	-	-	-	-	-	*M*	*M*	*M*	*M*
CLO-6 :	*Understand forming Techniques*	*2*	*80*	*70*	*H*	-	-	-	-	-	-	-	-	-	-	*M*	*M*	*M*	*M*

Duration (hour)		9	9	9	9	9
S-1	SLO-1	*Introduction to Composite Materials*	*Hooke's law for Isotropic Materials*	*Micro Mechanics*	*Governing differential equation of general laminate*	*Manufacturing of Glass fibers*
	SLO-2	*Natural Composites*	*Numericals solving*	*Micro Mechanics*		*Block diagram of Manufacturing*
S-2	SLO-1	*Basic Definitions*	*Generalized Hooke's law*	*Derivation of Volume Fraction, Mass Fraction*	*Angle ply laminates*	*Manufacturing of Carbon Fibers*
	SLO-2	*Basic Definitions*	*Numericals solving*	*Density and Void Content*	*Cross ply laminates*	*Block diagram of Manufacturing*
S-3	SLO-1	*Introduction to Fibers*	*Hooke's law for 3D Orthotropic Materials*	*Numericals solving*	*Numericals solving*	*Fabrication of Composite Materials*
	SLO-2	*Types of Fibers*	*Hooke's law for 3D Orthotropic Materials*	*Numericals solving*	*Numericals solving*	*Molding Techniques*
S-4	SLO-1	*Matrices*	*Numericals solving*	*Strength of Materials approach*	*Laminate Codes*	*Hand Layup Process*
	SLO-2	*Types of Matrices*		*Evaluation of four Elastic Modulii*	*Laminate Codes*	*Spray layup process*
S-5	SLO-1	*Properties of Fibers*	*Hooke's law for 2D Unidirectional lamina*	*Numericals solving*	*Special cases of laminates*	*Compression Molding*
	SLO-2	*Properties of Matrices*		*Numericals solving*	*ABD Matrix representation*	*Resin Transfer molding*
S-6	SLO-1	*Classification of Composite Materials*	*Numericals solving*	*Elasticity approach to determine Material Properties*	*Maximum Stress failure theory*	*Vacuum Bag and Pressure bag Mödling*
	SLO-2	*Block Diagram of Classification*	*Numericals solving*		*Maximum Strain failure theory*	*Autoclave Processing*
S-7	SLO-1	*Application of Composites*	*Hooke's law for 2D Angle Lamina*	*Macro Mechanics*	*Tsai Hill failure theory*	*Filament winding process*
	SLO-2	*Application of Composites*		*Macro mechanics*	*Tsai wu failure theory*	*Pultrusion Process*
S-8	SLO-1	*Hooke's Law*	*Numericals solving*	*Stress strain relationship with respect to neutral axis and arbitrary axis*	*Basic concept of sandwich construction*	*Types of resins*
	SLO-2	*Basics of Hooke's Law*	*Numericals solving*		*Materials used in sandwich construction*	*Properties and Applications*
S-9	SLO-1	*Numericals solving*	*Numericals solving*	*Experimental characterization of Lamina*	*Failure modes of Sandwich panels*	*Netting Analysis*
	SLO-2					

Learning Resources	1. *Autar K Kaw, "Mechanics of Composite Materials" CRC Press, Taylor and Francis Group 2005.* 2. *Jones.R.M, "Mechanics of Composite Materials", McGraw-Hill, Kogakusha Ltd., Tokyo, 1985.*	3. *Agarwal.B.D, and Broutman.L.J, "Analysis and Performance of Fibre Composites", John Wiley and sons. Inc., New York, 1995* 4. *Lubin.G, "Handbook on Advanced Plastics and Fibre Glass", Von Nostrand Reinhold Co., New York, 1989*

Learning Assessment

	Bloom's Level of Thinking	Continuous Learning Assessment (50% weightage)								Final Examination (50% weightage)	
		CLA – 1 (10%)		CLA – 2 (15%)		CLA – 3 (15%)		CLA – 4 (10%)#			
		Theory	Practice	Theory	Practice	Theory	Practice	Theory	Practice	Theory	Practice
Level 1	Remember Understand	*40 %*	-	*30 %*	-	*30 %*	-	*30 %*	-	*30%*	-
Level 2	Apply Analyze	*40 %*	-	*40 %*	-	*40 %*	-	*40 %*	-	*40%*	-
Level 3	Evaluate Create	*20 %*	-	*30 %*	-	*30 %*	-	*30 %*	-	*30%*	-
	Total	100 %		100 %		100 %		100 %		100 %	

CLA – 4 can be from any combination of these: Assignments, Seminars, Tech Talks, Mini-Projects, Case-Studies, Self-Study, MOOCs, Certifications, Conf. Paper etc.,

Course Designers

Experts from Industry	Experts from Higher Technical Institutions	Internal Experts
1. Dr. G.Balamurugan, National Aerospace Laboratories, Bangalore, gbala@nal.res.in	*1. Dr. V.Arumugam, Madras Institute of Technology, Chennai, arumugam.mitaero@gmail.com*	*Dr. L R Ganapathy Subramanian, SRMIST*
2. Dr.A. Sakthivel, CEMILAC, Bangalore, asakthironika@gmail.com	*2. Dr. R.Velmurugan, Indian Institute of Technology Madras, rvel@ae.iitm.ac.in*	*Mr. N. Bharat, SRMIST*

Course Code	18ASE205T	Course Name	THEORY OF PLATES AND SHELLS	Course Category	E	Professional Elective	L	T	P	C
							3	0	0	3

Pre-requisite Courses	18ASC304J	Co-requisite Courses	Nil	Progressive Courses	Nil
Course Offering Department	Aerospace Engineering	Data Book / Codes/Standards	Nil		

Course Learning Rationale (CLR):	*The purpose of learning this course is to:*	Learning			Program Learning Outcomes (PLO)														
		1	2	3	1	2	3	4	5	6	7	8	9	10	11	12	13	14	15
CLR-1 :	*Identify Plates and Shells*																		
CLR-2 :	*Understand the mechanical behavior of Plates and shells*																		
CLR-3 :	*Understand the existing technologies*																		
CLR-4 :	*Identifying the selection of materials*																		
CLR-5 :	*Identify Plates Application*																		
CLR-6 :	*Understand the application of various Plates and shells*																		
Course Learning Outcomes (CLO):	*At the end of this course, learners will be able to:*	Level of Thinking (Bloom)	Expected Proficiency (%)	Expected Attainment (%)	Engineering Knowledge	Problem Analysis	Design & Development	Analysis, Design, Research	Modern Tool Usage	Society & Culture	Environment & Sustainability	Ethics	Individual & Team Work	Communication	Project Mgt. & Finance	Life Long Learning	PSO - 1	PSO - 2	PSO – 3
CLO-1 :	*Aware of the plates and shells and it properties*	2	80	70	H	H	-	-	-	-	-	-	-	-	-	M	M	M	M
CLO-2 :	*Understands application of plates and shells in different aircraft components*	2	85	75	H	H	-	-	H	-	-	-	-	-	-	M	M	M	M
CLO-3 :	*Identify different treatments to strengthen materials*	2	75	70	H	-	H	H	-	-	-	-	-	-	-	M	M	M	M
CLO-4 :	*Understand Problem solving techniques*	2	85	80	H	H	-	-	H	-	-	-	-	-	-	M	M	M	M
CLO-5 :	*Understand Various terminologies used in Plates and shells*	2	85	75	H	-	H	-	-	-	-	-	-	-	-	M	M	M	M
CLO-6 :	*Understand forming Techniques*	2	80	70	H	-	-	-	-	-	-	-	-	-	-	M	M	M	M

Duration (hour)		9	9	9	9	9
S-1	SLO-1	*Introduction*	*Plates of Various shapes*	*Eigen value analysis*	*Approximate Methods*	*Introduction to shells*
	SLO-2	*Classical Plates theory*				
S-2	SLO-1	*Classical Plates theory- Assumptions*	*Leavy's Method of Solution for Rectangular Plates under Different Boundary Conditions*	*Stability of Rectangular Plates*	*Rayleigh – Ritz Method*	*Basic Concepts of Shell Type of Structures*
	SLO-2	*Theory*				
S-3	SLO-1	*Classical Plates theory-Differential equations*	*Leavy's Method of Solution for Rectangular Plates under Different Boundary Conditions- governing equations*	*Free Vibration Analysis of Rectangular Plates*	*Numericals solving*	*Membrane Theories for Circular Cylindrical Shells.*
	SLO-2					
S-4	SLO-1	*Classical Plates theory – Boundary conditions*	*Solution for Axi-symmetric loading*	*Numericals solving*	*Galerkin Methods*	*Bending Theories for Circular Cylindrical Shells.*
	SLO-2					
S-5	SLO-1	*Naviers method of solution for simply supported Rectangular plates*	*Numericals solving*	*Bending Theory of Plates*	*Finite Difference Method*	*Governing Equation for Buckling of Cylindrical Shells*
	SLO-2					
S-6	SLO-1	*Differential equation for cylindrical bending of plates*	*Annular Plates*	*Numericals solving*	*Numericals solving*	*Derivation of the Linearized Buckling Equation*
	SLO-2					
S-7	SLO-1	*Cylindrical Bending of Uniformly Loaded Rectangular Plates with Simply Supported Edges*	*Numericals solving*	*Bending-Membrane Theory of Plates*	*Application to Rectangular Plates for Static Analysis*	*Buckling under Axial Compression*
	SLO-2					
S-8	SLO-1	*Cylindrical Bending of Uniformly Loaded Rectangular Plates with Built-in Edges*	*Introduction to plates of other shapes*	*Numericals solving*	*Application to Rectangular Plates for free vibration analysis*	*Formulation for Buckling Stress and Buckling Mode*
	SLO-2					
S-9	SLO-1	*Cylindrical Bending of Uniformly Loaded Rectangular Plates with Elastically Built-in Edges*	*Theory of plates of other shapes*	*Equilibrium Equation and Boundary Conditions*	*Application to Rectangular Plates for stability analysis*	*Buckling Coefficient and Batdorf Parameter*
	SLO-2					

Learning Resources		
	1. Timoshenko, S.P. Winowsky. S., and Kreger, "Theory of Plates and Shells", McGraw-Hill Book Co. 1990.	*3. Flugge, W. "Stresses in Shells", Springer – Verlag, 1985.*
	2. T. K. Varadan and K. Bhaskar, "Theory of Plates and Shells", 1999, Narosa.	*4. Timoshenko, S.P. and Gere, J.M., "Theory of Elastic Stability", McGraw-Hill Book Co. 1986*

Learning Assessment											
	Bloom's Level of Thinking	Continuous Learning Assessment (50% weightage)								Final Examination (50% weightage)	
		CLA – 1 (10%)		CLA – 2 (15%)		CLA – 3 (15%)		CLA – 4 (10%)#			
		Theory	Practice	Theory	Practice	Theory	Practice	Theory	Practice	Theory	Practice
Level 1	Remember Understand	*40 %*	-	*30 %*	-	*30 %*	-	*30 %*	-	*30%*	-
Level 2	Apply Analyze	*40 %*	-	*40 %*	-	*40 %*	-	*40 %*	-	*40%*	-
Level 3	Evaluate Create	*20 %*	-	*30 %*	-	*30 %*	-	*30 %*	-	*30%*	-
	Total	100 %		100 %		100 %		100 %		100 %	

CLA – 4 can be from any combination of these: Assignments, Seminars, Tech Talks, Mini-Projects, Case-Studies, Self-Study, MOOCs, Certifications, Conf. Paper etc.,

Course Designers		
Experts from Industry	Experts from Higher Technical Institutions	Internal Experts
1. Dr. G.Balamurugan, National Aerospace Laboratories, Bangalore, gbala@nal.res.in	*1. Dr. V.Arumugam, Madras Institute of Technology, Chennai, arumugam.mitaero@gmail.com*	*Dr. L R Ganapathy Subramanian, SRMIST*
2. Dr.A. Sakthivel, CEMILAC, Bangalore, asakthironika@gmail.com	*2. Dr. R.Velmurugan, Indian Institute of Technology Madras, rvel@ae.iitm.ac.in*	*Mr. N. Bharat, SRMIST*

Course Code	18ASE206T	Course Name	THEORY OF ELASTICITY	Course Category	E	Professional Elective	L	T	P	C
							3	0	0	3

Pre-requisite Courses	18ASC304J	Co-requisite Courses	Nil	Progressive Courses	Nil
Course Offering Department	Aerospace Engineering	Data Book / Codes/Standards	Nil		

Course Learning Rationale (CLR):	*The purpose of learning this course is to:*
CLR-1 :	*Understand the various assumption in solving elasticity problems, equilibrium equations*
CLR-2 :	*Familiarize with stress-strain relations, strain-displacement relations, compatibility equations*
CLR-3 :	*Understand the solutions by polynomials, stresses & displacements for simple, cantilever beams.*
CLR-4 :	*Familiarize with problems in polar coordinates for axisymmetric problems*
CLR-5 :	*Know the various theory of torsion for circular, elliptical, sections.*
CLR-6 :	*Get a better understanding of solving elasticity problems*

		Learning			Program Learning Outcomes (PLO)														
		1	2	3	1	2	3	4	5	6	7	8	9	10	11	12	13	14	15
Course Learning Outcomes (CLO):	*At the end of this course, learners will be able to:*	Level of Thinking (Bloom)	Expected Proficiency (%)	Expected Attainment (%)	Engineering Knowledge	Problem Analysis	Design & Development	Analysis, Design, Research	Modern Tool Usage	Society & Culture	Environment & Sustainability	Ethics	Individual & Team Work	Communication	Project Mgt. & Finance	Life Long Learning	PSO - 1	PSO - 2	PSO – 3
CLO-1 :	*Apply the knowledge to form equilibrium equations & compatibility conditions.*	2	85	75	H	H	H	-	-	-	-	-	-	-	-	M	M	M	M
CLO-2 :	*Analyze the plane stress & plane strain problems.*	2	85	75	H	H	H	-	-	-	-	-	-	-	-	M	M	M	M
CLO-3 :	*Apply the solutions of polynomials to solve simple two dimensional problems in Cartesian coordinate*	2	85	75	H	H	H	H	-	-	-	-	-	-	-	M	M	M	M
CLO-4 :	*Analyze a two dimensional problems in polar coordinates.*	2	85	75	H	H	H	-	-	-	-	-	-	-	-	M	M	M	M
CLO-5 :	*Analyze the stresses induce due to torsion for non circular cross-sections*	2	85	75	H	H	H	-	-	-	-	-	-	-	-	M	M	M	M
CLO-6 :	*Accrue comprehensive knowledge in theory of elasticity problems*	2	85	75	H	H	H	H	-	-	-	-	-	-	-	M	M	M	M

Duration (hour)		9	9	9	9	9
S-1	SLO-1	*Introduction to Theory of Elasticity*	*Introduction to equations of elasticity*	*Airy's stress function*	*Equations of equilibrium in polar coordinates*	*Introduction to torsion of non-circular members*
	SLO-2	*Definitions of stress & strain*	*Stress-strain relations*	*Biharmonic equation equations*	*Equations of equilibrium in polar coordinates*	*Saint-Venant's theory of torsion*
S-2	SLO-1	*Sign conventions, notations for stress & strain*	*Lame's constant-cubical dilatation*	*Solutions by polynomials of second degree*	*Stress-strain relations*	*General solutions of torsion problems*
	SLO-2	*Sign conventions, notations for stress & strain*	*Lame's constant-cubical dilatation*	*Solutions by polynomials of second degree.*	*Strain components in polar coordinates*	*General solutions of torsion problems*
S-3	SLO-1	*Components of stress*	*Compressibility of materials, Bulk Modulus*	*Solutions by polynomials of third degree*	*Strain-displacement relations*	*Boundary conditions*
	SLO-2	*Generalized Hooke's Law*	*Solving problems*	*Solutions by polynomials of third degree*	*Strain-displacement relations*	*Conditions at the end of a twisted bar*
S-4	SLO-1	*Components of strain*	*Compatibility equations for plane stress with constant body force*	*Solutions by polynomials of fourth degree*	*Equations of compatibility in polar coordinates.*	*Solving problems*
	SLO-2	*Solving problems*	*Compatibility equations for plane stress with general body force.*	*Solutions by polynomials of fourth degree*	*Equations of compatibility in polar coordinates.*	*Applications of shafts of elliptical cross-sections*
S-5	SLO-1	*Stress at a point*	*Compatibility equations for plane strain with constant body force.*	*Solutions by polynomials of fifth degree*	*Solving problems*	*Solving problems*
	SLO-2	*Boundary conditions*	*Compatibility equations for plane stress with general body force.*	*Solutions by polynomials of fifth degree*	*Solving problems*	*Solving problems*
S-6	SLO-1	*Strain at a point*	*Principal stresses and strain*	*Stresses due to bending of a cantilever beam in Cartesian coordinate*	*Stress distribution symmetrical about an axis*	*Applications of shafts of rectangular cross-sections*
	SLO-2	*Solving Problems*	*Solving problems*	*Stresses due to bending of a cantilever beam in Cartesian coordinate*	*Stress distribution symmetrical about an axis*	*Applications of shafts of rectangular cross-sections*
S-7	SLO-1	*Equations of equilibrium in 2D*	*Mohr's circle for plane stress*	*Displacements due to bending of a cantilever beam in Cartesian coordinate*	*Stress distribution in pure bending of curved bars*	*Solving problems*
	SLO-2	*Solving problems*	*Solving problems*	*Displacements due to bending of a cantilever beam in Cartesian coordinate*	*Stress distribution in pure bending of curved bars*	*Solving problems*

S-8	SLO-1	*Equations of equilibrium in 3D*	*Mohr's circle for plane strain*	*Stresses due to bending of a simply supported beam in Cartesian coordinate*	*Stress distribution in rotating disc*	*Applications of shafts of equilateral cross-sections*
	SLO-2	*Solving problems*	*Solving problems*	*Stresses due to bending of a simply supported beam in Cartesian coordinate*	*Stress distribution in rotating disc*	*Applications of shafts of equilateral cross-sections*
S-9	SLO-1	*Index notations for stress & strain*	*Saint-Venant's Principle*	*Displacements due to bending of a simply supported beam in Cartesian coordinate*	*Solving problems*	*Solving problems*
	SLO-2	*Solving problems*	*Solving problems*	*Displacements due to bending of a simply supported beam in Cartesian coordinate*	*Solving problems*	*Solving problems*

Learning Resources	*1. Timoshenko, S.P and Goodier J.N., Theory of Elasticity,McGraw-Hill Education, Third Edidtion., 2017* *2. Enrico Voltorra and J.H.Caines, Advanced Strength of Materials, Prentice Hall, New Jersey,1991.*	*3. Wang, C.T., Applied Elasticity, Mc-Graw-Hill Co., New York 1993* *4. Sokolnkoff, IS., Mthematical Theory of Elasticity, Mc-Graw-Hill Co., New York 1978.*

Learning Assessment

	Bloom's Level of Thinking	Continuous Learning Assessment (50% weightage)								Final Examination (50% weightage)	
		CLA – 1 (10%)		CLA – 2 (15%)		CLA – 3 (15%)		CLA – 4 (10%)#			
		Theory	Practice	Theory	Practice	Theory	Practice	Theory	Practice	Theory	Practice
Level 1	Remember Understand	*40 %*	-	*30 %*	-	*30 %*	-	*30 %*	-	*30%*	-
Level 2	Apply Analyze	*40 %*	-	*40 %*	-	*40 %*	-	*40 %*	-	*40%*	-
Level 3	Evaluate Create	*20 %*	-	*30 %*	-	*30 %*	-	*30 %*	-	*30%*	-
	Total	100 %		100 %		100 %		100 %		100 %	

CLA – 4 can be from any combination of these: Assignments, Seminars, Tech Talks, Mini-Projects, Case-Studies, Self-Study, MOOCs, Certifications, Conf. Paper etc.,

Course Designers

Experts from Industry	Experts from Higher Technical Institutions	Internal Experts
1. Dr. G.Balamurugan, National Aerospace Laboratories, Bangalore, gbala@nal.res.in	*1. Dr. V.Arumugam, Madras Institute of Technology, Chennai, arumugam.mitaero@gmail.com*	*1. Dr.L.R.Ganapathy Subramanian, SRMIST*
2. Dr.A. Sakthivel, CEMILAC, Bangalore, asakthironika@gmail.com	*2. Dr. R.Velmurugan, Indian Institute of Technology Madras, rvel@ae.iitm.ac.in*	*2. Mr. S. Chandra Sekhar, SRMIST*

Course Code	18ASE207T	Course Name	FUNDAMENTALS OF COMBUSTION	Course Category	E	Professional Elective	L	T	P	C
							3	0	0	3

Pre-requisite Courses	18ASC102J, 18ASC103T	Co-requisite Courses	Nil	Progressive Courses	Nil
Course Offering Department	Aerospace Engineering	Data Book / Codes/Standards	Thermodynamic properties table of C-H-N-O system		

Course Learning Rationale (CLR):	*The purpose of learning this course is to:*
CLR-1 :	*Identify the chemistry of combustion, the efficiency of burning processes and about pollutant emissions.*
CLR-2 :	*Identify the applications of basic thermal and fluid sciences on Engineering systems.*
CLR-3 :	*Identify the significance of material identification for industrial applications, including burners and engines.*
CLR-4 :	*Create insights to the combustion in engines and gas turbines, controlled experimentation and computational combustion.*
CLR-5 :	*Analyze the principle of normal and microgravity flames for space activities and fire safety.*
CLR-6 :	*Utilize the combustion concepts for the broad understanding of system testing, validation and designing.*

Course Learning Outcomes (CLO):	*At the end of this course, learners will be able to:*	Learning 1: Level of Thinking (Bloom)	2: Expected Proficiency (%)	3: Expected Attainment (%)	PLO 1: Engineering Knowledge	2: Problem Analysis	3: Design & Development	4: Analysis, Design, Research	5: Modern Tool Usage	6: Society & Culture	7: Environment & Sustainability	8: Ethics	9: Individual & Team Work	10: Communication	11: Project Mgt. & Finance	12: Life Long Learning	13: PSO - 1	14: PSO - 2	15: PSO – 3
CLO-1 :	*Understand the combustion phenomenon and its applications to Aerospace Engineering.*	2	80	70	H	M	L	L	-	-	-	-	-	-	-	H	-	-	-
CLO-2 :	*Comprehend the concept and applications of the fundamental combustion parameters.*	2	80	70	H	M	M	M	-	-	L	-	-	L	-	H	M	M	M
CLO-3 :	*Understand combustion regimes: flame and detonation, premixed and diffusion combustion problems with applications.*	2	80	70	H	M	L	M	-	-	-	-	L	-	-	H	-	-	-
CLO-4 :	*Understand the chemical kinetics, chain reactions and related processes.*	2	80	70	H	M	M	M	-	-	M	M	M	M	L	H	M	M	M
CLO-5 :	*Utilize the physical understanding of flame speed and Numerical modelling of combustion processes.*	2	80	70	H	M	M	M	M	L	L	-	L	M	L	H	M	M	M
CLO-6 :	*Understand normal and microgravity flames and apply the knowledge to Aerospace Engineering Applications.*	2	80	70	H	M	M	M	M	L	L	M	L	M	L	H	M	M	M

Duration (hour)		9	9	9	9	9
S-1	SLO-1	*Basic Concepts: Ideal gases, mass and mole concept, fuel and oxidizer, basics of thermodynamics.*	*Combustion regimes and classification of combustible materials.*	*Introduction to Chemical kinetics, Rate laws, order and molecularity, Forward and Reverse Reactions.*	*Flame classification and structures.*	*Combustion in Normal and microgravity.*
	SLO-2	*Various modes of combustion and their characteristics*	*Flammability limits- Flame stabilization and material identification systems.*	*Energy Release Rates in a Chemical Reaction, Concentration, Law of Mass Action, Arrhenius Law.*	*Laminar flame speed, Factors affecting flame velocity--Methods of measuring flame velocity.*	*Factors affecting heat transfer and flame propagation in normal and low gravity flames.*
S-2	SLO-1	*Combustion and thermo chemistry - Review of property relations.*	*Maxwell equation and parametric analysis of enthalpies and internal energy*	*Variations of Reaction Rate, Temperature and Concentration in a Chemical Reaction with Time.*	*Stability limits of laminar flames.*	*Fire safety, Soot formation and related implications.*
	SLO-2	*Laws of thermodynamics-Reactant and product mixtures.*	*Phase transformation, Clausius Clapeyron equation and Gibbs-Helmholtz equation.*	*Rate of Reactions, Temperature dependence of rate coefficients, Pressure dependence of rate coefficients.*	*Flame propagation through combustible mixtures.*	*Interactive session with demo on practical working of premixed gas burners and candle flames.*
S-3	SLO-1	*Solving Problems*	*Solving Problems*	*Solving Problems*	*Solving Problems*	*Solving Problems*
	SLO-2	*Solving Problems*	*Solving Problems*	*Solving Problems*	*Solving Problems*	*Solving Problems*
S-4	SLO-1	*Combustion Stoichiometry, Heat of Formation, Reaction, combustion.*	*Combustion products, Flow analysis and approaches.*	*Phase Rule for a System with Chemical Reactions. Thermodynamic Equilibrium Constant for a Gaseous Reaction.*	*Introduction to diffusion flames; appearance, structure, theoretical considerations.*	*Comparison of normal and microgravity experiments.*
	SLO-2	*Lower Calorific Value (LCV) and Higher Calorific Value (HCV), Relationships between Calorific Values, Reaction Enthalpies and Formation Enthalpies*	*Partial differential equations for combustion analysis.*	*Chain Reactions and Methods of Solving Chemical Kinetic Rate Equations.*	*Burning in convective atmospheres and Thermal spontaneous ignition.*	*Flame spread over thin fuels in actual and simulated microgravity conditions.*
S-5	SLO-1	*Thermochemical calculations: Enthalpies, Internal energy, Entropy.*	*Vectors and conservation equations for energy and momentum.*	*Solving Problems*	*Solving Problems*	*Solving Problems*
	SLO-2	*Chemical reaction and Stoichiometric coefficients, Air-Fuel ratio, Equivalence ratio.*	*Application of Mass Energy and species Conservation.*	*Solving Problems*	*Solving Problems*	*Solving Problems*

S-6	SLO-1	*Calculation of Energy Release for Stoichiometric, oxidizer-rich and fuel rich Explosives.*	*Solving Problems*	*Introduction to diffusion mass transfer.*	*Image processing and combustion experimentation science.*	*Environnemental combustion considérations.*
	SLO-2	*Adiabatic flame temperature calculations: Analysis and practical considerations.*	*Solving Problems*	*Transport properties for gas mixtures.*	*Introduction to computational combustion and relevance.*	*Combustion, heat transfer and emission in industrial applications.*
S-7	SLO-1	*Chemical equilibrium, volumetric and gravimetric analysis.*	*Emission reduction and techniques in combustion instruments.*	*Mass transfer laws, Fick's law of Diffusion.*	*Numerical modeling of flame spreading phenomenon*	*Fire safety aspects of combustion sciences.*
	SLO-2	*Dissociation process and related issues.*	*Aerospace Engineering Applications of fundamental combustion physics.*	*Available and non-available energy of a source and finite body.*	*Numerical modeling of combustion processes.*	*Prospects in Aerospace propulsion and combustion.*
S-8	SLO-1	*Solving Problems*	*Solving Problems*	*Solving Problems*	*Solving Problems*	*Solving Problems*
	SLO-2	*Solving Problems*	*Solving Problems*	*Solving Problems*	*Solving Problems*	*Solving Problems*
S-9	SLO-1	*Chapter Doubt clarification.*	*Chapter Doubt clarification.*	*Chapter Doubt clarification.*	*Chapter Doubt clarification.*	*Chapter Doubt clarification.*
	SLO-2	*Chapter Doubt clarification.*	*Chapter Doubt clarification.*	*Chapter Doubt clarification.*	*Chapter Doubt clarification.*	*Chapter Doubt clarification.*

Learning Resources	1. *Stephen R. Turns, "An Introduction to Combustion: Concepts and Applications", 3rd Edition, McGraw-Hill Education, 2011.* 2. *Kenneth K Kuo, "Principles of Combustion", 2nd Edition, John Wiley and Sons, 2005.* 3. *D. P. Mishra., "Fundamentals of Combustion", Prentice Hall of India, New Delhi, 2008.*	4. *H.S. Mukunda., "Understanding Combustion", Universities Press, Second edition 2009.* 5. *Anil W. Date., "Analytic Combustion: With Thermodynamics, Chemical Kinetics and Mass Transfer", Cambridge University Press, 2011.* 6. *Irvin Glassman and Richard A. Yetter., "Combustion", 4th Edition, Elsevier, 2008.*

Learning Assessment

	Bloom's Level of Thinking	Continuous Learning Assessment (50% weightage)								Final Examination (50% weightage)	
		CLA – 1 (10%)		CLA – 2 (15%)		CLA – 3 (15%)		CLA – 4 (10%)#			
		Theory	Practice	Theory	Practice	Theory	Practice	Theory	Practice	Theory	Practice
Level 1	Remember Understand	*40%*	-	*30%*	-	*30%*	-	*30%*	-	*30%*	-
Level 2	Apply Analyze	*40%*	-	*40%*	-	*20%*	*20%*	*20%*	*20%*	*40%*	-
Level 3	Evaluate Create	*20%*	-	*30%*	-	*30%*	-	*30%*	-	*30%*	-
	Total	100 %		100 %		100 %		100 %		100 %	

CLA – 4 can be from any combination of these: Assignments, Seminars, Tech Talks, Mini-Projects, Case-Studies, Self-Study, MOOCs, Certifications, Conf. Paper etc.,

Course Designers

Experts from Industry	Experts from Higher Technical Institutions	Internal Experts
1. Dr. Vinay Kumar Gupta, National Physical Laboratory, guptavinay@nplindia.org	*1. Prof. D.P. Mishra, IIT Kanpur, mishra@ iitk.ac.in. (NPTEL- Fundamentals of Combustion)*	*1. Dr. T. Selvakumaran, SRMIST*
2. Dr.A. Sakthivel, CEMILAC, Bangalore, asakthironika@gmail.com	*2. Prof. Amit Kumar, IIT Madras, Chennai, amitk@ae.iitm.ac.in.*	*2. Dr. Pankaj Kumar, SRMIST*

Course Code	18ASE208T	Course Name	HEAT TRANSFER	Course Category	E	Professional Elective	L	T	P	C
							3	0	0	3

Pre-requisite Courses	18ASC102J, 18ASC103T	Co-requisite Courses	Nil	Progressive Courses	18ASE307T
Course Offering Department	Aerospace	Data Book / Codes/Standards	Heat & Mass Transfer Data Book, 9th edition by C P Kothandaraman, S Subramanyan		

Course Learning Rationale (CLR):	*The purpose of learning this course is to:*
CLR-1 :	*To familiarize the concept of different modes of heat transfer.*
CLR-2 :	*To familiarize the concept of conduction in plane wall and cylinders*
CLR-3 :	*To familiarize the Utilization of extended surface & Heat Generation*
CLR-4 :	*To familiarize the concept of convection mode and it various applications*
CLR-5 :	*To familiarize the concept of Radiationmode and it various applications*
CLR-6 :	*To solve the heat transfer practical problems*

Course Learning Outcomes (CLO):	*At the end of this course, learners will be able to:*	Learning 1: Level of Thinking (Bloom)	Learning 2: Expected Proficiency (%)	Learning 3: Expected Attainment (%)	PLO 1: Engineering Knowledge	PLO 2: Problem Analysis	PLO 3: Design & Development	PLO 4: Analysis, Design, Research	PLO 5: Modern Tool Usage	PLO 6: Society & Culture	PLO 7: Environment & Sustainability	PLO 8: Ethics	PLO 9: Individual & Team Work	PLO 10: Communication	PLO 11: Project Mgt. & Finance	PLO 12: Life Long Learning	PLO 13: PSO - 1	PLO 14: PSO - 2	PLO 15: PSO – 3
CLO-1 :	*Understand the heat diffusion equation under different coordinates*	2	80	70	H	H	H	-	-	-	-	-	-	-	-	M	M	M	H
CLO-2 :	*Estimate the heat transfer rate in a wall, composite walls and cylindrical objects*	2	85	75	H	H	H	-	-	-	-	-	-	-	-	M	M	M	H
CLO-3 :	*Estimate the size and numbers of extended surface or fin needed for heat transfer*	2	75	70	H	H	H	-	-	-	-	-	-	-	-	M	H	M	M
CLO-4 :	*Estimate the heat transfer rate in forced convection & natural convection*	2	85	80	H	H	H	-	-	-	-	-	-	-	-	M	M	M	H
CLO-5 :	*Estimate the heat transfer rate in Radiation mode*	2	85	75	H	H	H	-	-	-	-	-	-	-	-	L	M	M	M
CLO-6 :	*To solve the heat transfer practical problems*	3	80	70	H	H	H	H	-	-	M	-	-	-	-	L	M	M	H

Duration (hour)		9	9	9	9	9
S-1	SLO-1	*Introduction to heat transfer, Different modes of heat transfer and general principles*	*Conduction with Thermal Energy Generation – Plane wall systems*	*physical mechanism on convection,*	*Laminar convective heat transfer analysis in flows between parallel plates*	*Radiation: Processes, Black body radiation- Stefan Boltzmann law, Planck'slaw& Wein's Displacement law*
	SLO-2	*Solving problems*	*Solving problems*	*classification of fluid flows,*	*Solving problems*	*Solving problems*
S-2	SLO-1	*Introduction to Conduction – Heat diffusion equation Cartesian systems*	*Conduction with Thermal Energy Generation – composite Plane wall*	*Governing equation: Continuity equation*	*Turbulent convective heat transfer analysis in flows between parallel plates*	*Radiation intensity*
	SLO-2	*Heat diffusion equation Cartesian systems - Derivation*	*Solving Problems*	*Governing equation: Momentum Equation*	*Solving problems*	*Solving problems*
S-3	SLO-1	*Heat diffusion equation forCylindrical systems*	*Conduction with Thermal Energy Generation –radial systems*	*Governing equation: Energy Equation*	*Laminar convective heat transfer analysis in flows over a flat plate*	*Radiation properties, kirchoff's law*
	SLO-2	*Heat diffusion equation for Cylindrical systems - Derivation*	*Solving problems*	*Governing equation: Energy Equation*	*Solving problems*	*Solving problems*
S-4	SLO-1	*Heat diffusion equation for Spherical systems*	*Conduction with Thermal Energy Generation – composite radial systems*	*velocity and thermal boundary layer*	*Turbulent convective heat transfer analysis in flows over a flat plate*	*. Radiation shape Factors& Its relations*
	SLO-2	*Heat diffusion equation for Spherical systems - Derivation*	*Solving problems*	*Rayleigh number &Grashoff number*	*Solving problems*	*Solving problems*
S-5	SLO-1	*One-Dimensional, Steady-State Conduction – plane wall*	*Heat Transfer from Extended Surfaces – Rectangular circumferential Fins of Uniform Cross-Sectional Area, Fin Performance, Overall Surface Efficiency*	*Empirical Correlations: External Free Convection Flows over a vertical & horizontal flat plate*	*Laminar convective heat transfer analysis in flows over a circular pipe*	*Concept of black surface -Heat Exchange between two black bodies*
	SLO-2	*Solving Problems*	*Solving problems*	*Solving Problems*	*Solving problems*	*Solving problems*
S-6	SLO-1	*One-Dimensional, Steady-State Conduction – composite walls*	*Heat Transfer from Extended Surfaces – Cylindrical Fins of Uniform Cross-Sectional Area, Fin Performance, Overall Surface Efficiency*	*Empirical Correlations: External Free Convection Flows over a Inclined flat plate*	*turbulent convective heat transfer analysis in flows over a circular pipe*	*Radiation Heat Transfer in a grey surfaces - Net Radiation Heat Transfer between Any Two Surfaces*
	SLO-2	*Solving Problems*	*Solving problems*	*Solving Problems*	*Solving problems*	*Solving problems*
S-7	SLO-1	*One-Dimensional, Steady-State*	*Transient Conduction - The Lumped*	*Empirical Correlations: External Free*	*Laminar convective heat transfer analysis*	*Radiation Heat Transfer in Two-Surface*

		Conduction – Radial systems	*Capacitance Method,*	*Convection Flows over a vertical cylinder*	*in flows in a circular pipe*	*Enclosures*
	SLO-2	*Solving Problems*	*Solving Problems*	*Solving Problems*	*Solving problems*	*Solving problems*
S-8	SLO-1	*One-Dimensional, Steady-State Conduction – Spherical systems*	*Transient Conduction - Large walls & long cylinders*	*Empirical Correlations: External Free Convection Flows over a horizontal cylinder*	*turbulent convective heat transfer analysis in flows in a circular pipe*	*Radiation Heat Transfer in Three-Surface Enclosures*
	SLO-2	*Solving Problems*	*Solving Problems*	*Solving Problems*	*Solving problems*	*Solving problems*
S-9	SLO-1	*One-Dimensional, Steady-State Conduction – Radial & Spherical systems for Composite*	*Transient Conduction: Semi-infinite solids*	*Empirical Correlations: External Free Convection Flows over a Sphere*	*Laminar &turbulent convective heat transfer analysis in flows in a non-circular pipe*	*Radiation shields*
	SLO-2	*Solving Problems*	*Solving Problems*	*Solving Problems*	*Solving problems*	*Solving problems*

Learning Resources	1. *Yunus A. Cengel&Afshin J. Ghajar, "Heat & Mass Transfer", fifth Edition,McGraw-Hill, 2014* 2. *Theodore L. Bergman , Adrienne S. Lavine , Frank P. Incropera , David P. DeWitt, "Fundamentals of Heat and Mass Transfer", seventh Edition, John Wiley and Sons, New York, 2011*	3. *John H Lienhard, "A Heat Transfer Text Book", Dover publications inc, New York, 2011.*

Learning Assessment											
	Bloom's Level of Thinking	Continuous Learning Assessment (50% weightage)								Final Examination (50% weightage)	
		CLA – 1 (10%)		CLA – 2 (15%)		CLA – 3 (15%)		CLA – 4 (10%)#			
		Theory	Practice	Theory	Practice	Theory	Practice	Theory	Practice	Theory	Practice
Level 1	Remember Understand	*40%*	-	*30%*	-	*30%*	-	*30%*	-	*30%*	-
Level 2	Apply Analyze	*40%*	-	*40%*	-	*40%*	-	*40%*	-	*40%*	-
Level 3	Evaluate Create	*20%*	-	*30%*	-	*30%*	-	*30%*	-	*30%*	-
	Total	100 %		100 %		100 %		100 %		100 %	

CLA – 4 can be from any combination of these: Assignments, Seminars, Tech Talks, Mini-Projects, Case-Studies, Self-Study, MOOCs, Certifications, Conf. Paper etc.,

Course Designers		
Experts from Industry	Experts from Higher Technical Institutions	Internal Experts
1.Dr Raja Samikkannu, Senior Principal Scientist at National Aerospace Laboratories	*1.Dr.K.M.Parammasivam,Professor,, MIT, Chennai,* *Email Id:mparams@annauniv.edu*	*1. Mr. K.B.Ravichandrakumar,SRMIST*

Course Code	18ASE209T	Course Name	THEORY OF FIRE PROPAGATION AND SAFETY	Course Category	E	Professional Elective	L	T	P	C
							3	0	0	3

Pre-requisite Courses	18ASC102J, 18ASC103T	Co-requisite Courses	Nil	Progressive Courses	Nil
Course Offering Department	Aerospace Engineering	Data Book / Codes/Standards			

Course Learning Rationale (CLR):	*The purpose of learning this course is to:*
CLR-1 :	*Identify the fire dynamics, the burning processes and implications.*
CLR-2 :	*Identify the engineering applications of basic chemical combustion driven engineering systems.*
CLR-3 :	*Identify the significance of material identification for industrial applications, including burners and engines.*
CLR-4 :	*Create insights to the fires in engines, buildings, forests and compartments.*
CLR-5 :	*Analyze the fire related hazards in practical, functional, engineering, industrial applications.*
CLR-6 :	*Utilize the fire safety principles for system testing, validation and designing.*

Course Learning Outcomes (CLO):	*At the end of this course, learners will be able to:*	Learning 1: Level of Thinking (Bloom)	Learning 2: Expected Proficiency (%)	Learning 3: Expected Attainment (%)	PLO 1: Engineering Knowledge	PLO 2: Problem Analysis	PLO 3: Design & Development	PLO 4: Analysis, Design, Research	PLO 5: Modern Tool Usage	PLO 6: Society & Culture	PLO 7: Environment & Sustainability	PLO 8: Ethics	PLO 9: Individual & Team Work	PLO 10: Communication	PLO 11: Project Mgt. & Finance	PLO 12: Life Long Learning	PLO 13: PSO - 1	PLO 14: PSO - 2	PLO 15: PSO – 3
CLO-1 :	*Understand fire phenomenon, its applications and safety.*	2	80	70	H	M	L	L	-	-	-	-	-	-	-	H	-	-	-
CLO-2 :	*Comprehend the concept and applications of energy conservation in fires utilizations and apply the same for recent engineering advancement.*	2	80	70	H	M	M	M	-	-	L	-	-	L	-	H	M	M	M
CLO-3 :	*Understand basic knowledge to the physical principles governing fire growth.*	2	80	70	H	M	L	M	-	-	-	-	L	-	-	H	-	-	-
CLO-4 :	*Understand the behavior and chemical reactions related.*	2	80	70	H	M	M	M	-	-	M	M	M	M	L	H	M	M	M
CLO-5 :	*Apply the latest engineering capability in fire detection, prevention systems and life safety*	2	80	70	H	M	M	M	M	L	L	-	L	M	L	H	M	M	M
CLO-6 :	*Understanding prospects of normal and microgravity fire safety for Aerospace Engineering Applications.*	2	80	70	H	M	M	M	M	L	L	M	L	M	L	H	M	M	M

Duration (hour)		9	9	9	9	9
S-1	SLO-1	*Introduction to Fire Science, fires in history, fire losses, fire and combustion.*	*Importance of fire dynamics on a fire strategy.*	*Development and behavior of fire propagation in free and confined atmosphere.*	*Identifying fire spread hazards and risks.*	*Active and Passive Fire Protection Features.*
	SLO-2	*Relevant material properties, combustion and heat transfer.*	*Fundamentals of heat and mass transfer for fire, smoke production and transport.*	*Factors affecting fire growth.*	*Safety and financial implications, developing safe work systems.*	*Fire prevention-handling and storing flammable and combustible liquids/fuels/propellants.*
S-2	SLO-1	*Chemistry and classification of fires- Composition of Combustion- (Flame, heat, fire gases, smoke).*	*Fundamentals of ignition and flame propagation.*	*Buoyant Plumes, Combusting Plumes, Starting plume.*	*Introduction to Fires causes / Explosion hazards in Chemical, Electrical units.*	*Elimination of ignition sources.*
	SLO-2	*Review of Thermodynamics and Fluid Mechanics in fire behavior*	*Role of Material flammability in fire propagation.*	*Fireball, Transient Aspects of Fire Plumes.*	*Finite Real Fire Effects.*	*Fire protection in plants and factories, Fire walls, fire doors.*
S-3	SLO-1	*Solving Problems*	*Solving Problems*	*Solving Problems*	*Solving Problems*	*Solving Problems*
	SLO-2	*Solving Problems*	*Solving Problems*	*Solving Problems*	*Solving Problems*	*Solving Problems*
S-4	SLO-1	*Heat and mass transfer. Relevance of fire classification and governing dynamics.*	*Parameters affecting ignition, flame spread.*	*Fire spread over liquid and solid fuel surfaces.*	*Fire hazards (health–flammability-reactivity (stability)).*	*Fire prevention/suppression features, Microgravity fires control.*
	SLO-2	*Material Flammability principles, Thermal Ignition.*	*Heat release rate and flame extinction phenomenon.*	*Enclosure fires, Incineration.*	*Air contaminants in fires-toxic effects of fire gases.*	*Fire suppression. Fixed automatic sprinklers. Sprinkler system and design.*
S-5	SLO-1	*Sources of ignition of combustible materials.*	*Explosions and fires –fundamental combustion principles.*	*Solving Problems*	*Solving Problems*	*Solving Problems*
	SLO-2	*Application of Mass Energy and species Conservation.*	*Egress– principles and calculations.*	*Solving Problems*	*Solving Problems*	*Solving Problems*
S-6	SLO-1	*Rate of burning. Heat transfer from Flames- Ignition temperature.*	*Solving Problems*	*Forest fires Analysis of fire plumes.*	*Smoldering combustion science.*	*Environnemental fire propagation considérations.*
	SLO-2	*Flash point, Fire point, Flash over.*	*Solving Problems*	*Fire safety aspects of plumes.*	*Introduction to smoke formation, composition and movement, hazards.*	*Role of combustion detectors (Fire detection, smoke detection, types of ionization-photo electric-light intensity-*

						scattered light detectors.
S-7	SLO-1	*Components and objectives of a fire safety strategy.*	*Fire safety techniques in combustion instruments.*	*Standardized material flammability testing.*	*Essential conditions for explosion occurrence.*	*Heat detectors. Flame detectors -infra red detector - ultraviolet flame detector).*
	SLO-2	*Fire dynamics process and related issues.*	*Aerospace Engineering Applications of fire dynamics.*	*Solid, liquid and gaseous fuel combustion and its relation to fire safety.*	*Explosion characteristics and Prevention.*	*Portable fire Extinguishers-Types-extinguisher-location, Inspection–testing, principles and calculations.*
S-8	SLO-1	*Solving Problems*	*Solving Problems*	*Solving Problems*	*Solving Problems*	*Solving Problems*
	SLO-2	*Solving Problems*	*Solving Problems*	*Solving Problems*	*Solving Problems*	*Solving Problems*
S-9	SLO-1	*Chapter Doubt clarification.*	*Chapter Doubt clarification.*	*Chapter Doubt clarification.*	*Chapter Doubt clarification.*	*Chapter Doubt clarification.*
	SLO-2	*Chapter Doubt clarification.*	*Chapter Doubt clarification.*	*Chapter Doubt clarification.*	*Chapter Doubt clarification.*	*Chapter Doubt clarification.*

Learning Resources	1. *James G. Quintiere, "Fundamentals of Fire Phenomena", 2006 Wiley.* 2. *Dougal Drysdale, "An Introduction to Fire Dynamics", 2011 Wiley.* 3. *Akhil Kumar Das., "Principles of Fire Safety Engineering: Understanding Fire and Fire Protection", Prentice Hall of India, New Delhi, 2014.*	4. *R.S. Gupta., "A Hand Book of Fire Technology", Second edition, Modern press, 2005.* 5. *V, K, Jain, "Fire safety in buildings", New age international publisher, 2006.* 6. *Niamh Nic Daeid., "Fire Investigation", CRC Press, 2004.*

Learning Assessment											
	Bloom's Level of Thinking	Continuous Learning Assessment (50% weightage)								Final Examination (50% weightage)	
		CLA – 1 (10%)		CLA – 2 (15%)		CLA – 3 (15%)		CLA – 4 (10%)#			
		Theory	Practice	Theory	Practice	Theory	Practice	Theory	Practice	Theory	Practice
Level 1	Remember Understand	40%	-	30%	-	30%	-	30%	-	30%	-
Level 2	Apply Analyze	40%	-	40%	-	40%	-	40%	-	40%	-
Level 3	Evaluate Create	20%	-	30%	-	30%	-	30%	-	30%	-
	Total	100 %		100 %		100 %		100 %		100 %	

CLA – 4 can be from any combination of these: Assignments, Seminars, Tech Talks, Mini-Projects, Case-Studies, Self-Study, MOOCs, Certifications, Conf. Paper etc.,

Course Designers		
Experts from Industry	Experts from Higher Technical Institutions	Internal Experts
1. Dr. Vinay Kumar Gupta, National Physical Laboratory, guptavinay@nplindia.org	1.Prof. Raghavan, V., IIT Madras, Chennai, raghavan@iitm.ac.in.	1.Dr. T. Selvakumaran, SRMIST
	2.Prof. Amit Kumar, IIT Madras, Chennai, amitk@ae.iitm.ac.in.	2.Mr. Vinayak Malhotra, SRMIST

Course Code	18ASE210T	Course Name	AIRFRAME MAINTENANCE AND REPAIR	Course Category	E	Professional Elective	L	T	P	C
							3	0	0	3

Pre-requisite Courses	Nil	Co-requisite Courses	Nil	Progressive Courses	Nil
Course Offering Department	Aerospace Engineering	Data Book / Codes/Standards	Nil		

Course Learning Rationale (CLR):	*The purpose of learning this course is to:*
CLR-1 :	*Identify the type of welding and riveting process to be used in aircraft.*
CLR-2 :	*Perform Plastic and Composite material repair in Aircraft Structures*
CLR-3 :	*Carryout Assembly & Rigging of Aircraft Flight Controls.*
CLR-4 :	*Execution of Inspection & Maintenance of major and auxiliary systems*
CLR-5 :	*Identify the various hazardous materials and storage practices.*
CLR-6 :	*Utilize the knowledge acquired for repair and maintenance activities on aircraft structure.*

		Learning			Program Learning Outcomes (PLO)														
		1	2	3	1	2	3	4	5	6	7	8	9	10	11	12	13	14	15
Course Learning Outcomes (CLO):	*At the end of this course, learners will be able to:*	Level of Thinking (Bloom)	Expected Proficiency (%)	Expected Attainment (%)	Engineering Knowledge	Problem Analysis	Design & Development	Analysis, Design, Research	Modern Tool Usage	Society & Culture	Environment & Sustainability	Ethics	Individual & Team Work	Communication	Project Mgt. & Finance	Life Long Learning	PSO - 1	PSO - 2	PSO – 3
CLO-1 :	*Acquire knowledge on welding and sheet metal repair operations and maintenance practices in aviation industry*	2	80	70	H	-	M	L	M	-	-	-	-	-	-	L	L	M	M
CLO-2 :	*Gain knowledge on maintenance and repair procedures on plastics and composite structures*	2	80	70	H	-	M	L	M	-	-	-	-	-	-	-	M	M	M
CLO-3 :	*Understand the Assembly & Rigging procedures and operation of Aircraft flight controls.*	2	80	70	H	-	L	L	M	-	-	-	M	-	-	L	M	M	M
CLO-4 :	*Learn the inspection and maintenance of major and auxiliary systems*	2	80	70	H	-	L	L	M	-	M	M	-	-	-	L	M	M	M
CLO-5 :	*Acquire knowledge on Hazardous materials, safety , Inventory Procedures & Troubleshooting practices*	2	80	70	H	L	L	L	M	-	-	-	-	M	-	L	H	H	M
CLO-6 :	*Acquire comprehensive knowledge onairframe maintenance and repair.*	2	80	70	H	L	L	L	M	-	M	M	M	M	-	L	M	M	M

Duration (hour)		9	9	9	9	9
S-1	SLO-1	*Introduction to Aircraft Welding*	*Applications & Advantages of Plastics used in Aircraft.*	*Introduction to Aircraft Assembly and Rigging operations.*	*Inspection of Landing Gear System*	*Introduction to Hazardous Materials*
	SLO-2	*Nomenclature & Types.of Welding*	*Classification & Types of Plastics*	*Rigging Specifications*	*Maintenance of Landing Gear System*	*Types*
S-2	SLO-1	*Equipments used in Welding shop*	*Identification of Clear Plastics*	*Aircraft Leveling Procedure*	*Inspection of Air - conditioning System*	*Flammables - Handling, Storage & Emergency Procedure*
	SLO-2	*Need for Maintenance of Welding Equipments*	*Storage and Protection, Cutting, & Drilling of Plastics*	*Assembly of Major Structural Components*	*Maintenance of Air - conditioning System*	*Corrosives - Handling, Storage & Emergency Procedure*
S-3	SLO-1	*Maintenance of Welding Equipments*	*Forming of Plastics.*	*Assembly of Movable Control Surfaces*	*Inspection of Pressurization System*	*Toxins &Reactives - Handling, Storage & Emergency Procedure*
	SLO-2		*Cementing, Annealing & Cleaning of Plastics*	*Fixed Surface Alignment – Symmetry Check*	*Maintenance of Pressurization System*	*Physical & Biological Hazards*
S-4	SLO-1	*Characteristics of a good weld & Ensuring Quality Weld*	*Installation of Plastic Windows and Windshields*	*Demonstration of Symmetry Check in Cessna Aircraft*	*Inspection of Aircraft Instruments*	*Handling, Storage & Emergency Procedure*
	SLO-2	*Introduction to Non-fusion Welding Process - Soldering & Brazing*	*Inspection of Plastic Components*		*Maintenance of Aircraft Instruments*	*Osha's Hazardous Communication Standards*
S-5	SLO-1	*Requirements & Process*	*Repair of Cracks in Plastics.*	*Effects of Rigging on Flight*	*Testing of Instruments*	*Material Safety Data Sheet*
	SLO-2	*Advantages & Disadvantages.*	*Repair of Holes in Plastics.*	*Checking & Adjusting Dihedral angle.*	*Handling of Instruments*	*Inventory & Labeling*
S-6	SLO-1	*Classification of Damage*	*Introduction to Advanced Composites in Aircraft.*	*Checking & Adjusting Incidence angle.*	*Inspection of Fire Protection Systems*	*Introduction to Troubleshooting Theory*
	SLO-2	*Damage Investigation*	*Advantages of Composites over Metals in Aerospace Applications*	*Alignment Check of Empennage*	*Maintenance of Fire Protection Systems*	*Types*
S-7	SLO-1	*Repair Layout Techniques*	*Equipments used in Composite Fabrication*	*Alignment Check of Wings*	*Inspection of Ice Protection Systems*	*Troubleshooting with Chart*
	SLO-2	*Repair Practices*	*Wet Layup Process of Building Composite Parts.*	*Alignment Check of Engines.*	*Maintenance of Ice Protection Systems*	*Examples*

S-8	SLO-1	*Introduction to Riveting Process in Aviation Industry.*	*Prepreg Process of Building Composite Parts.*	*Demonstration of various checks in Cessna Aircraft*	*Inspection of Water & Waste Systems*	*Troubleshooting without chart*
	SLO-2	*Types & Nomenclature of Rivets*	*Repair of Composite Components*		*Maintenance of Water & Waste Systems*	*Examples*
S-9	SLO-1	*Equipments used for Riveting*	*Special Precautions*	*Need for Balancing Control Surfaces*	*Inspection of Position & Warning Systems*	*Troubleshooting intermittent discrepancies*
	SLO-2	*Installation of Rivets*	*NDT methods in Composite Materials.*	*Procedure for Balancing Control Surfaces*	*Maintenance of Position & Warning Systems*	*Examples*

Learning Resources	1. *Michael J.Kroes, William A.Watkins ad Frank Delp, Aircraft Maintenance and Repair, 7th ed., Tata McGraw Hill, 2013* 2. *Aviation Maintenance Technician Handbook – Airframe, Vol.1, 2, U.S.Dept. of Transportation,Federal Aviation Administration, Flight Standards Service, 2012*	3. *Larry Reithmeir., Aircraft Repair Manual, Palamar Books, Marquette,1992.* 4. *Civil Aircaft Inspection Procedures Part I & II, CAA, English Book House, New Delhi 1986.*

Learning Assessment											
	Bloom's Level of Thinking	Continuous Learning Assessment (50% weightage)								Final Examination (50% weightage)	
		CLA – 1 (10%)		CLA – 2 (15%)		CLA – 3 (15%)		CLA – 4 (10%)#			
		Theory	Practice	Theory	Practice	Theory	Practice	Theory	Practice	Theory	Practice
Level 1	Remember Understand	*40 %*	-	*30 %*	-	*30 %*	-	*30 %*	-	*30%*	-
Level 2	Apply Analyze	*40 %*	-	*40 %*	-	*40 %*	-	*40 %*	-	*40%*	-
Level 3	Evaluate Create	*20 %*	-	*30 %*	-	*30 %*	-	*30 %*	-	*30%*	-
	Total	100 %		100 %		100 %		100 %		100 %	

CLA – 4 can be from any combination of these: Assignments, Seminars, Tech Talks, Mini-Projects, Case-Studies, Self-Study, MOOCs, Certifications, Conf. Paper etc.,

Course Designers		
Experts from Industry	Experts from Higher Technical Institutions	Internal Experts
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2..Mr.K.Senthilkumar,Deputy Chief Aircraft Engineer, Air India , Bangalore ks_senthilkumar@yahoo.co	*2. Dr.Wg.Cdr.N.Muthusamy, Rajalakshmi Engineering college, Chennai, muthusamy55@gmail.com*	*2. Mr. G. Mahendra Perumal, SRMIST*

Course Code	18ASE211T	Course Name	AIRBORNE SENSORS AND ACTUATORS	Course Category	E	Professional Elective	L	T	P	C
							3	0	0	3

Pre-requisite Courses	Nil	Co-requisite Courses	Nil	Progressive Courses	Nil
Course Offering Department	Aerospace Engineering	Data Book / Codes/Standards	Nil		

Course Learning Rationale (CLR):	*The purpose of learning this course is to:*
CLR-1 :	*Understand the advanced concepts in airborne sensors and actuators*
CLR-2 :	*Provide mathematical knowledge for modelling*
CLR-3 :	*Understand the aircraft actuation systems*
CLR-4 :	*Understand the servo components*
CLR-5 :	*Learn the modeling of sensors and actuators*
CLR-6 :	*To solve problems in avionics engineering*

		Learning			Program Learning Outcomes (PLO)														
		1	2	3	1	2	3	4	5	6	7	8	9	10	11	12	13	14	15
Course Learning Outcomes (CLO):	*At the end of this course, learners will be able to:*	Level of Thinking (Bloom)	Expected Proficiency (%)	Expected Attainment (%)	Engineering Knowledge	Problem Analysis	Design & Development	Analysis, Design, Research	Modern Tool Usage	Society & Culture	Environment & Sustainability	Ethics	Individual & Team Work	Communication	Project Mgt. & Finance	Life Long Learning	PSO - 1	PSO - 2	PSO – 3
CLO-1 :	*Describe the concepts of airborne sensors and actuators*	*2*	*85*	*75*	*H*	-	-	-	-	-	-	-	-	-	-	-	-	*M*	-
CLO-2 :	*To apply mathematical knowledge in modeling of sensors and actuators*	*2*	*85*	*75*	*H*	*H*	*H*	-	-	-	-	-	-	-	-	-	*M*	*M*	-
CLO-3 :	*Describe the aircraft actuation systems*	*2*	*85*	*75*	*H*	-	*H*	*H*	-	-	-	-	-	-	-	-	-	*M*	-
CLO-4 :	*Describe the servo components*	*2*	*85*	*75*	*H*	*H*	-	-	*H*	-	-	-	-	-	-	-	*M*	*M*	*M*
CLO-5 :	*Model the sensors and actuators*	*2*	*85*	*75*	*H*	-	*H*	-	*H*	-	-	-	-	-	-	-	*M*	*M*	*M*
CLO-6 :	*Solve problems in avionics engineering*	*2*	*85*	*75*	*H*	*H*	*H*	*H*	*H*	-	-	-	-	-	-	-	*M*	*M*	*M*

Duration (hour)		9	9	9	9	9
S-1	SLO-1 SLO-2	*Introduction to aircraft actuation systems*	*Servo Actuators*	*Linear and non linear actuation systems*	*Gyroscope principles*	*Testing philosophies*
S-2	SLO-1 SLO-2	*Introduction to aircraft actuation systems*	*Linear Servo Actuators and types*	*Modeling of actuation systems*	*Gyro equation*	*Testing protocols*
S-3	SLO-1 SLO-2	*Principles of aircraft actuation systems*	*Rotary Servo Actuators and types*	*Modeling of actuation systems*	*Rate gyro and integration*	*Testing process*
S-4	SLO-1 SLO-2	*Hardware elements for the actuation systems*	*Servo Valves*	*Servo loop analysis*	*Free gyro, Vertical and directional gyro*	*Solenoid voltmeter, wheatstone bridge*
S-5	SLO-1 SLO-2	*Functional block diagram of the actuation systems*	*Hydraulic servo valves and types*	*Servo loop analysis*	*Inertial navigation*	*EMF meter, electrometer*
S-6	SLO-1 SLO-2	*Types of actuation systems*	*Electro hydraulic servo valves and types*	*Actuator design*	*Basic principles theory and applications*	*Signal generators*
S-7	SLO-1 SLO-2	*Electromagnetic actuators*	*Servo amplifier pick off*	*Testing methodologies*	*Accelerometer- principle and theory*	*Performance testing of sensors*
S-8	SLO-1 SLO-2	*Electric motors*	*Selection factors of servo amplifier*	*Performance testing*	*Spring, mass, force balance*	*Data evaluation*
S-9	SLO-1 SLO-2	*Solenoid actuators*	*Power supply consideration for servo amplifier*	*Test equipment for actuation systems*	*Piezoelectric accelerometer and MEMS sensors*	*Calculation of performance parameters*

Learning Resources	1. *James Ephraim Johnson, Electro hydraulic servo systems, hydraulics and pneumatic magazines, 1984* 2. *Pallett, EHJ, Aircraft instruments, principles and applications, pitman publishers, London, 1981* 3. *Neal E wood et al, Electromechanical actuation development AFFDL-TR-150. Dec 1978*	4. *Alan S Moris, Measurement and instrumentation principles, Third edition, 2001* 5. *J Jaidev vyas et al, Electro hydraulic actuation systems: Design testing, Identification and validation, 2019* 6. *Oing Guo, Non linera control techniques for electro hydraulic actuators, 2017*

Learning Assessment											
	Bloom's Level of Thinking	Continuous Learning Assessment (50% weightage)								Final Examination (50% weightage)	
		CLA – 1 (10%)		CLA – 2 (15%)		CLA – 3 (15%)		CLA – 4 (10%)#			
		Theory	Practice	Theory	Practice	Theory	Practice	Theory	Practice	Theory	Practice
Level 1	Remember Understand	*40 %*	-	*30 %*	-	*30 %*	-	*30 %*	-	*30%*	-
Level 2	Apply Analyze	*40 %*	-	*40 %*	-	*40 %*	-	*40 %*	-	*40%*	-
Level 3	Evaluate Create	*20 %*	-	*30 %*	-	*30 %*	-	*30 %*	-	*30%*	-
	Total	100 %		100 %		100 %		100 %		100 %	

CLA – 4 can be from any combination of these: Assignments, Seminars, Tech Talks, Mini-Projects, Case-Studies, Self-Study, MOOCs, Certifications, Conf. Paper etc.,

Course Designers		
Experts from Industry	Experts from Higher Technical Institutions	Internal Experts
1. Dr. S. Raja, National Aerospace Laboratories, Bangalore, raja@nal.res.in	*1. Dr.Parammasivam, professor, MIT, Chennai, mparams@mitindia.edu*	*1. Mr. Umar Rizwan M, SRMIST*

Course Code	18ASE301T	Course Name	AIRCRAFT CONTROL SYSTEMS	Course Category	E	Professional Elective	L	T	P	C
							3	0	0	3

Pre-requisite Courses	18ASC305T	Co-requisite Courses	Nil	Progressive Courses	Nil
Course Offering Department	Aerospace Engineering	Data Book / Codes/Standards			

Course Learning Rationale (CLR):	*The purpose of learning this course is to:*
CLR-1 :	*Understand the basics of control system*
CLR-2 :	*Understand the root locus analysis*
CLR-3 :	*Understand the frequency response analysis*
CLR-4 :	*Understand the time and frequency domain design of control system*
CLR-5 :	*Understand the control system design in state space*
CLO-6 :	*Understand control systems, various response analysis and control system in state space*

Course Learning Outcomes (CLO):	*At the end of this course, learners will be able to:*	Learning 1: Level of Thinking (Bloom)	Learning 2: Expected Proficiency (%)	Learning 3: Expected Attainment (%)	PLO 1: Engineering Knowledge	PLO 2: Problem Analysis	PLO 3: Design & Development	PLO 4: Analysis, Design, Research	PLO 5: Modern Tool Usage	PLO 6: Society & Culture	PLO 7: Environment & Sustainability	PLO 8: Ethics	PLO 9: Individual & Team Work	PLO 10: Communication	PLO 11: Project Mgt. & Finance	PLO 12: Life Long Learning	PLO 13: PSO - 1	PLO 14: PSO - 2	PLO 15: PSO – 3
CLO-1 :	*Design a mathematical model of a dynamic system*	2	85	75	H	-	-	-	-	-	-	-	-	-	-	-	-	M	M
CLO-2 :	*Analyze the system using Root Locus plot*	2	85	75	H	H	H	H	-	-	-	-	-	-	-	-	M	-	-
CLO-3 :	*Analyze the system using Frequency response analysis*	2	85	75	H	-	H	H	-	-	-	-	-	-	-	-	-	M	M
CLO-4 :	*Design a control system in time and frequency domain*	2	85	75	H	H	H	-	-	-	-	-	-	-	-	-	M	M	-
CLO-5 :	*Design and analyze the control system in state space*	2	85	75	H	-	-	H	-	-	-	-	-	-	-	-	M	-	M
CLO-6 :	*Design and analyze control systems, various response analysis and control system in state space*	2	85	75	H	H	H	H	-	-	-	-	-	-	-	-	M	M	M

Duration (hour)		9	9	9	9	9
S-1	SLO-1	*Introduction to Control Systems*	*Introduction to Root Locus Analysis*	*Bode Diagrams*	*Introduction to time domain and frequency domain design of control system*	*Lyapunov Stability*
	SLO-2	*Open-Loop, Closed-Loop Control, Feedback control system*		*Rules for Constructing the Bode Plots*		
S-2	SLO-1	*Block Diagrams and their Simplification*	*General Rules for Constructing the Root Locus*	*Nyquist Plots*	*PD Controller Design*	*Asymptotic Stability*
	SLO-2			*Rules for Constructing the Nyquist Plots*	*PIController Design*	*Input-Output Stability*
S-3	SLO-1	*Mason's Gain Formula*	*Positive feedback Systems*	*Stability and Relative Stability Analysis*	*PID Controller Design*	*State Transition Matrix*
	SLO-2	*Numerical*				*Controllability and Observability*
S-4	SLO-1	*Mathematical Modeling ofDynamical Systems*	*Root Locus plot for positive feedback system*	*Systems with Transport Lags*	*Lead Compensation*	*The Lyapunov Equation*
	SLO-2				*Lag Compensation*	
S-5	SLO-1	*Modeling in the State Space*	*Negative feedback Systems*	*Gain Margin*	*Lead-Lag Compensation*	*Full-State Feedback Control Designand Pole Placement*
	SLO-2			*Phase Margin*		
S-6	SLO-1	*Transfer Functions*	*Root Locus plot for Negative feedback system*	*Closed-Loop Frequency Response*	*Sensitivity*	*Optimal State Space Control System*
	SLO-2	*ImpulseResponse Functions*				
S-7	SLO-1	*Delay Time, Rise Time, Peak Time, Maximum Overshoot,and Settling Time*	*Parameter Variation*	*Frequency Domain Performance Specifications*	*Complimentary Sensitivity Transfer Functions*	*Linear Quadratic Regulator*
	SLO-2	*Stability Analysis and Routh's Stability Criterion*				
S-8	SLO-1	*Proportional, Derivative, and Integral Control Actions*	*Stability analysis of positive feedback system using root locus*	*Peak Resonance*	*Disturbance Rejection*	*Classical Control Theory*
	SLO-2			*Resonant Frequency*		
S-9	SLO-1	*Steady-State Error Analysis in Feedback Systems*	*Stability analysis of Negative feedback system using root locus*	*Bandwidth*	*Loop Shaping*	*Modern Control Theory*
	SLO-2			Numerical example		

Learning Resources	
	1. *Ogata, K., Modern Control Engineering, Prentice Hall, 2002* 2. *Kuo, B.C., Automatic Control Systems, Prentice Hall, 1991* 3. *Franklin, G.F., Powell, J.D., and Emami-Naeini, A., Feedback Control of Dynamic Systems, AddisonWesley, 1994.* 4. *Dorf, R.C., and Bishop, R.H., Modern Control Systems, Prentice Hall, 2001.* 5. *Nise, N.S., Control Systems Engineering, Benjamin-Cummings, 1995.*

Learning Assessment											
	Bloom's Level of Thinking	Continuous Learning Assessment (50% weightage)								Final Examination (50% weightage)	
		CLA – 1 (10%)		CLA – 2 (15%)		CLA – 3 (15%)		CLA – 4 (10%)#			
		Theory	Practice	Theory	Practice	Theory	Practice	Theory	Practice	Theory	Practice
Level 1	Remember / Understand	*40 %*	-	*30 %*	-	*30 %*	-	*30 %*	-	*30%*	-
Level 2	Apply / Analyze	*40 %*	-	*40 %*	-	*40 %*	-	*40 %*	-	*40%*	-
Level 3	Evaluate / Create	*20 %*	-	*30 %*	-	*30 %*	-	*30 %*	-	*30%*	-
	Total	100 %		100 %		100 %		100 %		100 %	

CLA – 4 can be from any combination of these: Assignments, Seminars, Tech Talks, Mini-Projects, Case-Studies, Self-Study, MOOCs, Certifications, Conf. Paper etc.,

Course Designers		
Experts from Industry	Experts from Higher Technical Institutions	Internal Experts
1. Dr. S. Raja, Senior Principal Scientist and Professor, NAL – Bangalore. raja@nal.res.in	*1. Dr.K.M.Parammasivam, Professor, MIT-Chennai. mparams@mitindia.edu*	*1. Mr.A.Vinoth Kumar, SRMIST.*

Course Code	18ASE302T	Course Name	HELICOPTER AERODYNAMICS	Course Category	E	Professional Elective	L	T	P	C
							3	0	0	3

Pre-requisite Courses	18ASC202J	Co-requisite Courses	Nil	Progressive Courses	Nil
Course Offering Department	Aerospace Engineering	Data Book / Codes/Standards	Nil		

Course Learning Rationale (CLR):	*The purpose of learning this course is to:*
CLR-1 :	*Understand the helicopter configurations, characteristics and its rotor systems*
CLR-2 :	*Learn the momentum theory used in the analysis of helicopter aerodynamics*
CLR-3 :	*Comprehend the performance of helicopter in hovering and climbing.*
CLR-4 :	*Understand the flow states of the rotor and helicopter vertical descent performance*
CLR-5 :	*Study the performance of helicopter in horizontal flight.*
CLR-6 :	*Acquaint with forward flight performance of helicopter and theory of blade stall.*

Course Learning Outcomes (CLO):	*At the end of this course, learners will be able to:*	Learning 1 Level of Thinking (Bloom)	2 Expected Proficiency (%)	3 Expected Attainment (%)	PLO 1 Engineering Knowledge	2 Problem Analysis	3 Design & Development	4 Analysis, Design, Research	5 Modern Tool Usage	6 Society & Culture	7 Environment & Sustainability	8 Ethics	9 Individual & Team Work	10 Communication	11 Project Mgt. & Finance	12 Life Long Learning	13 PSO - 1	14 PSO - 2	15 PSO – 3
CLO-1 :	*Acquire knowledge of helicopter fundamentals, configurations and rotor systems.*	2	85	80	H	M	L	L	-	-	-	-	-	-	-	L	M	M	H
CLO-2 :	*Apply momentum theory in the analysis of helicopter parameters.*	2	90	75	H	H	M	M	L	-	-	-	-	-	-	L	H	M	M
CLO-3 :	*Acquire theoretical foundation on the hovering and climbing performance of helicopter.*	2	85	75	H	M	M	L	-	-	-	-	-	-	-	L	M	H	M
CLO-4 :	*Analyze the vertical descent performance of helicopter.*	2	80	70	H	M	L	L	-	-	-	-	-	-	-	L	M	M	M
CLO-5 :	*Acquire basic understanding of helicopter performance in horizontal flight.*	2	85	75	H	M	L	L	-	-	-	-	-	-	-	L	H	H	M
CLO-6 :	*Accrue information on the helicopter performance in forward flight and theory of blade stall.*	2	80	70	H	M	M	M	L	-	-	-	-	-	-	L	M	M	H

Duration (hour)		9	9	9	9	9
S-1	SLO-1	*Introduction to Helicopters – History*	*Momentum Theory - Introduction*	*Performance in Hovering and Climbing*	*Flow States of the Rotor – Introduction*	*Forward Flight – Performance Equation*
	SLO-2	*Helicopter Configurations – Single Rotor, Two Rotor and Multi Rotor Machines*				
S-2	SLO-1	*Specifics of Helicopters*	*Thrust Generation*	*Optimum Hovering Rotor*	*Normal Working, Vortex-Ring and Windmill States*	*Drag-Lift Ration – Forward Flight*
	SLO-2	*Articulated Rotor System*				*Parasite Drag Coefficient – Forward Flight*
S-3	SLO-1	*Definitions – Tip Path, Tip Path Plane, Axis of Rotation, Shaft Axis, Disc Area, Chord, Blade Angle, Angle of Attack*	*Hovering*	*Induced Torque*	*Vertical Descent Performance*	*Climb Drag-Lift Ratio – Forward Flight*
	SLO-2					
S-4	SLO-1	*Definitions – Feathering Angle, Feathering, Disc Loading, Blade Loading, Solidity, Flapping, Lead-Lagging*	*Figure of Merit*	*Profile Drag Torque*	*Curves for Calculating Vertical-Descent Velocities, Flight Modes of a Rotor, Autorotation Diagrams*	*Profile Drag-Lift Ratio – Forward Flight*
	SLO-2					
S-5	SLO-1	*Effect of Cyclic Pitch Change*	*Blade Element Theory*	*Numerical Problems on Optimum Hovering Rotor, Induced Torque, Profile Drag Torque*	*Performance in Horizontal Flight – Introduction*	*Induced Drag – Forward Flight*
	SLO-2	*Swash Plate*				
S-6	SLO-1	*Rotor Systems – Fully Articulated, Semi-Rigid Rotor, Rigid Rotor*	*General Expression for Induced Velocity*	*Performance Equation*	*Flapping and Lag Hinge – Horizontal Flight*	*Profile Power and Parasite Power in Forward Flight*
	SLO-2				*Steady Hover – Horizontal Flight*	
S-7	SLO-1	*The Atmosphere*	*Local Solidity*	*Optimum Rotor Design*	*Ideally Twisted Blade – Horizontal Flight*	*Introduction to Blade Stall*
	SLO-2	*International Standard Atmosphere (ISA)*				
S-8	SLO-1	*Atmospheric Density and Power Required – Definitions of Rotor Profile Power, Induced Power, Parasite Power*	*Tip Loss*	*Ground Effect*	*No Twist Case – Horizontal Flight*	*Introduction to Quadcopter / Multirotaor Aerodynamics*
	SLO-2		*Equivalent Chord*			
S-9	SLO-1	*Tutorial*	*Tutorial*	*Tutorial*	*Tutorial*	*Tutorial*
	SLO-2					

Learning Resources	1. *Rathakrishnan E., Helicopter Aerodynamics, PHI Learning Private Limited, Delhi, 2019.* 2. *Nikolsky Alexander A., Helicopter Analysis, John Wiley & Sons Inc., New York, 1951* 3. *Alfred Gessow, Garry C. Myers Jr., Aerodynamics of the Helicopter, College Park Press, USA, 1999.*	4. *George H. Saunders, Dynamics of Helicopter Flight, John Wiley & Sons Inc., New York, 1975.* 5. *Wayne Johnson, Helicopter Theory, Dover Publications, USA, 1994.* 6. *Gordon Leishman J., Principles of Helicopter Aerodynamics, Cambridge University Press, New York, 2000.* 7. *John Seddon, Simon Newman, Basic Helicopter Aerodynamics, 3rd Edition, John Wiley & Sons, Ltd., 2011.*

Learning Assessment											
	Bloom's Level of Thinking	Continuous Learning Assessment (50% weightage)								Final Examination (50% weightage)	
		CLA – 1 (10%)		CLA – 2 (15%)		CLA – 3 (15%)		CLA – 4 (10%)#			
		Theory	Practice	Theory	Practice	Theory	Practice	Theory	Practice	Theory	Practice
Level 1	Remember Understand	*40 %*	-	*30 %*	-	*30 %*	-	*30 %*	-	*30%*	-
Level 2	Apply Analyze	*40 %*	-	*40 %*	-	*40 %*	-	*40 %*	-	*40%*	-
Level 3	Evaluate Create	*20 %*	-	*30 %*	-	*30 %*	-	*30 %*	-	*30%*	-
	Total	100 %		100 %		100 %		100 %		100 %	

CLA – 4 can be from any combination of these: Assignments, Seminars, Tech Talks, Mini-Projects, Case-Studies, Self-Study, MOOCs, Certifications, Conf. Paper etc.,

Course Designers		
Experts from Industry	Experts from Higher Technical Institutions	Internal Expert
Dr. Manishankar C., Senior Scientist, NAL, Bangalore	*Prof. Arun Kumar P., Assistant Professor, IIT Jammu*	*Dr. S. M. Aravindh Kumar, SRMIST*

Course Code	18ASE303T	Course Name	ROCKET AERODYNAMICS	Course Category	E	Professional Elective	L	T	P	C
							3	0	0	3

Pre-requisite Courses	18ASC301J	Co-requisite Courses	Nil	Progressive Courses	Nil
Course Offering Department	Aerospace Engineering	Data Book / Codes/Standards	Nil		

Course Learning Rationale (CLR):	*The purpose of learning this course is to:*
CLR-1 :	*Understand the concept of boundary layer and its characteristics.*
CLR-2 :	*Learn basics of incompressible and compressible flat plate boundary layer, importance of shock-wave boundary layer interactions.*
CLR-3 :	*Understand and appreciate the qualitative aspects of hypersonic flow, hypersonic shock-wave and Expansion-wave relations, application of Newtonian theory in hypersonic flow*
CLR-4 :	*Study different classifications and external aerodynamic configurations of missiles.*
CLR-5 :	*Apply cross-flow analysis in the analysis of aerodynamics characteristics of missiles, vortex shedding and flow separation.*
CLR-6 :	*Understand the various aerodynamic launching problems of missiles.*

Course Learning Outcomes (CLO):	*At the end of this course, learners will be able to:*	Learning 1 Level of Thinking (Bloom)	Learning 2 Expected Proficiency (%)	Learning 3 Expected Attainment (%)	PLO 1 Engineering Knowledge	PLO 2 Problem Analysis	PLO 3 Design & Development	PLO 4 Analysis, Design, Research	PLO 5 Modern Tool Usage	PLO 6 Society & Culture	PLO 7 Environment & Sustainability	PLO 8 Ethics	PLO 9 Individual & Team Work	PLO 10 Communication	PLO 11 Project Mgt. & Finance	PLO 12 Life Long Learning	PLO 13 PSO - 1	PLO 14 PSO - 2	PLO 15 PSO – 3
CLO-1 :	*Acquire knowledge of boundary layer theory.*	2	85	75	H	M	L	L	-	-	-	-	-	-	-	L	H	M	M
CLO-2 :	*Acquire the fundamental differences between incompressible and compressible boundary layers, importance of boundary layer interaction with shock layer.*	2	80	70	H	M	L	M	-	-	-	-	-	-	-	L	M	H	M
CLO-3 :	*Appreciate the various qualitative aspects of hypersonic flow.*	2	85	75	H	H	M	L	L	-	-	-	-	-	-	L	H	M	M
CLO-4 :	*Accrue knowledge of different aerodynamic configurations of missiles, missile classification.*	2	80	70	H	M	L	M	-	-	-	-	-	-	-	L	M	M	H
CLO-5 :	*Acquire basic understanding of cross-flow analysis in study of missile aerodynamics*	2	85	75	H	L	L	L	-	-	-	-	-	-	-	L	M	M	M
CLO-6 :	*Accrue information on aerodynamic launching problems of missiles.*	2	80	75	H	M	L	L	-	-	-	-	-	-	-	L	M	M	M

Duration (hour)		9	9	9	9	9
S-1	SLO-1	*Concept of Boundary Layer*	*Qualitative Aspects of Hypersonic Flow – Thin shock layer, Viscous Interaction, High Temperature Shock Layer.*	*Classification of Missiles*	*Aerodynamic Characteristics of Slender and Blunt Bodies*	*Aerodynamic Launching Problems*
	SLO-2	*Boundary Layer Definitions and Characteristics*				*Considerations for Safety of Parent Aircraft*
S-2	SLO-1	*Boundary Layer - Boundary Conditions, Laminar and Turbulent Boundary Layers*	*Qualitative Aspects of Hypersonic Flow – Entropy Layer, Low-Density Flow, High Temperature Effects, etc.*	*External Aerodynamic Configurations of Missiles - Wing Control, Canard Control Tail Control, Tail-Less (or Wing Control), Body Extension*	*Missiles at Small Angles of Attack*	*Considerations for Safety of Parent Aircraft (Air Launch) – Introduction to Missile-Aircraft Collision, Missile Structural Failure*
	SLO-2	*Boundary Layer Thickness - Types*			*Cross-Flow Analysis*	
S-3	SLO-1	*Displacement Thickness of Boundary Layer – Concept, Derivation*	*Aerodynamic heating of re-entry bodies – slender and blunt re-entry vehicles.*	*External Aerodynamic Configurations of Missiles - Nose Flap Control, Dorsal, Jet Control, Wing Arrangements (Monowing, Triform, Cruciform)*	*Total Lift on a Missile Body – Cross-Flow Analysis*	*Launch Boundaries – Introduction to Launch-Aircraft Trajectory, Missile Trajectory, Launch Boundary Determination*
	SLO-2		*Hypersonic Flight Paths – Velocity-Altitude Map*			
S-4	SLO-1	*Momentum Thickness of Boundary Layer – Concept, Derivation*	*Newtonian Theory*	*Forces Acting on Missile during Atmospheric Flight, Effect of Angle of Attack on Aerodynamics Forces and Moments*	*Total Lift on a Slender Wing – Cross Flow Analysis*	*Ground Launch – Problem of Launching Missiles from the Ground*
	SLO-2		*Newton's Sine-Squared Law – Derivation,*			*Sources of Detrimental Effects causing Excessive Missile Dispersion*
S-5	SLO-1	*Incompressible Boundary Layer - Incompressible flow over a flat plate, Governing Equations, Numerical Results.*	*Modified Newtonian Law Mach Number Independence*	*Introduction to Bodies of Revolution – Nose, Mid-Section, Boat-tail*	*Total Lift on a Wing-Body Combination – Cross-Flow Analysis*	*Factors Affecting Missile Launch Dispersion – Launcher Deflection, Tip-Off,*
	SLO-2					
S-6	SLO-1	*Compressible Boundary Layer - Compressible flow over a flat plate, Governing equations*	*Numerical Problems on Newtonian Theory and Exact Shock-Expansion Theory*	*Different Shapes of Missile Fore Bodies – Advantages and Disadvantages*	*Introduction to wing-body interference of missile*	*Factors Affecting Missile Launch Dispersion - Thrust and Fin Malalignment, Wind*
	SLO-2					

S-7	SLO-1	*Boundary Layer Separation – Introduction*	*Hypersonic Similarity Parameter*	*Boat Tail – Introduction and its Importance*	*Flow Separation on a Missile Body at Low and High Angles of Attack*	*Rocket separation – Importance of Rocket Separation, Separation Mechanisms*
	SLO-2			*Base Pressure*		
S-8	SLO-1	*Shock Wave Boundary Layer Interaction*	*Shock wave and Expansion Wave Relations of Inviscid Hypersonic Flows*	*Introduction to Missile Drag – Friction drag, Pressure drag, Induced drag, Interference drag*	*Vortex Shedding – Cross-Flow Regimes of Missile at Different Angles of Attack*	*Impulse Devices for Separation – Stage Ignition, Auxiliary Rockets, Thrust Reversal, Springs*
	SLO-2					
S-9	SLO-1	*Tutorial*	*Tutorial*	*Tutorial*	*Tutorial*	*Tutorial*
	SLO-2					

Learning Resources	1. *John D. Anderson Jr., Fundamentals of Aerodynamics, 5th Edition, McGraw-Hill Companies, Inc., 2010.* 2. *John D. Anderson., Modern Compressible Flows, 3rd Edition, McGraw-Hill Companies, Inc., 2003.* 3. *Rathakrishnan E., High Enthalpy Gas Dynamics, John Wiley & Sons Singapore Pte. Ltd., 2015.*	4. *John D. Anderson Jr., Hypersonic and High-Temperature Gas Dynamics, 3rd Edition, AIAA Education Series, AIAA, 2003.* 5. *Chin S. S., Missile Configuration Design, McGraw-Hill Book Company Inc., New York, 1961.* 6. *Jack N. Nielsen, Missile Aerodynamics, McGraw-Hill Book Company Inc., New York, 1960.*

Learning Assessment

	Bloom's Level of Thinking	Continuous Learning Assessment (50% weightage)								Final Examination (50% weightage)	
		CLA – 1 (10%)		CLA – 2 (15%)		CLA – 3 (15%)		CLA – 4 (10%)#			
		Theory	Practice	Theory	Practice	Theory	Practice	Theory	Practice	Theory	Practice
Level 1	Remember Understand	40 %	-	30 %	-	30 %	-	30 %	-	30%	-
Level 2	Apply Analyze	40 %	-	40 %	-	40 %	-	40 %	-	40%	-
Level 3	Evaluate Create	20 %	-	30 %	-	30 %	-	30 %	-	30%	-
	Total	100 %		100 %		100 %		100 %		100 %	

CLA – 4 can be from any combination of these: Assignments, Seminars, Tech Talks, Mini-Projects, Case-Studies, Self-Study, MOOCs, Certifications, Conf. Paper etc.,

Course Designers

Experts from Industry	Experts from Higher Technical Institutions	Internal Expert
Dr. Manishankar C., Senior Scientist, NAL, Bangalore	*Prof. Arun Kumar P., Assistant Professor, IIT Jammu*	*Dr. S. M. Aravindh Kumar, SRMIST*

Course Code	18ASE304T	Course Name	SPACE MISSION DESIGN & ANALYSIS	Course Category	E	Professional Elective	L	T	P	C
							3	0	0	3

Pre-requisite Courses	18ASC306T, 18ASC303J	Co-requisite Courses	Nil	Progressive Courses	Nil
Course Offering Department	Aerospace Engineering	Data Book / Codes/Standards	Nil		

Course Learning Rationale (CLR):	*The purpose of learning this course is to:*
CLR-1 :	*Understand the space mission profiles and types of space missions*
CLR-2 :	*Understand the mission objectives, constraints, needs, and requirements*
CLR-3 :	*Know the complete set of space systems and various modules of space system and spacecraft*
CLR-4 :	*Know the basics of spacecraft motions and the governing equations of spacecraft motions*
CLR-5 :	*Comprehend the satellite attitude dynamics and reentry vehicle dynamics*
CLR-6 :	*Interpret the interplanetary mission trajectories and associated concepts*

Course Learning Outcomes (CLO):	*At the end of this course, learners will be able to:*	Learning 1: Level of Thinking (Bloom)	Learning 2: Expected Proficiency (%)	Learning 3: Expected Attainment (%)	PLO 1: Engineering Knowledge	PLO 2: Problem Analysis	PLO 3: Design & Development	PLO 4: Analysis, Design, Research	PLO 5: Modern Tool Usage	PLO 6: Society & Culture	PLO 7: Environment & Sustainability	PLO 8: Ethics	PLO 9: Individual & Team Work	PLO 10: Communication	PLO 11: Project Mgt. & Finance	PLO 12: Life Long Learning	PLO 13: PSO - 1	PLO 14: PSO - 2	PLO 15: PSO – 3
CLO-1 :	*Describe the space mission and the classifications of space mission*	2	85	80	H	-	M	M	-	-	-	-	-	-	-	-	-	L	-
CLO-2 :	*Describe the various aspects space environments, mission objective, needs and design of the space mission*	2	85	80	H	-	-	-	-	-	L	-	-	-	-	-	-	-	-
CLO-3 :	*Explain the importance of the spacecraft systems and instrumentation*	2	80	75	H	L	L	H	-	-	-	-	-	-	-	-	-	M	-
CLO-4 :	*Explain the necessity of Kepler's equations and orbit maneuvers*	2	80	75	H	H	M	M	-	-	-	-	-	-	-	-	-	-	-
CLO-5 :	*Describe the key features reentry flight physics and injection of spacecrafts*	2	80	75	H	M	M	H	-	-	L	-	-	-	-	-	-	L	-
CLO-6 :	*Demonstrate the interplanetary mission profile and the importance*	2	80	75	H	L	M	H	-	-	L	-	-	-	-	-	-	L	-

Duration (hour)		9	9	9	9	9
S-1	SLO-1	*Definition of space mission*	*Requirements, constraints of spacecraft design*	*The N-body problem*	*Basis of launching of a satellite*	*General aspects of interplanetary trajectory*
	SLO-2	*Classification of space missions*	*Design process of spacecraft*	*The N-body problem*	*General aspects of satellite injection*	*Interplanetary Hohmann transfer*
S-2	SLO-1	*Low Earth Orbit mission, medium altitude mission*	*Spacecraft configuration*	*The orbit equation*	*Launch vehicle ascent trajectory*	*Rendezvous opportunities*
	SLO-2	*Geosynchronous Earth Orbit mission, deep space mission*	*Integrating the spacecraft design*	*The energy law.*	*Dependence of orbital parameters on in-plane injection parameters*	*Sphere of influence*
S-3	SLO-1	*Space mission life cycle*	*Spacecraft payload design*	*Revision of circular orbits and elliptical orbits*	*Launch vehicle performance*	*Method of patched conics*
	SLO-2	*Mission objectives*	*Payload sizing process*	*Parabolic trajectories*	*Orbit deviation due to injection errors*	*Planetary departure*
S-4	SLO-1	*Identification of mission needs, requirements, and constraints*	*Mission requirements*	*Hyperbolic trajectories*	*Small injection errors*	*Planetary rendezvous*
	SLO-2	*Mission characterization*	*Observation of payload design*	*Keplers equation*	*Basics of reentry flight dynamics*	*Planetary flyby*
S-5	SLO-1	*Mission evaluation*	*Observation of payload sizing*	*Lamberts problem*	*Fundamentals of entry flight mechanics*	*Design of transfer ellipse*
	SLO-2	*Orbit design*	*Spacecraft subsystems*	*Restricted three body problem*	*Fundamentals of entry heating*	*Design of transfer ellipse*
S-6	SLO-1	*Constellation design*	*Propulsion subsystem selection and sizing*	*The Lagrange coefficients*	*Entry vehicle design*	*Design of departure trajectory*
	SLO-2	*Space environment peculiarities*	*Basic of rocket propulsion and its types*	*The Lagrange coefficients*	*Landing techniques*	*Design of arrival trajectory*
S-7	SLO-1	*Space environment survivability*	*Attitude determination and control*	*Jacobi constants*	*Recovery techniques*	*Gravity assist maneuver*
	SLO-2	*Selection of spacecraft material*	*Telemetry, tracking and command system*	*Introduction to orbit perturbation*	*Reentry errors*	*Establishing planetary orbit*
S-8	SLO-1	*Basic launch vehicle considerations*	*Command and data handling*	*Earth gravity harmonics*	*Overview of existing reentry mission*	*Motion of the Earth-Moon system*
	SLO-2	*Launch systems selection process*	*Power and thermal system*	*Lunisolar gravitational attractions*	*Challenges of existing reentry mission*	*Time of flight*
S-9	SLO-1	*Determining the spacecraft design envelop and environments*	*Guidance and navigation system*	*Radiation pressure effects, atmospheric drag*	*Parametric design of a reentry capsule*	*Time of injection velocity*
	SLO-2	*Payload environments*	*Ground system design*	*Tidal friction effects and Mutual gravitational attraction*	*Planetary entry vehicle optimization*	*Lunar patched conic*

Learning Resources	1. *Larson, Wiley J., and James Richard Wertz. Space mission analysis and design. No. DOE/NE/32145-T1. Torrance, CA (United States); Microcosm, Inc., 1992.* 2. *Curtis, Howard D. Orbital mechanics for engineering students. Butterworth-Heinemann, 2013.* 3. *Cornelisse, Jacobus W., H. F. R. Schoyer, and Karel F. Wakker. "Rocket propulsion and spaceflight dynamics."London: Pitman, 1979 (1979).*	4. *Tewari, Ashish. Atmospheric and space flight dynamics. Birkhũser Boston, 2007.* 5. *Griffin, Michael Douglas. Space vehicle design. AIAA, 2004.* 6. *Fortescue, Peter, Graham Swinerd, and John Stark, eds.Spacecraft systems engineering. John Wiley & Sons, 2011.*

Learning Assessment

	Bloom's Level of Thinking	Continuous Learning Assessment (50% weightage)								Final Examination (50% weightage)	
		CLA – 1 (10%)		CLA – 2 (15%)		CLA – 3 (15%)		CLA – 4 (10%)#			
		Theory	Practice	Theory	Practice	Theory	Practice	Theory	Practice	Theory	Practice
Level 1	Remember Understand	*40 %*	-	*30 %*	-	*30 %*	-	*30 %*	-	*30%*	-
Level 2	Apply Analyze	*40 %*	-	*40 %*	-	*40 %*	-	*40 %*	-	*40%*	-
Level 3	Evaluate Create	*20 %*	-	*30 %*	-	*30 %*	-	*30 %*	-	*30%*	-
	Total	100 %		100 %		100 %		100 %		100 %	

CLA – 4 can be from any combination of these: Assignments, Seminars, Tech Talks, Mini-Projects, Case-Studies, Self-Study, MOOCs, Certifications, Conf. Paper etc.

Course Designers		
Experts from Industry	Experts from Higher Technical Institutions	Internal Experts
Mr. Amit Palankar, GE aviation, Bangalore, palankr.amit@gmail.com	*Dr. S. Elangovan, Professor and Dean, Dept. Of Aeronautical Engineering, Bharath Institute of Higher Education and Research, subelango@yahoo.co.in*	*Dr. Malaikannan G, SRMIST*

Course Code	18ASE305T	Course Name	VIBRATIONS AND ELEMENTS OF AEROELASTICITY	Course Category	E	Professional Elective	L	T	P	C
							3	0	0	3

Pre-requisite Courses	18ASC101T	Co-requisite Courses	Nil	Progressive Courses	Nil
Course Offering Department	Aerospace Engineering	Data Book / Codes/Standards	Nil		

Course Learning Rationale (CLR):	*The purpose of learning this course is to:*
CLR-1 :	*Understand the concept of drawing a vibratory model*
CLR-2 :	*Understand the methods of deriving the equations of motion*
CLR-3 :	*Identify the problems of vibration in aerospace industry*
CLR-4 :	*Know the functioning of various vibration measuring instruments*
CLR-5 :	*Learn the various approximate methods of solving natural frequency of various systems*
CLR-6 :	*Get an idea of the various aero elastic phenomena that arise in real time flight conditions.*

Course Learning Outcomes (CLO):	*At the end of this course, learners will be able to:*	Learning 1	2	3	Program Learning Outcomes (PLO) 1	2	3	4	5	6	7	8	9	10	11	12	13	14	15
		Level of Thinking (Bloom)	Expected Proficiency (%)	Expected Attainment (%)	Engineering Knowledge	Problem Analysis	Design & Development	Analysis, Design, Research	Modern Tool Usage	Society & Culture	Environment & Sustainability	Ethics	Individual & Team Work	Communication	Project Mgt. & Finance	Life Long Learning	PSO - 1	PSO - 2	PSO – 3
CLO-1 :	*Describe the elements of a vibratory model*	2	85	75	H	-	H	H	-	-	-	-	-	-	-	M	M	M	M
CLO-2 :	*Describe the equations of motion of any vibratory system*	2	85	75	H	H	H	H	-	-	-	-	-	-	-	M	M	M	M
CLO-3 :	*Explain the solving methods of approach to any vibration problem*	2	85	75	H	H	H	H	-	-	-	-	-	-	-	M	M	M	M
CLO-4 :	*Explain the functionality of various vibration measuring instruments*	2	85	75	H	H	-	H	-	-	-	-	-	-	-	M	M	M	M
CLO-5 :	*Describe the various approximate methods in determining the natural frequency of various vibratory systems.*	2	85	75	H	H	H	H	-	-	-	-	-	-	-	M	M	M	M
CLO-6 :	*Investigate the different aero elastic phenomena for different flight conditions*	2	85	75	H	H	H	H	-	-	-	-	-	-	-	M	M	M	M

Duration (hour)		9	9	9	9	9
S-1	SLO-1	*Introduction-Basic Terminology*	*Single degree of freedom system*	*Multi degree of freedom system*	*A three degree of freedom rotor system*	*Introduction to Aeroelasticity*
	SLO-2	*Elements of vibratory system*	*Examples-spring mass system*	*Free body diagram and equations of motion*	*Numerical solving*	*Collar's triangle*
S-2	SLO-1	*Degrees of freedom*	*Solution of equation of motion-Complementary function*	*Natural modes of vibration*	*Vehicle suspension problem*	*Torsional divergence 2D case*
	SLO-2	*Examples of vibratory system*	*Forced damped vibratory system*	*Mode shapes*	*Automobile problem*	*Numerical solving*
S-3	SLO-1	*Simple Harmonic motion-Definition and explanation*	*Numerical solving –solution of equation of motion*	*Principal Coordinates*	*Discrete systems*	*Torsional divergence-finite wing*
	SLO-2	*Sum of harmonic motions-different conditions*	*Numerical solving –solution of equation of motion*	*Principal modes*	*Examples*	*Numerical solving*
S-4	SLO-1	*Numerical solving*	*Solution of equation of motion-Particular Integral*	*Orthogonal condition*	*Rayleigh method of finding the natural frequency*	*Aileron control reversal*
	SLO-2	*Numerical solving*	*Solution of equation of motion-Particular Integral*	*Eigen value problem*	*Numerical Solving*	*Numerical solving*
S-5	SLO-1	*Newton's law*	*Transient motion of damped forced vibration problem*	*Hamilton's principle*	*Semi-definite system*	*Flutter*
	SLO-2	*D'Alembert's principle*	*Numerical solving*	*Vibration of elastic bodies*	*Numerical solving*	*Numerical solving*
S-6	SLO-1	*Equation of motion-Newton's law of motion*	*Logarithmic decrement*	*Lateral Vibration of a string*	*Method of influence coefficient matrix*	*Bufeting*
	SLO-2	*Example*	*Numerical solving*	*Numerical solving*	*Numerical solving*	*Numerical solving*
S-7	SLO-1	*Equation of motion- Energy method*	*Elevator and control tab numerical*	*Longitudinal vibration of rod*	*Dunkerley method*	*Dynamic response*
	SLO-2	*Example*	*Helicopter rotor blade numerical*	*Numerical solving*	*Numerical –cantilever beam*	*Numerical solving*
S-8	SLO-1	*Free Vibrations-Forced Vibrations*	*Springs connected in series*	*Lateral vibration of beam*	*Lagrange's equation*	*Control Effectiveness*
	SLO-2	*Damped vibrations-Undamped vibrations*	*Springs connected in parallel*	*Numerical solving*	*Numerical solving*	*Numerical solving*
S-9	SLO-1	*Periodic vibrations-Aperiodic vibrations*	*Support Excitation*	*Torsional vibration of shaft*	*Holzer method*	*Case studies*
	SLO-2	Numerical Solving	Vibration measuring instruments	Numerical solving	Numerical solving	

Learning Resources	1. *Timoshenko S., "Vibration Problems in Engineering" – John Wiley and Sons, New York, 1993.* 2. *Fung Y.C., "An Introduction to the Theory of Aeroelasticity, - John Wiley & Sons, New York, 1995.* 3. *Bisplinghoff R.L., Ashley H and Hoffman R.L., "Aeroelasticity"- Addison Wesley Publication, New York, 1983.*	4. *Tse, F.S., Morse, I.F., Hinkle, R.T., "Mechanical Vibrations " – Prentice Hall, New York, 1984* 5. *Scanlan R.H. & Rosenbaum R., "Introduction to the study of Aircraft Vibration & Flutter", John Wiley and Sons. New York, 1982* 6. *Tongue. B.H., "Principles of Vibration ". Oxford University Press, 2000.*

Learning Assessment

	Bloom's Level of Thinking	Continuous Learning Assessment (50% weightage)								Final Examination (50% weightage)	
		CLA – 1 (10%)		CLA – 2 (15%)		CLA – 3 (15%)		CLA – 4 (10%)#			
		Theory	Practice	Theory	Practice	Theory	Practice	Theory	Practice	Theory	Practice
Level 1	Remember Understand	*40 %*	-	*30 %*	-	*30 %*	-	*30 %*	-	*30%*	-
Level 2	Apply Analyze	*40 %*	-	*40 %*	-	*40 %*	-	*40 %*	-	*40%*	-
Level 3	Evaluate Create	*20 %*	-	*30 %*	-	*30 %*	-	*30 %*	-	*30%*	-
	Total	100 %		100 %		100 %		100 %		100 %	

CLA – 4 can be from any combination of these: Assignments, Seminars, Tech Talks, Mini-Projects, Case-Studies, Self-Study, MOOCs, Certifications, Conf. Paper etc.,

Course Designers

Experts from Industry	Experts from Higher Technical Institutions	Internal Experts
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2. Dr.A. Sakthivel, CEMILAC, Bangalore, asakthironika@gmail.com	*2. Dr. R.Velmurugan, Indian Institute of Technology Madras, rvel@ae.iitm.ac.in*	*2. Mr. S. Chandra Sekhar,SRMIST*

Course Code	18ASE306T	Course Name	DIGITAL AVIONICS	Course Category	E	Professional Elective	L	T	P	C
							3	0	0	3

Pre-requisite Courses	Nil	Co-requisite Courses	Nil	Progressive Courses	Nil
Course Offering Department	Aerospace Engineering	Data Book / Codes/Standards	Nil		

Course Learning Rationale (CLR):	*The purpose of learning this course is to:*
CLR-1 :	*Understand the avionics systems and its design*
CLR-2 :	*Understand the avionics system Integration*
CLR-3 :	*Know the architecture & communication Protocols used in Avionics communication*
CLR-4 :	*Know the display techniques used in Glass cockpit*
CLR-5 :	*Know the Electromagnetic interference sources in the aircraft and cooling techniques*
CLR-6 :	*Understand the maintenance aspect of avionics systems*

Course Learning Outcomes (CLO):	*At the end of this course, learners will be able to:*	Learning 1 Level of Thinking (Bloom)	2 Expected Proficiency (%)	3 Expected Attainment (%)	PLO 1 Engineering Knowledge	2 Problem Analysis	3 Design & Development	4 Analysis, Design, Research	5 Modern Tool Usage	6 Society & Culture	7 Environment & Sustainability	8 Ethics	9 Individual & Team Work	10 Communication	11 Project Mgt. & Finance	12 Life Long Learning	13 PSO - 1	14 PSO - 2	15 PSO – 3
CLO-1 :	*Describe the avionics systems and integration*	2	85	75	H	-	-	-	-	-	-	-	-	-	-	-	H	H	H
CLO-2 :	*Describe about Avionics certification and design*	2	85	75	H	H	H	-	-	-	-	-	-	-	-	-	H	H	H
CLO-3 :	*Explain the architecture and communication protocols of the avionics systems*	2	85	75	H	-	H	H	-	-	-	-	-	-	-	-	M	H	H
CLO-4 :	*Differentiate the difference in display techniques used in Glass cockpit*	2	85	75	H	H	-	-	-	-	-	-	-	-	-	-	M	H	H
CLO-5 :	*Identify the electromagnetic sources and interference prevention techniques*	2	85	75	H	-	H	-	-	-	-	-	-	-	-	-	H	H	M
CLO-6 :	*Explain the maintenance procedures for avionics wiring, testing and maintenance*	2	85	75	H	H	H	H	-	-	-	-	-	-	-	-	H	H	H

Duration (hour)		9	9	9	9	9
S-1	SLO-1	*Introduction to Avionics*	*Network Topologies & types of data bus used in Avionics network*	*Introduction to Head Up Display*	*Electromagnetic interference (EMI) and its effect*	*Aluminum wires/cables*
	SLO-2	*Need for Avionics*	*Types Bit encoding & Types of communication Protocol*	*Principle & Optical configuration*	*EMI on current carrying conductor*	*Bonding*
S-2	SLO-1	*Role of Avionics in civil aircrafts*	*Introduction to ARINC 429*	*Functional description of HUD*	*Need for EMI prevention*	*Types of bonding in composite materials*
	SLO-2	*Role of Avionics in Military aircrafts*	*Hardware elements,Word format, Bit encoding and protocols*	*Introduction to Helmet mounted display*	*Shielding, Twisted pairs and bandwidth*	*Lightning protection in composite aircrafts*
S-3	SLO-1	*Top-Down design Procedure for Avionics system Design*	*Introduction to MIL-STD 1553B*	*Optical configurations*	*Radiated EMI*	*Earth Returns*
	SLO-2	*Avionics Design factors*	*Hardware element, Bit encoding*	*Helmet Design factors and Functional description of HMD*	*EMI susceptibility*	*Aircraft manuals*
S-4	SLO-1	*Ilities of Avionics Systems*	*Word format and protocols*	*Introduction to MFD*	*EMI reduction*	*Maintenance manuals*
	SLO-2	*Avionics certification*	*RT-BC, BC-RT & RT-RT protocols*	*Working of MFD*	*Continuing airworthiness*	*Wiring diagram manuals*
S-5	SLO-1	*FTA- Fault tree analysis*	*Introduction to AFDX network*	*Direct voice input techniques and HOTAS*	*Wire and cable installation*	*Circuit Testing*
	SLO-2	*Qualitative and quantitative methods*	*Hardware elements, Protocols*	*FLIR- IR vision*	*Cable definition*	*Avometer and its types*
S-6	SLO-1	*FMEA- Failure mode and effect analysis*	*Ethernet frame format, AFDX frame format*	*Evaluating Avionics cooling requirements*	*Failure modes of wires and cables*	*Bonding meter*
	SLO-2	*Steps in FMEA*	*Difference between CPIOM & GPM*	*Heat transmission in Avionics Rack*	*Wiring procedure*	*oscilloscopes*
S-7	SLO-1	*Pros & cons of FTA & FMEA*	*Trends in Display technologies*	*Avionics cooling specifications*	*Cables and wire looms*	*Automatic Test equipments*
	SLO-2	*Difference between FTA & FMEA*	*CRT construction & working*	*Avionics cooling for Airplanes*	*Current rating of wire looms*	*Built In Test equipment*
S-8	SLO-1	*Avionics Architectures evolution*	*LCD& LED construction and working*	*Avionics cooling for missiles*	*Guidelines for the installation of wire looms*	*Difference between ATE & BITE*
	SLO-2	*A320 & B777 architecture examples*	*Plasma panels And EL panels construction and working*	*Avionics cooling for satellites& Spacecrafts*	*Types of wire looms*	*Centralized Maintenance systems*
S-9	SLO-1	*A380 & B787 architecture examples*	*Comparison of CRT, LCD, LED, Plasma and EL panels*	*Radiation heat transfer in space*	*Hydrolysis in wires and cables*	*Aircraft communication and addressing systems*
	SLO-2	*Attributes of Data bus & transmission classes*	*Capacitive and resistive touch screen technologies*	*Effect of α/e ratio on temperature in space*	*Wire connectors*	*Cost of maintenance*

Learning Resources	1. *Carry R spitzer, "The Avionics Handbook", CRC Press,2000* 2. *Spitzer CR, "Digital Avionics systems",* 3. *Lan Moir, "Civil Avionics Systems", Second edition wiley publications, 1996*	4. *RPG Collinson, " Introduction to Avionics", Chapman and Hall, 1996* 5. *Dave S Steinberg, "Cooling Techniques for electronic equipments", Second edition,1991* 6. *Jim curren, "Trends in Advanced Avionics", IOWA state university, 1992*

Learning Assessment

	Bloom's Level of Thinking	Continuous Learning Assessment (50% weightage)								Final Examination (50% weightage)	
		CLA – 1 (10%)		CLA – 2 (15%)		CLA – 3 (15%)		CLA – 4 (10%)#			
		Theory	Practice	Theory	Practice	Theory	Practice	Theory	Practice	Theory	Practice
Level 1	Remember Understand	*40 %*	-	*30 %*	-	*30 %*	-	*30 %*	-	*30%*	-
Level 2	Apply Analyze	*40 %*	-	*40 %*	-	*40 %*	-	*40 %*	-	*40%*	-
Level 3	Evaluate Create	*20 %*	-	*30 %*	-	*30 %*	-	*30 %*	-	*30%*	-
	Total	100 %		100 %		100 %		100 %		100 %	

CLA – 4 can be from any combination of these: Assignments, Seminars, Tech Talks, Mini-Projects, Case-Studies, Self-Study, MOOCs, Certifications, Conf. Paper etc.,

Course Designers

Experts from Industry	Experts from Higher Technical Institutions	Internal Experts
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Course Code	18ASE307T	Course Name	COMPUTATIONAL HEAT TRANSFER AND FLUID DYNAMICS	Course Category	E	Professional Elective	L	T	P	C
							3	0	0	3

Pre-requisite Courses	18MAB202T, 18ASE208T	Co-requisite Courses	Nil	Progressive Courses	Nil
Course Offering Department	Aerospace Engineering	Data Book / Codes/Standards	Nil		

Course Learning Rationale (CLR):	*The purpose of learning this course is to:*
CLR-1 :	*Introduce the students with various techniques of problem solving*
CLR-2 :	*Make the students to understand the governing equations for flow and heat transfer analysis*
CLR-3 :	*Provide sufficient background to the students to gain the ability to discretize fluid flow problems*
CLR-4 :	*Make the students to simulate and analyze fluid flow problems*
CLR-5 :	*Make the students to choose proper numerical schemes fluid flows*
CLR-6 :	*Enable the students to write computer programs for elementary fluid flow/heat transfer problems*

Course Learning Outcomes (CLO):	*At the end of this course, learners will be able to:*	Learning			Program Learning Outcomes (PLO)														
		1	2	3	1	2	3	4	5	6	7	8	9	10	11	12	13	14	15
		Level of Thinking (Bloom)	Expected Proficiency (%)	Expected Attainment (%)	Engineering Knowledge	Problem Analysis	Design & Development	Analysis, Design, Research	Modern Tool Usage	Society & Culture	Environment & Sustainability	Ethics	Individual & Team Work	Communication	Project Mgt. & Finance	Life Long Learning	PSO - 1	PSO - 2	PSO – 3
CLO-1 :	*Understand the governing equations for flow and heat transfer analysis*	2	80	70	H	H	H	H	M	-	-	-	-	-	-	L	L	H	L
CLO-2 :	*Apply discretization techniques to solve the differential equations of fluid flow and heat transfer problems*	2	80	70	H	H	H	H	H	-	-	-	-	-	-	-	M	H	-
CLO-3 :	*Acquire the experience to judge the accuracy of numerical solutions and the numerical uncertainty.*	2	80	70	H	H	H	H	M	-	-	-	-	-	-	L	M	H	-
CLO-4 :	*Analyze convection-conduction problems through numerical algorithms*	2	80	70	H	H	H	H	H	-	M	M	L	L	-	L	M	H	-
CLO-5 :	*Gain fundamental knowledge about numerical code development*	2	80	70	H	M	M	H	M	-	-	-	H	-	-	L	-	H	-

Duration (hour)		9	9	9	9	9
S-1	SLO-1	*The Three Fundamental Approaches to problem solving - Analytical, Experimental & Numerical*	*Basics of Finite Difference Method*	*Discretization of 1 – D unsteady diffusion Equation*	*Discretization of 1 – D convection diffusion Equation*	*Collocated Grid*
	SLO-2	*Introduction to CFD*	*Finite Difference Approximation of derivatives*			*Staggered Grid*
S-2	SLO-1	*Processes involved in CFD*	*Truncation error*	*Interface conductivity*	*Central differencing scheme*	*Checker-board pressure oscillations*
	SLO-2	*Applications of CFD*	*Order of magnitude of error*	*Nonlinearity*	*Numerical oscillations of Central differencing scheme*	*Basics of Pressure-velocity coupling algorithm*
S-3	SLO-1	*Conservation Principles*	*Basics of Finite volume Method*	*Explicit Approaches*	*Properties of Discretization scheme*	*Discretization of 2D continuity equation*
	SLO-2	*Lagrangian vs Eulerian Approach*	*Integration Over a Control Volume*	*Implicit Approaches*	*Scarborough Criterion*	*Discretization of two-dimensional u-momentum equation*
S-4	SLO-1	*Derivation of continuity equation*	*Discretization of Computational Domain*	*Illustrative example*	*Transportiveness*	*Discretization of two-dimensional v-momentum equation*
	SLO-2		*Discretization of 1 – D diffusion equation*		*Conservativeness*	
S-5	SLO-1	*Derivation of momentum equations*	*Example of numerical solution – 1-D steady Heat conduction problem in a rod*	*Tri – diagonal Matrix Algorithm*	*Assessment of central differencing scheme*	*Pressure correction equation formulation*
	SLO-2					
S-6	SLO-1	*Newton's hypothesis for fluid flow*	*Example of numerical solution – cooling of a circular fin by convective heat transfer*	*Analysis of Numerical oscillations*	*Upwind Differencing Scheme*	*SIMPLE Algorithm*
	SLO-2	*Navier-Stokes equations*			*First order upwind scheme*	*Applications of SIMPLE*
S-7	SLO-1	*Conservation law for Energy equation*		*Stability condition for Explicit Approach*	*Assessment of Upwind Differencing Scheme*	*Overview of other pressure-velocity coupling algorithms*
	SLO-2	*Work done by surface forces & Energy flux due to heat conduction*	*Comparison with analytical solution*	*Stability condition for Implicit Approach*		
S-8	SLO-1	*Derivation of Energy equation*	*Coding using MATLAB*	*Overrelaxation and underrelaxation*	*Overview of other upwind schemes*	*Types of practical boundary conditions*
	SLO-2			*Grid layout-2D domain*		
S-9	SLO-1	*Equilibrium and marching problems*	*Discretization of 2 – D diffusion equation*	*Discretization of 2 – D unsteady diffusion Equation*	*Numerical Diffusion*	*Grid independency Test*
	SLO-2	*Initial and boundary conditions*	*General forms of discretized equations*			*Best practices for CFD solution*

Learning Resources	1. *Anil Date, Introduction to CFD Cambridge University Press First Edition (2005)* 2. *Versteeg. H.K and Malalasekera. W, "An Introduction to Computational Fluid Dynamics, the Finite Volume Method" Addison Wesley Longmen Limited, Second Edition (2007)*	3. *Patankar. S.V. "Numerical Heat Transfer and Fluid Flow", Hemisphere Publishing corporation, First Edition (1980.)* 4. *John.D.Anderson jr., "Computational Fluid Dynamics – The basics with applications" McGraw Hill First Edition (1995)*

Learning Assessment											
	Bloom's Level of Thinking	Continuous Learning Assessment (50% weightage)								Final Examination (50% weightage)	
		CLA – 1 (10%)		CLA – 2 (15%)		CLA – 3 (15%)		CLA – 4 (10%)#			
		Theory	Practice	Theory	Practice	Theory	Practice	Theory	Practice	Theory	Practice
Level 1	Remember Understand	*40 %*	-	*30 %*	-	*30 %*	-	*30 %*	-	*30%*	-
Level 2	Apply Analyze	*40 %*	-	*40 %*	-	*40 %*	-	*40 %*	-	*40%*	-
Level 3	Evaluate Create	*20 %*	-	*30 %*	-	*30 %*	-	*30 %*	-	*30%*	-
	Total	100 %		100 %		100 %		100 %		100 %	

CLA – 4 can be from any combination of these: Assignments, Seminars, Tech Talks, Mini-Projects, Case-Studies, Self-Study, MOOCs, Certifications, Conf. Paper etc.,

Course Designers		
Experts from Industry	Experts from Higher Technical Institutions	Internal Experts
Mr. N. R. Hero Hemaraj, Senior Data Scientist, General Electric, Bangalore	*Dr. B. Premachandran, Professor, Mechanical Engineering, IIT Delhi*	*Dr. S. Senthilkumar, SRMIST*

Course Code	18ASE308T	Course Name	ROCKETS AND MISSILES	Course Category	E	Professional Elective	L	T	P	C
							3	0	0	3

Pre-requisite Courses	*18ASC303J*	Co-requisite Courses	Nil	Progressive Courses	Nil
Course Offering Department	Aerospace Engineering	Data Book / Codes/Standards	Nil		

Course Learning Rationale (CLR):	*The purpose of learning this course is to:*
CLR-1 :	*To impart design basics of rockets and missiles systems, their construction and functions.*
CLR-2 :	*To focus on design principles, materials selection, testing and performance assessment.*
CLR-3 :	*To understand aerodynamics, flight dynamics, optimization of performance of multi-stage rockets and separation dynamics.*

Course Learning Outcomes (CLO):	*At the end of this course, learners will be able to:*	Learning 1: Level of Thinking (Bloom)	Learning 2: Expected Proficiency (%)	Learning 3: Expected Attainment (%)	PLO 1: Engineering Knowledge	PLO 2: Problem Analysis	PLO 3: Design & Development	PLO 4: Analysis, Design, Research	PLO 5: Modern Tool Usage	PLO 6: Society & Culture	PLO 7: Environment & Sustainability	PLO 8: Ethics	PLO 9: Individual & Team Work	PLO 10: Communication	PLO 11: Project Mgt. & Finance	PLO 12: Life Long Learning	PLO 13: PSO - 1	PLO 14: PSO - 2	PLO 15: PSO – 3
CLO-1 :	*To learn about the different systems of rockets and missiles, formulation of the equation of motion and about the advanced rockets for future missions*	2	80	70	H	H	H	H	M	-	-	-	-	-	-	M	H	H	L
CLO-2 :	*To understand the function of the solid propellant propulsion and pyrotechnic systems and the design principles*	2	80	70	H	H	H	H	H	-	M	-	-	M	M	M	H	H	-
CLO-3 :	*To understand the function of the liquid propellant propulsion and control systems and the design principles*	2	80	70	H	H	H	H	M	-	M	-	-	M	M	M	H	H	-
CLO-4 :	*To formulate the equation of motions for a mission and spent stage separation dynamics, understanding the principles of navigation, guidance and control of rockets and missiles, and design of a multistage rocket*	2	80	70	H	H	H	H	H	-	H	-	L	L	H	H	H	H	-
CLO-5 :	*To understand the system design, construction, function, performance and testing aspects. and to familiarize with the selection of suitable materials for different rocket systems*	3	80	70	H	M	M	H	M	L	H	L	H	M	H	H	H	H	L

Duration (hour)		**9**	**9**	**9**	**9**	**9**
S-1	SLO-1	*Introduction*	*Solid propellant rocket fundamentals*	*Liquid propellant rocket fundamentals*	*Multi-staging of rockets*	*Design of prototype rocket*
	SLO-2	*Classification of launch vehicles and missiles*				
S-2	SLO-1	*Different space missions*	*Propellant ingredients, Propellant properties*	*Liquid propellant rocket applications*	*Performance estimation of multi-stage rockets*	*Requirement and design approach*
	SLO-2	*Rocket flight systems*	*Propellant grain processing*	*Liquid propellant rocket types*		
S-3	SLO-1	*Forces and moments acting on a rocket*	*Propellant Grain types, requirements*	*Design of propellant feed system*	*Multi-stage vehicle optimization techniques*	*Product design*
	SLO-2	*Propulsion, aerodynamics*				
S-4	SLO-1	*Gravity, control systems*	*Grain design, properties*	*Gas pressure feed system*	*Flight trajectory optimisation*	*Process planning aspects*
	SLO-2	*Stability analysis*			*Constraints in optimisation*	
S-5	SLO-1	*Inertial and non-inertial frames, coordinate transformation*	*Ballistics of missiles*	*Design of fuel tanks*	*Rocket flight simulation techniques*	*Material selection criteria*
	SLO-2	*Coriolis theorem*		*Turbo-pump design*		*Super alloys, Composites*

S-6	SLO-1	*equations of motion for three dimensional motion through vacuum and atmosphere*	*Burn rate control design and evaluation*	*Liquid propellant rocket engine cycle*	*Stage separation system*	*Test and Qualification*
	SLO-2				*Stage separation dynamics*	
S-7	SLO-1	*Reentry flight dynamics*	*Solid rocket components*	*Cooling systems*	*Separation techniques*	*Types of tests*
	SLO-2				*reentry vehicles landing techniques*	
S-8	SLO-1	*Rocket flight performance dispersion*	*Solid rocket motor design*	*Liquid Slosh, Pogo*	*Navigation, guidance and control systems in launch vehicle*	*Environmental tests*
	SLO-2	*Computation methods*		*Water hammer, Geyser effect*		
S-9	SLO-1	*Introduction to single stage to orbit concepts, reusable launch vehicles*	*Separation systems*	*Thrust vector control (TVC) system*	*Missiles guidance*	*Planning details*
	SLO-2	*Advanced space propulsion systems*	*Pyrotechnic devices*	*Performance improvement of TVC*	*Aerodynamic control systems*	*Concluding a normal and incomplete test*

Learning Resources	*1. Ramamurthi.K: "Rocket Propulsion", Macmillan Publishers, New Delhi-110002, March, 2010* *2. George.P.Sutton, Oscar Biblarz: "Rocket Propulsion Elements" John Wiley India,New Delhi-110002, June,2010* *3. Taylor, Travis. S:"Introduction to rocket science and engineering" CRC Press, New York, 2009.* *4. Cornelisse, J.W, Schoyer H F R, and Wakker K F, "Rocket Propulsion and Space Dynamic", Pitman Publishing Co., 1979* *5. Ashish Tewari, "Atmospheric and Space Flight Dynamics", Birkhauser Boston, 2007*	*6. Martin J L Turner, " Rocket and Spacecraft Propulsion", Springer Praxix Publising Co, 2004* *7. Ronald Humble, Henry and Larson, "Space Propulsion Analysis and Design", McGraw-Hill,1995* *8. George M Siouris, "Missile guidance and control systems", Springer , 2004* *9. W J Larson and J R Wertz, "Space Mission Analysis and Design", Kluwer Academic Publishers,1999* *10. Michael Griffin, "Space Vehicle Design", AIAA education series, 2004*

Learning Assessment

	Bloom's Level of Thinking	Continuous Learning Assessment (50% weightage)								Final Examination (50% weightage)	
		CLA – 1 (10%)		CLA – 2 (15%)		CLA – 3 (15%)		CLA – 4 (10%)#			
		Theory	Practice	Theory	Practice	Theory	Practice	Theory	Practice	Theory	Practice
Level 1	Remember Understand	*40 %*	-	*30 %*	-	*30 %*	-	*30 %*	-	*30%*	-
Level 2	Apply Analyze	*40 %*	-	*40 %*	-	*40 %*	-	*40 %*	-	*40%*	-
Level 3	Evaluate Create	*20 %*	-	*30 %*	-	*30 %*	-	*30 %*	-	*30%*	-
	Total	100 %		100 %		100 %		100 %		100 %	

CLA – 4 can be from any combination of these: Assignments, Seminars, Tech Talks, Mini-Projects, Case-Studies, Self-Study, MOOCs, Certifications, Conf. Paper etc.,

Course Designers

Experts from Industry	Experts from Higher Technical Institutions	Internal Experts
Dr. Manishankar C., Senior Scientist, NAL, Bangalore	*Prof. Arun Kumar P., Assistant Professor, IIT Jammu*	*Dr. S. M. Aravindh Kumar, SRMIST*
		Mr. K. Allwyn, SRMIST

Course Code	18ASE309T	Course Name	FATIGUE AND FRACTURE MECHANICS	Course Category	E	Professional Elective	L	T	P	C
							3	0	0	3

Pre-requisite Courses	18ASC304J	Co-requisite Courses	Nil	Progressive Courses	Nil
Course Offering Department	Aerospace Engineering	Data Book / Codes/Standards	Nil		

Course Learning Rationale (CLR):	*The purpose of learning this course is to:*
CLR-1 :	*Understand the concepts of plotting S-N curve, mean stress, stress concentration*
CLR-2 :	*Emphasis the study of low cycle fatigue, load histories, cumulative damage & statistical aspects of fatigue.*
CLR-3 :	*Familiarize with physical aspects, surface effects, temperature effects of fatigue.*
CLR-4 :	*Familiarize with types of fracture, strain energy release rate, theoretical strength of materials.*
CLR-5 :	*Familiarize the various design philosophies, case histories, fatigue resistance of fiber laminates..*
CLR-6 :	*Get a better understanding of solving Fatigue problems*

Course Learning Outcomes (CLO):	*At the end of this course, learners will be able to:*	Learning 1 Level of Thinking (Bloom)	2 Expected Proficiency (%)	3 Expected Attainment (%)	PLO 1 Engineering Knowledge	2 Problem Analysis	3 Design & Development	4 Analysis, Design, Research	5 Modern Tool Usage	6 Society & Culture	7 Environment & Sustainability	8 Ethics	9 Individual & Team Work	10 Communication	11 Project Mgt. & Finance	12 Life Long Learning	13 PSO - 1	14 PSO - 2	15 PSO – 3
CLO-1 :	*Apply the knowledge to plot S-N curve for various materials.*	2	85	75	H	H	H	-	-	-	-	-	-	-	-	M	M	M	M
CLO-2 :	*Analyze low cycle fatigue & load histories problems.*	2	85	75	H	H	H	-	-	-	-	-	-	-	-	M	M	M	M
CLO-3 :	*Apply the physical aspects of fatigue for solving problems.*	2	85	75	H	H	H	H	-	-	-	-	-	-	-	M	M	M	M
CLO-4 :	*Analyze fracture of various materials*	2	85	75	H	H	H	-	-	-	-	-	-	-	-	M	M	M	M
CLO-5 :	*Analyze the various design philosophies.*	2	85	75	H	H	H	-	-	-	-	-	-	-	-	M	M	M	M
CLO-6 :	*Accrue comprehensive knowledge in fatigue & fracture problems*	2	85	75	H	H	H	H	-	-	-	-	-	-	-	M	M	M	M

Duration (hour)		9	9	9	9	9
S-1	SLO-1	*Introduction to Fatigue & Fracture*	*Low cycle fatigue*	*Structural aspects of fatigue, Crack initiation, slip band crack growth*	*Types of fracture in metals*	*Introduction to various design philosophies*
	SLO-2	*S-N curve*	*High cycle fatigue*	*Structural aspects of fatigue, Crack initiation, slip band crack growth*	*Types of fracture in metals*	*Safe life and fail safe design philosophy*
S-2	SLO-1	*Endurance limit*	*Coffin-Manson's relation*	*Crack growth on planes of high tensile stress, Ultimate fracture*	*Theoretical cohesive strength*	*Infinite life and manage tolerant design philosophies*
	SLO-2	*Effect of mean stress on fatigue*	*Transition life*	*Crack growth on planes of high tensile stress, Ultimate fracture.*	*Theoretical cohesive strength*	*Infinite life and manage tolerant design philosophies*
S-3	SLO-1	*Goodman diagram*	*Solving problems*	*Fatigue crack propagation, Paris law*	*Solving problems*	*Uncertainties, scatter and safety margins*
	SLO-2	*Gerber and Soderberg relations*	*Solving problems*	*Fatigue crack propagation, Paris law*	*Solving problems*	*Uncertainties, scatter and safety margins*
S-4	SLO-1	*Solving problems*	*Cyclic hardening, cyclic softening, cyclic stress strain curve*	*Solving problems*	*Griffith theory of brittle fracture.*	*Some case histories, Improved shoulder fillets*
	SLO-2	*Solving problems*	*Cyclic hardening, cyclic softening, cyclic stress strain curve*	*Solving problems*	*Irwin-Orwin theory.*	*Secondary bending due to non-symmetric holes.*
S-5	SLO-1	*Notches and Stress concentrations*	*Solving problems*	*Size effects on fatigue*	*Solving problems*	*Cracked aircraft wing panel repaired with a poorly designed patch*
	SLO-2	*Notches and Stress concentrations*	*Solving problems*	*Surface effects on fatigue*	*Solving problems*	*Online structural monitoring of the Tsing Ma bridge*
S-6	SLO-1	*Solving problems*	*Strain life equations*	*Surface roughness, surface properties*	*Strain energy release rate*	*Fatigue resistance of fiber-metal laminates, laminated sheet without fibers*
	SLO-2	*Solving problems*	*Solving problems*	*Surface residual stresses*	*Stress intensity factor, Crack deformation modes*	*Fatigue resistance of fiber-metal laminates, laminated sheet without fibers*
S-7	SLO-1	*Neuber's stress concentrations*	*Analysis of load histories*	*Fatigue under combined stresses*	*Solving problems*	*Fiber-metal laminate Arall and Glare, Fiber metal laminate concept*
	SLO-2	*Solving problems*	*Level crossing method*	*Fatigue under combined stresses*	*Solving problems*	*Fiber-metal laminate Arall and Glare, Fiber metal laminate concept*

S-8	SLO-1	*Plastic stress concentration*	*Range counting method, Rain flow method*	*Effects of metallurgical variables on fatigue*	*Fracture toughness and design*	*Fiber-metal laminate Arall and Glare, Fiber metal laminate concept*
	SLO-2	*Solving problems*	*Solving problems*	*Corrosion fatigue, fretting*	*Plane strain toughness testing*	*Fiber-metal laminates as sheet material*
S-9	SLO-1	*Notched S-N curve*	*Cumulative damage, Miner's rule*	*Effect of low temperature fatigue*	*Solving problems*	*Crack growth on Glare*
	SLO-2	*Solving problems*	*Solving problems*	*Effect of high temperature fatigue*	*Solving problems*	*Fatigue properties of Glare components*

Learning Resources	*1. George E.Dieter., "Mechanical Metallurgy", McGraw Hill Education (India) Private Limited, New Delhi, Third Edition, 2013.* *2. Jaap Schijve, "Fatigue of structures and materials" Springer, Second edition, 2009.*	*3. Barrels, W., and Ripley, "Fatigue of Aircraft Structures", Pergamon Press, Oxford, 1983* *4. Knott J.F., "Fundamentals of fracture Mechanics", Butterworth & Co., (Publisher) Ltd., London, 1983*

Learning Assessment

	Bloom's Level of Thinking	Continuous Learning Assessment (50% weightage)								Final Examination (50% weightage)	
		CLA – 1 (10%)		CLA – 2 (15%)		CLA – 3 (15%)		CLA – 4 (10%)#			
		Theory	Practice	Theory	Practice	Theory	Practice	Theory	Practice	Theory	Practice
Level 1	Remember Understand	*40 %*	-	*30 %*	-	*30 %*	-	*30 %*	-	*30%*	-
Level 2	Apply Analyze	*40 %*	-	*40 %*	-	*40 %*	-	*40 %*	-	*40%*	-
Level 3	Evaluate Create	*20 %*	-	*30 %*	-	*30 %*	-	*30 %*	-	*30%*	-
	Total	100 %		100 %		100 %		100 %		100 %	

CLA – 4 can be from any combination of these: Assignments, Seminars, Tech Talks, Mini-Projects, Case-Studies, Self-Study, MOOCs, Certifications, Conf. Paper etc.,

Course Designers

Experts from Industry	Experts from Higher Technical Institutions	Internal Experts
1. Dr. G.Balamurugan, National Aerospace Laboratories, Bangalore, gbala@nal.res.in	*1. Dr. V.Arumugam, Madras Institute of Technology, Chennai, arumugam.mitaero@gmail.com*	*1. Dr.L.R.Ganapathy Subramanian, SRMIST*
2. Dr.A. Sakthivel, CEMILAC, Bangalore, asakthironika@gmail.com	*2. Dr. R.Velmurugan, Indian Institute of Technology Madras, rvel@ae.iitm.ac.in*	*2. Mr. S. Chandra Sekhar, SRMIST*

Course Code	18ASE310T	Course Name	CRYOGENIC ENGINEERING	Course Category	E	Professional Elective	L	T	P	C
							3	0	0	3

Pre-requisite Courses	18ASC103T	Co-requisite Courses	Nil	Progressive Courses	Nil
Course Offering Department	AEROSPACE ENGINEERING	Data Book / Codes/Standards	Nil		

Course Learning Rationale (CLR):	The purpose of learning this course is :
CLR-1 :	*To have a detailed study of the basics of cryogenic systems and to provide the knowledge of evolution of low temperature science*
CLR-2 :	*To familiarize with various Gas-Liquefaction Systems, Cryo-coolers and gas Refrigeration Systems*
CLR-3 :	*To provide the knowledge of cryogenic insulations and Cryogenic technology*
CLR-4 :	*To gain knowledge about different cryogenic instrumentation and to understand Cryo pumping.*
CLR-5 :	*To provide design aspects of cryogenic storage and transfer lines.*
CLR-6 :	*To understand cryogenic systems, gas liquefaction system and pumping system and applcations*

		Learning			Program Learning Outcomes (PLO)														
		1	2	3	1	2	3	4	5	6	7	8	9	10	11	12	13	14	15
Course Learning Outcomes (CLO):	*At the end of this course, learners will be able to:*	Level of Thinking (Bloom)	Expected Proficiency (%)	Expected Attainment (%)	Engineering Knowledge	Problem Analysis	Design & Development	Analysis, Design, Research	Modern Tool Usage	Society & Culture	Environment & Sustainability	Ethics	Individual & Team Work	Communication	Project Mgt. & Finance	Life Long Learning	PSO - 1	PSO - 2	PSO – 3
CLO-1 :	*Analyze the Cryogenic systems*	2	80	70	H	-	-	-	-	-	-	-	-	-	-	H	-	-	M
CLO-2 :	*Have a detailed knowledge of, Gas-Liquefaction Systems, cryo-coolers and gas Refrigeration Systems*	2	85	75	H	H	H	H	-	-	-	-	-	-	-	-	M	-	M
CLO-3 :	*Understand Cryogenic Insulations and Cryogenic Technology.*	2	75	70	H	H	H	H	-	-	-	-	-	-	-	H	M	M	-
CLO-4 :	*Understand different cryogenic instrumentation*	2	85	80	H	-	-	-	-	-	-	-	-	-	-	H	-	M	M
CLO-5 :	*Know and to understand various cryogenic fluid storage and transport systems*	2	85	75	H	-	-	-	-	-	-	-	-	-	-	-	H	M	-
CLO-6 :	*Know cryogenic systems, gas liquefaction system and pumping system and applications*	2	85	75	H	H	H	H								H	M	M	M

Duration (hour)		9	9	9	9	9
S-1	SLO-1	*Introduction - Cryogenic propellants*	*Claude cycle*	*Vuilleumier refrigerator*	*Numerical Problems on Gas Separation System*	*Mechanical vacuum pumps*
	SLO-2	*Liquid hydrogen, liquid oxygen*		*Cryogenic regenerators*		
S-2	SLO-1	*liquid nitrogen, liquid helium*	*Claude Liquefaction System*	*Numerical Problems on Cryogenic Refrigeration system*	*Numerical Problems on Gas Separation System*	*Diffusion pumps*
	SLO-2	*Properties of cryogenic fluids at cryogenic temperature - Mechanical properties*				
S-3	SLO-1	*Thermal properties*	*Heylandt System*	*Thermodynamic ideal Gas separation system*	*Pre purification of Air*	*Cryo-Pumping*
	SLO-2	*Electrical properties*	*Comparison of Claude and L.H system*	*Principles of gas separation*	*Vacuum Technology- Introduction*	*Cryogenic fluid storage vessels*
S-4	SLO-1	*Ortho Hydrogen & Para Hydrogen*	*Numerical Problems on Claude cycle*	*Linde single column gas separation*	*Production of high vacuum*	*Cryogenic Insulation - Introduction*
	SLO-2	*Safety in Cryogenics*		*Linde double column gas separation*		
S-5	SLO-1	*Applications in Space Technology*	*Numerical Problems on L-H cycle*	*Argon and Neon separation systems*	*Flow Regimes in Vacuum*	*Methods of Cryogenic Insulation*
	SLO-2		*Cryocoolers- Introduction*			
S-6	SLO-1	*Gas Liquefaction systems- Introduction*	*Classification of Cryocoolers*	*Cryogenic Gas Adsorption*	*Conductance in Vacuum*	*Evacuated powder insulation*
	SLO-2		*Stirling Cryo – cooler*		*Pressure drop- Slip flow and mixed flow*	*Opacified powder insulation*
S-7	SLO-1	*Joule Thomson effect*	*Gifford-McMahon Cry cooler*	*Cryo-condensation Process*	*Numerical Problems on Vacuum Technology*	
	SLO-2	*Joule Thomson Coefficient*	*Gas Cycle Refrigeration system- Introduction*			*Gas filled powders Multilayer super-insulation*
S-8	SLO-1	*Linde –Hampson cycle*	*Classification of Gas Cycle refrigeration*	*Numerical problems on Gas separation system*	*Numerical Problems on Vacuum Technology*	*Fibrous materials Multilayer super-insulation*
	SLO-2					*Propellant servicing*
S-9	SLO-1	*Linde –Hampson System*	*Pulse tube refrigerator*	*Numerical problems on Gas separation system*	*Numerical Problems on Vacuum Technology*	*Propellant management*
	SLO-2		*Solvay cycle refrigerator*			*Cryogenic fluid transfer systems*

Learning Resources	
	1. *Randall F. Barron., "Cryogenic Systems", Oxford University, Second edition,1985*
	2. *Walker.G ,"Cryocoolers", Plenum Press, First edition,New York (1983)*
	3. *Mamata Mukhopadhyay ,"Fundamentals of Cryogenic Engineering",PHI Learning (P) Ltd, India, Fourth edition 2010*
	4. *J.H.Bell ,"Cryogenic Engineering" , Prentice Hall, Englewood Cliffs,First edition,1963*
	5. *Parner, S. F., "Propellant Chemistry", Reinhold Publishing Corpn., New York,1985*
	6. *R.B.Scott , "Cryogenic Engineering" , Van Nostrand Co, New Jercy,1959*

Learning Assessment											
	Bloom's Level of Thinking	Continuous Learning Assessment (50% weightage)								Final Examination (50% weightage)	
		CLA – 1 (10%)		CLA – 2 (15%)		CLA – 3 (15%)		CLA – 4 (10%)#			
		Theory	Practice	Theory	Practice	Theory	Practice	Theory	Practice	Theory	Practice
Level 1	Remember Understand	*40%*	-	*30%*	-	*30%*	-	*30%*	-	*30%*	-
Level 2	Apply Analyze	*40%*	-	*40%*	-	*40%*	-	*40%*	-	*40%*	-
Level 3	Evaluate Create	*20%*	-	*30%*	-	*30%*	-	*30%*	-	*30%*	-
	Total	100 %		100 %		100 %		100 %		100 %	

CLA – 4 can be from any combination of these: Assignments, Seminars, Tech Talks, Mini-Projects, Case-Studies, Self-Study, MOOCs, Certifications, Conf. Paper etc.,

Course Designers		
Experts from Industry	Experts from Higher Technical Institutions	Internal Experts
Dr. S. Raja, Senior Principal Scientist and Professor, NAL – Bangalore. *raja@nal.res.in*	*1.Dr.Parthasarathi Ghosh, Head, Cryogenic Engineering Centre, IIT Kharagpur* *psghosh@hijli.iitkgp.ernet.in*	*1.Mr. G. Saravanan* *SRMIST*
	2. Dr P.K Dsah, Professor and Head, Department of Aeronautical Engineering *Nitte Menakshi Institute of Technology, Bangalore.* *drpdash@gmail.com*	*2.Mr Vinayak Malhotra* *SRMIST*

Course Code	18ASE311T	Course Name	AIRCRAFT ENGINE AND INSTRUMENT SYSTEMS	Course Category	E	Professional Elective	L	T	P	C
							3	0	0	3

Pre-requisite Courses	Nil	Co-requisite Courses	Nil	Progressive Courses	Nil
Course Offering Department	Aerospace Engineering	Data Book / Codes/Standards	Nil		

Course Learning Rationale (CLR):	The purpose of learning this course is to:
CLR-1 :	*Identify the type ofReciprocating enginefuel metering system and its components used in aircraft.*
CLR-2 :	*Layout the components and accessories of gas turbine engine fuel system.*
CLR-3 :	*Demonstrate the type ofinduction and exhaust system in aircraft engines.*
CLR-4 :	*Identify the electrical systems used in in aircraft engines.*
CLR-5 :	*Identify the various aircraft engine instruments and their functions.*
CLR-6 :	*Utilize the knowledge acquired for design, development & maintenance of aircraft & aero engine systems.*

Course Learning Outcomes (CLO):	At the end of this course, learners will be able to:	Learning 1: Level of Thinking (Bloom)	Learning 2: Expected Proficiency (%)	Learning 3: Expected Attainment (%)	PLO 1: Engineering Knowledge	PLO 2: Problem Analysis	PLO 3: Design & Development	PLO 4: Analysis, Design, Research	PLO 5: Modern Tool Usage	PLO 6: Society & Culture	PLO 7: Environment & Sustainability	PLO 8: Ethics	PLO 9: Individual & Team Work	PLO 10: Communication	PLO 11: Project Mgt. & Finance	PLO 12: Life Long Learning	PLO 13: PSO - 1	PLO 14: PSO - 2	PLO 15: PSO – 3
CLO-1 :	*Understand the operation of Reciprocating enginefuel metering system and its components used in aircraft.*	2	80	70	H	-	L	L	L	-	-	-	-	-	-	L	L	M	M
CLO-2 :	*Acquire knowledge on components and accessories of gas turbine engine fuel system.*	2	80	70	H	-	M	L	M	-	-	-	-	-	-	-	M	M	M
CLO-3 :	*Learn the working of induction and exhaust system in aircraft engines.*	2	80	70	H	-	L	L	M	-	-	-	-	-	-	L	M	M	M
CLO-4 :	*Appreciate the need and functions of aircraft electrical systems used in in aircraft engines.*	2	80	70	H	-	L	L	L	-	M	M	-	-	-	L	M	M	M
CLO-5 :	*Gain knowledge on principle and operation of various aircraft engine instruments.*	2	80	70	H	L	L	L	M	-	-	-	-	M	-	L	H	H	M
CLO-6 :	*Acquire comprehensive knowledge of aircraft systems, engine systems and its instrumentation.*	2	80	70	H	L	L	L	M	-	M	M	-	M	-	L	M	M	M

Duration (hour)		9	9	9	9	9
S-1	SLO-1	*Introduction to Reciprocating Engines*	*Introduction to Gas Turbine Engines*	*Introduction to Induction Systems*	*Electrical Power Evolution*	*Introduction to Aircraft Engine Instruments*
	SLO-2	*Design and Construction, modular concept*	*Gas Turbine Enginesmodular concept*	*Reciprocating Engine Induction Systems*	*Aircraft Electrical Systems*	*Reciprocating engine instruments*
S-2	SLO-1	*Fuels and their characteristics for IC engines.*	*Fuels and their characteristics for gas turbine engines*	*Basic Carburetor Induction System*	*Basic Aircraft Electrical Systems*	*Operation of Oil pressure*
	SLO-2	*Contamination of fuels and prevention*	*Contamination of fuels and prevention*	*Induction System Icing,Induction System Filtering*	*Power Generation*	*Oil temperature indicators*
S-3	SLO-1	*Fuel system- Basic Fuel System*	*Turbine Engine Fuel System*	*Supercharged Induction Systems*	*DC Power Generation*	*Operation of Cylinder head temperature (CHT) indicator*
	SLO-2	*Fuel System Requirements*	*General Requirements*	*Operation & Advantages*	*Typical Aircraft DC System*	*Manifold pressure indicator*
S-4	SLO-1	*Fuel Metering Devices for Reciprocating Engines*	*Hydro mechanical Fuel Control*	*Reciprocating Engine Exhaust Systems*	*AC Power Generation*	*Operation of Fuel quantity, Fuel pressure*
	SLO-2	*Fuel/Air Mixtures, Carburetion Principles*	*Hydromechanical/Electronic Fuel Control*	*Exhaust Systems With Turbocharger.*	*Inverters, rectifiers*	*Carburetor temperature, Tachometer indicators*
S-5	SLO-1	*Application of Venturi Principle to Carburetor*	*Operation of Hydromechanical/Electronic Fuel Control*	*Gas Turbine Engines engine inlet systems*	*Transformers, Batteries*	*Introduction to Gas Turbine Engine instruments types*
	SLO-2	*Carburetor Systems,Carburetor Types*	*Introduction to FADEC*	*Compressor Inlet Screens*	*Airplane lighting systems*	*Principle & Operation of Oil pressure*
S-6	SLO-1	*Float-Type Carburetors, Float Chamber Mechanism System*	*FADEC Fuel Control Systems*	*Turboprop and Turboshaft Compressor Inlets*	*Classification of lighting systems*	*Exhaust gas temperature (EGT)*
	SLO-2	*Main Metering,Idling, Accelerating and EconomizerSystem*	*FADEC for an Auxiliary Power Unit*	*Turbofan Engine Inlet Sections*	*External Lighting Systems*	*Turbine inlet temperature (TIT) or turbine gas temperature (TGT)*
S-7	SLO-1	*Pressure Injection Carburetors*	*FADEC Fuel Control Propulsion Engine*	*Gas Turbine Engines Engine Exhaust Systems*	*Internal Lighting Systems*	*Engine pressure ratio (EPR)*
	SLO-2	*Operation of Pressure Injection Carburetors*	*Operation and its Advantages*	*Turbine engine exhaust nozzles*	*Airplane lighting– Power utilization in airplanes*	*Principle & Operation of Fuel quantity, Fuel pressure*

S-8	SLO-1	Manual Mixture Control	Engine Fuel System Components	Thrust Reversers	Ground Power	Fuel flow indicator
	SLO-2	Automatic Mixture Control (AMC)	Main Fuel Pumps, Fuel Heater, Fuel Filters	Afterburning / Thrust augmentation	Emergency Power Generation	Principle & Operation of Tachometer (percent calibrated) N1 and N2 compressor speeds
S-9	SLO-1	Fuel-Injection Systems	Flow Divider,Fuel Pressurizing and Dump Valves	Thrust Vectoring	Ram Air Turbine, Backup Power Converters	Principle & Operation of Torquemeter
	SLO-2	Bendix/Precision Fuel-Injection System	Fuel Spray Nozzles and Fuel Manifolds	Engine noise suppression, Turbine engine emissions.	Permanent Magnet Generators (PMGs)	Torquemeter (on turboprop and turboshaft engines)

Learning Resources	1. Aviation Maintenance Technician Handbook – Airframe, Vol.2, U.S.Dept. of Transportation,Federal Aviation Administration, Flight Standards Service, 2012 2. Aviation Maintenance Technician Handbook – Powerplant, Vol.1, 2, U.S.Dept. of Transportation,Federal Aviation Administration, Flight Standards Service, 2012	3. E.H.J.Pallet, Aircraft Instruments, 2nd edition,Pearson Publishing Company, 2009 4. Adrian P. Mouritz, "Introduction to aerospace materials" Woodhead Publishing Limited, 2012 5. Michael J.Kroes, William A.Watkins ad Frank Delp, Aircraft Maintenance and Repair, 7th ed., Tata McGraw Hill, 2013

Learning Assessment

	Bloom's Level of Thinking	Continuous Learning Assessment (50% weightage)								Final Examination (50% weightage)	
		CLA – 1 (10%)		CLA – 2 (15%)		CLA – 3 (15%)		CLA – 4 (10%)#			
		Theory	Practice	Theory	Practice	Theory	Practice	Theory	Practice	Theory	Practice
Level 1	Remember Understand	40 %	-	30 %	-	30 %	-	30 %	-	30%	-
Level 2	Apply Analyze	40 %	-	40 %	-	40 %	-	40 %	-	40%	-
Level 3	Evaluate Create	20 %	-	30 %	-	30 %	-	30 %	-	30%	-
	Total	100 %		100 %		100 %		100 %		100 %	

CLA – 4 can be from any combination of these: Assignments, Seminars, Tech Talks, Mini-Projects, Case-Studies, Self-Study, MOOCs, Certifications, Conf. Paper etc.,

Course Designers

Experts from Industry	Experts from Higher Technical Institutions	Internal Experts
1. Wg.CdrK.Manoharan (Retd), Blue Dart Aviation Ltd., manoharank@bluedart.com	1. Dr. A. P. Haran, Park College of Engineering & Technology, ap_haran@rediffmail.com	1. Dr. S. Sivakumar, SRMIST
2.. Mr.K.Senthilkumar,Deputy Chief Aircraft Engineer, Air India , Bangalore ks_senthilkumar@yahoo.co	2. Dr.Wg.Cdr.N.Muthusamy, Rajalakshmi Engineering college, Chennai, muthusamy55@gmail.com	2. Mr. S. Raj Kumar SRMIST

Course Code	18ASE312T	Course Name	HELICOPTER MAINTENANCE	Course Category	E	Professional Elective	L	T	P	C
							3	0	0	3

Pre-requisite Courses	Nil	Co-requisite Courses	Nil	Progressive Courses	Nil
Course Offering Department	Aerospace Engineering	Data Book / Codes/Standards	Nil		

Course Learning Rationale (CLR):	*The purpose of learning this course is to:*
CLR-1 :	*Identify the type of rotor, helicopter controls ,gears, bearings and ground handling*
CLR-2 :	*Layout the main rotor system components and its maintenance.*
CLR-3 :	*Demonstrate the engine power transmission to rotors.*
CLR-4 :	*Identify the power plant installation and maintenance*
CLR-5 :	*Identify the various airframe construction and related systems.*
CLR-6 :	*Utilize the knowledge acquired for design, development & maintenance of Helicopter.*

Course Learning Outcomes (CLO):	*At the end of this course, learners will be able to:*	Learning 1	Learning 2	Learning 3	PLO 1	PLO 2	PLO 3	PLO 4	PLO 5	PLO 6	PLO 7	PLO 8	PLO 9	PLO 10	PLO 11	PLO 12	PLO 13	PLO 14	PLO 15
		Level of Thinking (Bloom)	Expected Proficiency (%)	Expected Attainment (%)	Engineering Knowledge	Problem Analysis	Design & Development	Analysis, Design, Research	Modern Tool Usage	Society & Culture	Environment & Sustainability	Ethics	Individual & Team Work	Communication	Project Mgt. & Finance	Life Long Learning	PSO - 1	PSO - 2	PSO – 3
CLO-1 :	*Understand the helicopter fundamentals and its main components.*	2	80	70	H	-	L	L	L	-	-	-	-	-	-	L	L	M	M
CLO-2 :	*Acquire knowledge on main rotor components and its maintenance.*	2	80	70	H	-	M	L	M	-	-	-	-	-	-	-	M	M	M
CLO-3 :	*Learn the working of helicopter transmission system.*	2	80	70	H	-	L	L	M	-	-	-	-	-	-	L	M	M	M
CLO-4 :	*Acquire knowledge of installation and maintenance of helicopter engines.*	2	80	70	H	-	L	L	M	-	M	M	-	-	-	L	M	M	M
CLO-5 :	*Gain knowledge on helicopter fuselage construction and related systems.*	2	80	70	H	L	L	L	M	-	-	-	-	M	-	L	H	H	M
CLO-6 :	*Acquire comprehensive knowledge of helicopter rotors ,transmission, fuselage and other components and its maintenance activities*	2	80	70	H	L	L	L	M	-	M	M	-	M	-	L	M	M	M

Duration (hour)		9	9	9	9	9
S-1	SLO-1	*Introduction to Helicopters*	*Head maintenance*	*Gradient control boosts*	*Different types of power plant*	*Structural components and materials-Body structure*
	SLO-2	*Evolution of helicopter*	*Blade alignment*	*Maintenance in control rigging*	*Different types of power plant maintenance*	*Bottom structure*
S-2	SLO-1	*Helicopter rotor arrangements*	*Static main rotor balance*	*Inspection in control rigging*	*Maintenance of typical Eurocopter Engine*	*Cabin section*
	SLO-2	*Rigid rotor arrangements*	*Vibration, Tracking methods*	*Engine transmission coupling*	*Tail rotor system*	*Rear section*
S-3	SLO-1	*Semi-rigid rotor arrangements*	*Spanwise dynamic balance*	*Drive shaft*	*Servicing tail rotor track*	*Tail Boom*
	SLO-2	*Helicopter flight controls*	*Blade sweeping*	*Maintenance clutch*	*System rigging*	*Vertical fin*
S-4	SLO-1	*Basic directions ,colour codes*	*Electronic balancing*	*Freewheeling units*	*Rotary wing fuselage structural construction*	*Horizontal stablizer*
	SLO-2	*Ground handling*	*Dampener maintenance*	*Spray clutch*	*Tubular, sheet metal construction*	*Skid gear*
S-5	SLO-1	*Towing*	*Counter weight adjustments*	*Roller unit*	*Bonded construction*	*Antivibration device*
	SLO-2	*Towing precautions*	*Auto rotation adjustments*	*Torque meter*	*Bell-206*	*Special purpose equipments*
S-6	SLO-1	*Helicopter protection*	*Mast& Flight Control rotor*	*Rotor brake*	*Eurocopter BO-105*	*High skid gear*
	SLO-2	*protection equipments*	*Mast Stabilizer*	*Rotor brake maintenance of roller unit*	*Fueslage*	*Floats*
S-7	SLO-1	*Bearing and It's types*	*Mast Dampeners*	*Rotor brake maintenance of torque meter*	*Fuselage maintenance*	*Resque hoists*
	SLO-2	*Bearing installation*	*Swash plate flight control systems collective*	*Vibrations in transmission systems*	*Airframe systems*	*Cargo Hooks*
S-8	SLO-1	*Bearing maintenance*	*Cyclic*	*Mounting systems*	*Stress and loads on airframe*	*Litter Installations*
	SLO-2	*Elastomeric bearings*	*Push-pull tubes*	*Transmissions*	*Wheel*	*Light Installations*
S-9	SLO-1	*Gear, types*	*Torque tubes, bell cranks*	*Fixed wing power plant modifications*	*Skid gear*	*Spray equipment*
	SLO-2	*Gear pattern*	*Mixer box*	*Installation of typical Eurocopter engine*	*Visibility*	*Stabilation devices*

Learning Resources		
	1. Jeppesen,Helicopter Maintenance Hand Book, Jeppesons and Sons Inc,2000.	*3. Civil Aircraft Inspection procedures part I and II ,CAA.English Book House ,New Delhi,1986.*
	2. Gupta L,Helicopter Engineering , Himalayan books ,1996	*4. Larry Reiethmier ,Aircraft repair manual ,Palamar Books Marquette,1992*

Learning Assessment											
	Bloom's Level of Thinking	Continuous Learning Assessment (50% weightage)								Final Examination (50% weightage)	
		CLA – 1 (10%)		CLA – 2 (15%)		CLA – 3 (15%)		CLA – 4 (10%)#			
		Theory	Practice	Theory	Practice	Theory	Practice	Theory	Practice	Theory	Practice
Level 1	Remember Understand	*40 %*	-	*30 %*	-	*30 %*	-	*30 %*	-	*30%*	-
Level 2	Apply Analyze	*40 %*	-	*40 %*	-	*40 %*	-	*40 %*	-	*40%*	-
Level 3	Evaluate Create	*20 %*	-	*30 %*	-	*30 %*	-	*30 %*	-	*30%*	-
	Total	100 %		100 %		100 %		100 %		100 %	

CLA – 4 can be from any combination of these: Assignments, Seminars, Tech Talks, Mini-Projects, Case-Studies, Self-Study, MOOCs, Certifications, Conf. Paper etc.,

Course Designers		
Experts from Industry	Experts from Higher Technical Institutions	Internal Experts
1. Wg.CdrK.Manoharan (Retd), Blue Dart Aviation Ltd., manoharank@bluedart.com	*1. Dr. A. P. Haran, Park College of Engineering & Technology, ap_haran@rediffmail.com*	*1. Dr. S. Sivakumar, SRMIST*
2. Mr.K.Senthilkumar,Deputy Chief Aircraft Engineer, Air India , Bangalore ks_senthilkumar@yahoo.co	*2. Dr.Wg.Cdr.N.Muthusamy, Rajalakshmi Engineering college, Chennai, muthusamy55@gmail.com*	*2. Mr. S. Raj Kumar SRMIST*

Course Code	18ASE313T	Course Name	AERIAL ROBOTICS	Course Category	E	Professional Elective	L	T	P	C
							3	0	0	3

Pre-requisite Courses	Nil	Co-requisite Courses	Nil	Progressive Courses	Nil
Course Offering Department	Aerospace Engineering	Data Book / Codes/Standards			

Course Learning Rationale (CLR):	*The purpose of learning this course is to:*
CLR-1 :	*Understand the kinematics and dynamics of fixed wing unmanned aerial vehicle*
CLR-2 :	*Understand the kinematics and dynamics of multirotor micro aerial vehicle.*
CLR-3 :	*Understand the State estimation of Aerial Robots*
CLR-4 :	*Understand the flight controls methods of Aerial Robots*
CLR-5 :	*Understand the applications of Aerial Robots*
CLO-6 :	*Know dynamics of different types of aerial vehicle,, flight control methods and its applications*

Course Learning Outcomes (CLO):	*At the end of this course, learners will be able to:*	Learning 1	Learning 2	Learning 3	PLO 1	PLO 2	PLO 3	PLO 4	PLO 5	PLO 6	PLO 7	PLO 8	PLO 9	PLO 10	PLO 11	PLO 12	PLO 13	PLO 14	PLO 15
		Level of Thinking (Bloom)	Expected Proficiency (%)	Expected Attainment (%)	Engineering Knowledge	Problem Analysis	Design & Development	Analysis, Design, Research	Modern Tool Usage	Society & Culture	Environment & Sustainability	Ethics	Individual & Team Work	Communication	Project Mgt. & Finance	Life Long Learning	PSO - 1	PSO - 2	PSO – 3
CLO-1 :	*Mathematically model the kinematics and dynamics of fixed wing unmanned aerial vehicle*	*2*	*85*	*75*	*H*	-	*H*	-	-	-	-	-	-	-	-	-	-	-	*M*
CLO-2 :	*Mathematically model the kinematics and dynamics of multirotor micro aerial vehicle*	*2*	*85*	*75*	*H*	-	*H*	-	-	-	-	-	-	-	-	-	*M*	*M*	-
CLO-3 :	*Estimate the state of Aerial Robots*	*2*	*85*	*75*	*H*	*H*	*H*	*H*	-	-	-	-	-	-	-	-	*M*	*M*	*M*
CLO-4 :	*Design flight controls of Aerial Robots*	*2*	*85*	*75*	*H*	-	-	-	*H*	-	-	-	-	-	-	-	*M*	*M*	*M*
CLO-5 :	*Utilise the applications of Aerial Robots*	*2*	*85*	*75*	*H*	-	-	-	-	*H*	-	-	-	-	-	-	-	-	-
CLO-6 :	*Understand dynamics of different types of aerial vehicle, flight controls and its applications*	*2*	*85*	*75*	*H*	-	*H*	*H*	*H*	*H*	-	-	-	-	-	-	*M*	*M*	*M*

Duration (hour)		9	9	9	9	9
S-1	SLO-1	*Introduction of Fixed Wing Unmanned Aerial Vehicle(FWUAV)*	*Introduction of Multirotor Micro Aerial Vehicle (MMAV)*	*Navigational Sensors*	*Introduction to Control Methods of UAV*	*Applications of Aerial Robots*
	SLO-2					
S-2	SLO-1	*History of Fixed Wing Unmanned Aerial Vehicle*	*History of Multirotor Micro Aerial Vehicle(MMAV)*	*Inertial Sensors*	*PID Control*	*Aerial Robots for Military*
	SLO-2					*Reconnaissance*
S-3	SLO-1	*Classification of Fixed Wing Unmanned Aerial Vehicle*	*Classification of Multirotor Micro Aerial Vehicle(MMAV)*	*Magnetometer*	*Lateral control of MMAV using PID*	*Target attacking aerial robots*
	SLO-2			*Pressure Sensor*		*Civil Applications*
S-4	SLO-1	*Modelling and Dynamics Formulation*	*Propeller Theory*	*GPS based Navigation*	*LQR Control*	*Surveying Aerial Robots*
	SLO-2					*Aerial mapping*
S-5	SLO-1	*Frame Rotations and Representations*	*Thrust and Drag moment*	*Camera based Navigation*	*Design of LQR servo control in MATLAB*	*Aerial robots for Precision Agriculture*
	SLO-2	*Euler angles*				
S-6	SLO-1	*Quaternion*	*Dynamics of a Multirotor Micro Aerial Vehicle(MMAV)*	*Position Estimation*	*Model Predictive Control for UAV*	*Payload Delivery*
	SLO-2					*Film making*
S-7	SLO-1	*Gravitational force modelling of FWUAV*	*Gravitational force modelling of MMAV*	*Velocity Estimation*	*Linear Model Predictive Control*	*Scientific Research*
	SLO-2	*Propulsive force modelling of FWUAV*	*Propulsive force modelling of MMAV*			
S-8	SLO-1	*Aerodynamic Force modelling FWUAV*	*Aerodynamic Force modelling MMAV*	*Inertial Navigation Systems*	*Design ofa Linear MPC for MMAV*	*Search and Rescue*
	SLO-2	*Moments acting on FWUAV*	*Moments acting on MMAV*			
S-9	SLO-1	*Dynamics of a Fixed-Wing Unmanned Aerial Vehicle*	*Mathematical modelling of Multirotor Micro AerialVehicle(MMAV)*	*Attitude estimation*	*Implementation of a Linear MPC for MMAV*	*Mineral Exploration Aerial Robots*
	SLO-2					

Learning Resources	
	1. R. Beard, and T. W. McLain, 'Small Unmanned Aircraft: Theory and Practice' Princeton University Press, 2012.
	2. R.C. Nelson., Flight Stability and Automatic Control, McGraw Hill, New York 1998.
	3. L.R. Newcome., Unmanned Aviation, a Brief History of Unmanned Aerial Vehicles, American Institute of Aeronautics and Astronautics, Reston 2004.
	4. Kuo, B.C., Automatic Control Systems, Prentice Hall, 1991.

Learning Assessment											
	Bloom's Level of Thinking	Continuous Learning Assessment (50% weightage)								Final Examination (50% weightage)	
		CLA – 1 (10%)		CLA – 2 (15%)		CLA – 3 (15%)		CLA – 4 (10%)#			
		Theory	Practice	Theory	Practice	Theory	Practice	Theory	Practice	Theory	Practice
Level 1	Remember Understand	*40 %*	-	*30 %*	-	*30 %*	-	*30 %*	-	*30%*	-
Level 2	Apply Analyze	*40 %*	-	*40 %*	-	*40 %*	-	*40 %*	-	*40%*	-
Level 3	Evaluate Create	*20 %*	-	*30 %*	-	*30 %*	-	*30 %*	-	*30%*	-
	Total	100 %		100 %		100 %		100 %		100 %	

CLA – 4 can be from any combination of these: Assignments, Seminars, Tech Talks, Mini-Projects, Case-Studies, Self-Study, MOOCs, Certifications, Conf. Paper etc.,

Course Designers		
Experts from Industry	Experts from Higher Technical Institutions	Internal Experts
1. Dr. S. Raja, Senior Principal Scientist and Professor, NAL – Bangalore. raja@nal.res.in	*1. Dr.K.M.Parammasivam, Professor, MIT-Chennai. mparams@mitindia.edu*	*Mr.A.Vinoth Kumar, SRMIST.*

ACADEMIC CURRICULA

Professional Elective Courses

AUTOMOBILE ENGINEERING

Regulations - 2018

SRM INSTITUTE OF SCIENCE & TECHNOLOGY
(Deemed to be University u/s 3 of UGC Act, 1956)

SRM INSTITUTE OF SCIENCE AND TECHNOLOGY

(Deemed to be University u/s 3 of UGC Act, 1956)

Kattankulathur, Kancheepuram, Tamil Nadu, India

Course Code	18AUE321T	Course Name	AUTOMOTIVE COMPONENTS MANUFACTURING	Course Category	E	Professional Elective	L	T	P	C
							3	0	0	3

Pre-requisite Courses	Nil	Co-requisite Courses	Nil	Progressive Courses	Nil
Course Offering Department	Automobile Engineering	Data Book / Codes/Standards	Nil		

Course Learning Rationale (CLR):	*The purpose of learning this course is to:*
CLR-1 :	*acquire knowledge in understanding the manufacturing processes of automotive components*
CLR-2 :	*understanding the professional and ethical responsibility*
CLR-3 :	*Understand The process to meet desired needs within realistic*

Course Learning Outcomes (CLO):	*At the end of this course, learners will be able to:*	Learning 1: Level of Thinking (Bloom)	Learning 2: Expected Proficiency (%)	Learning 3: Expected Attainment (%)	PLO 1: Engineering Knowledge	PLO 2: Problem Analysis	PLO 3: Design & Development	PLO 4: Analysis, Design, Research	PLO 5: Modern Tool Usage	PLO 6: Society & Culture	PLO 7: Environment & Sustainability	PLO 8: Ethics	PLO 9: Individual & Team Work	PLO 10: Communication	PLO 11: Project Mgt. & Finance	PLO 12: Life Long Learning	PLO 13: PSO - 1	PLO 14: PSO - 2	PLO 15: PSO – 3
CLO-1 :	*Understand the automotive component to be manufactured*	*1*	*90*	*85*	*H*	*M*	*M*	*M*	*L*	*H*	*M*	*H*	*M*	*L*	*M*	*M*	*H*	*H*	*M*
CLO-2 :	*Select the suitable materials for the component based on its functionality*	*2*	*95*	*90*	*H*	*M*	*M*	*M*	*L*	*M*	*M*	*H*	*H*	*L*	*L*	*M*	*H*	*M*	*L*
CLO-3 :	*Identify the suitable manufacturing process for the component*	*2*	*90*	*85*	*H*	*H*	*M*	*M*	*L*	*L*	*M*	*H*	*H*	*L*	*L*	*M*	*H*	*H*	*M*
CLO-4 :	*Examine the primary & secondary machining operation.*	*2*	*95*	*90*	*H*	*M*	*M*	*M*	*L*	*L*	*M*	*H*	*M*	*L*	*M*	*M*	*H*	*M*	*M*
CLO-5 :	*Identify the possible defects and suggest suitable remedies*	*2*	*85*	*80*	*H*	*M*	*M*	*M*	*L*	*L*	*M*	*H*	*M*	*L*	*L*	*M*	*H*	*H*	*L*

		Introduction to Automotive Engine Components	Manufacturing of Automotive Engine Components	Manufacturing of Air filters and catalytic converter of spark plugs	Manufacturing of glass & rubber processing technology	Manufacturing of Automotive body
Duration (hour)		09	09	09	09	09
S-1	SLO-1	*Introduction to automotive engines - parts, Their function requirement,*	*Manufacturing of main bearing – Description, Purpose, Material-Production requirement – Consistent wall thickness, Precise crush height, process requirement*	*Manufacturing of Air filters-Description of Air filters, Functional requirement of air filters*	*Raw material preparation & melting-Properties of glass-Classification of glass for automotive application*	*Automotive materials-Automotive steel grades*
	SLO-2	*Material used in the automotive sector*	*Centrifugal casting Mold material, Consideration for main bearing in centrifugal casting.-Surface finishing for main bearing*	*Materials – Core materials, sealing agents, supporting materials.-Production*	*Glass melting furnace- Pot furnace, Day tank, Continuous tank, Electric furnace*	*High strength &ultra-strength-Stamping aluminum sheet*
S-2	SLO-1	*Manufacturing of an engine block of cylinder head-Functional requirement of an engine block*	*Manufacturing of main bearing cap-Functional requirement*	*Manufacturing of oil filters-Description of oil filters*	*Shaping process in glass working-Shaping of Glass- Spinning, processing, blowing*	*Automotive stamping process & die-Die operations & tooling*
	SLO-2	*cylinder head-Materials used in engine block casting*	*Material requirement – Special treatment materials for cap*	*Functional requirement of oil filters*	*Shaping of flat glass – Rolling, float, Drawing of glass tubs*	*Blank holder-Draw B*
S-3	SLO-1	*Manufacturing process –Low pressure die casting, High pressures die-casting, expendable pattern casting.*	*Production requirement-Process requirement – Hot chamber die casting*	*Manufacturing of oil filters-Materials*	*Forming of glass fibers-Centrifugal spraying*	*Blanking & sharing dies-Binding*
	SLO-2	*Machining–Cutting, Milling, Drilling, Boring, Honing, Reaming*	*Cold chamber die casting-Precision drilling operation*	*Manufacturing of oil filters-Production*	*Drawing of continuous filaments*	*Deep drawing-Coating & lubrication*
S-4	SLO-1	*Quality consideration during manufacturing*	*Vibration damper-Functional requirement, Description of vibration, Material requirement, Production requirement,*	*Manufacturing of ceramic catalytic convertor-Description of ceramic catalytic convertor*	*Heat treatment & finishing-Annealing*	*Advances in metal forming-Hydro forming & extrusion*
	SLO-2	*Possible defects during manufacturing*	*Process description.-Vacuum casting Consideration for casting damper-Why vacuum casting & its advantages*	*Functional requirement*	*Tempered glass*	*Industrial origami : Metal folding – based forming-Flexible stamping procedure*

S-5	SLO-1	Manufacturing of Camshaft-Functional requirement of Camshaft	Piston ring & pin-Description - types-Functional requirement	ceramic catalytic convertor-Material properties	Finishing – Primary design	Automotive TIG welding-Robotic spot welders
	SLO-2	Materials used in Camshaft, Production requirement-Process requirement	Material-Production requirement-Process requirement	Processing – Processing of starting materials, Shaping, sintering, finishing	secondary design considerations in glass processing	Adhesive bonding
S-6	SLO-1	Closed die forging, Impression die forging-forging force	Valves-Description, Functional requirement- Types of valves Monometallic, Bimetal, Stellied welded, Chrome plate, Nitrate	Manufacturing of metallic catalytic convertor-Description of ceramic catalytic convertor	Manufacturing of tires	Advances in automotive welding-Friction the welding
	SLO-2	Finishing operations. Heat treatment	Process – Cutting, Friction welding (Bimetal Special purpose), Upsetting, Forging, Stellied welding, Heat treatment, Grinding	metallic catalytic convertor Functional requirement	The construction of tires	Lack welding-Weld bonding
S-7	SLO-1	Manufacturing of crankshaft-Functional requirement of crankshaft	Automotive springs-Description, Functional requirement- Manufacturing process – Hot rolling, oil tempering, cold oiling,	metallic catalytic convertor Material properties-Need for honey comb structure is metal catalytic convertor	The production of tires	Automotive joining- automotive frame
	SLO-2	Materials used in crankshaft manufacturing	Stress relieving, Coil and grinding, nitriding, slot peering, Strain aging.	Methods of forming honey comb	The process of tires	Set assembling automotive doors
S-8	SLO-1	Production requirement	Inlet Manifold-Description, Functional requirement	Manufacturing of spark plug-Description of ceramic cat com	Performing of components	Final assembly-Installation of trim assembly
	SLO-2	Process requirement	Inlet Manifold Functional requirement	Functional requirement	Building the carcass	Installation of the chases-Final assembly & testing
S-9	SLO-1	Forging, Precision machining	Process Injection molding, Plastic materials,	Spark plug-Material selection	Molding of curing	Ergonomics of the final assembly
	SLO-2	Heat treatment	Injection molding, Injection molds.	Manufacturing of process – Processing of ceramic, forming of electrode, bonding.	Molding process	Mechanical fastening & bolting

Learning Resources	1. SeropeKalpakjian, "Manufacturing Engineering and Technology", 6th Edition,Addison-Wesley Publishing Co., Boston, 2010 2. Mohammed A. Omar, "The Automotive Body Manufacturing System and Processes"1st Edition, John Wiley & Sons Inc, USA, 2011.	3. Mikell P. Groover"Fundamentals of Modern Manufacturing", 4th Edition,John Wiley & Sons Inc, 2010 4. Benjamin W Niebel,"Modern Manufacturing Process Engineering", McGraw- HILL international editions

Learning Assessment

	Bloom's Level of Thinking	Continuous Learning Assessment (50% weightage)								Final Examination (50% weightage)	
		CLA – 1 (10%)		CLA – 2 (15%)		CLA – 3 (15%)		CLA – 4 (10%)#			
		Theory	Practice	Theory	Practice	Theory	Practice	Theory	Practice	Theory	Practice
Level 1	Remember Understand	40 %	-	30 %	-	30 %	-	30 %	-	30%	-
Level 2	Apply Analyze	40 %	-	40 %	-	40 %	-	40 %	-	40%	-
Level 3	Evaluate Create	20 %	-	30 %	-	30 %	-	30 %	-	30%	-
	Total	100 %		100 %		100 %		100 %		100 %	

CLA – 4 can be from any combination of these: Assignments, Seminars, Tech Talks, Mini-Projects, Case-Studies, Self-Study, MOOCs, Certifications, Conf. Paper etc,

Course Designers

Experts from Industry	Experts from Higher Technical Institutions	Internal Experts
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2. Mr.Dalpat Singh M & M, singh.dalpat@mahindra.com	2. Dr.R.Elansezhian, Pondicherry Engineering College,elansezhianr@gmail.com	2. Mr. S.Madhan Kumar, SRMIST, madhanks@srmist.edu.in

Course Code	18AUE322T	Course Name	WELDING AND JOINING TECHNIQUE	Course Category	E	Professional Elective	L	T	P	C
							3	0	0	3

Pre-requisite Courses	Nil	Co-requisite Courses	Nil	Progressive Courses	Nil
Course Offering Department	Automobile Engineering	Data Book / Codes/Standards	Nil		

Course Learning Rationale (CLR):	*The purpose of learning this course is to:*
CLR-1 :	*Acquire knowledge on fusion welding processes and weld joints*
CLR-2 :	*Select various welding process based on applications.*
CLR-3 :	*List welding parameters and filler metals for various welding process*
CLR-4 :	*Understand advanced welding techniques and its applications*

Course Learning Outcomes (CLO):	*At the end of this course, learners will be able to:*	Learning 1: Level of Thinking (Bloom)	2: Expected Proficiency (%)	3: Expected Attainment (%)	PLO 1: Engineering Knowledge	2: Problem Analysis	3: Design & Development	4: Analysis, Design, Research	5: Modern Tool Usage	6: Society & Culture	7: Environment & Sustainability	8: Ethics	9: Individual & Team Work	10: Communication	11: Project Mgt. & Finance	12: Life Long Learning	13: PSO - 1	14: PSO - 2	15: PSO – 3
CLO-1 :	*Categorize the various types of welding processes.*	*1*	*80*	*75*	*M*	*M*	*M*	*M*	*L*	*L*	*M*	*M*	*M*	*M*	*L*	*L*	*H*	*H*	*H*
CLO-2 :	*Explain various arc welding techniques and its applications*	*2*	*85*	*80*	*H*	*H*	*M*	*L*	*M*	*M*	*M*	*M*	*H*	*L*	*M*	*M*	*M*	*H*	*M*
CLO-3 :	*Determine welding parameters for different types of materials*	*1*	*85*	*80*	*H*	*M*	*M*	*M*	*M*	*L*	*M*	*L*	*M*	*H*	*M*	*H*	*H*	*M*	*H*
CLO-4 :	*Predict the welding process suitable for automotive applications*	*2*	*80*	*75*	*H*	*H*	*L*	*M*	*M*	*H*	*H*	*H*	*M*	*M*	*M*	*M*	*H*	*H*	*H*
CLO-5 :	*Compare advanced welding with conventional welding techniques*	*2*	*75*	*70*	*H*	*H*	*M*	*M*	*H*	*M*	*M*	*M*	*H*	*M*	*H*	*M*	*M*	*H*	*M*

		Welding Technology	Fusion Welding Processes	Weldability of metals and Allied Processes	Resistance Welding and Thermo-chemical welding	Solid state and high energy beam Welding
Duration (hour)		9	9	9	9	9
S-1	SLO-1	*Classification of fusion welding processes*	*Introduction to Arc Welding*	*Oxygen cutting*	*Spot welding and types of equipment*	*Friction welding*
	SLO-2					*Diffusion joining and process variables and its applications,*
S-2	SLO-1 SLO-2	*Heat source intensity, Heat Input rates*	*Carbon arc welding*	*Flame cut ability of metals, effect of cutting on structure and properties of steel*	*Rocker arm press type welding and it's applications*	*Forge welding*
S-3	SLO-1 SLO-2	*Shielding methods*	*Gas tungsten arc welding*	*Oxygen lancing machine cutting, Powder cutting*	*Seam welding and its applications*	*Ultra sonic welding*
S-4	SLO-1 SLO-2	*Metallurgical effect of weld thermal cycle*	*Gas Metal Arc Welding*	*Welding of different types of materials - carbon and alloy steels.*	*Projection welding and its applications*	*Explosive welding*
S-5	SLO-1 SLO-2	*Residual stresses*	*Plasma arc welding*	*Welding of different types of materials - Cast iron non-ferrous metals and alloys, aluminum.*	*Flash and butt welding applications*	*Laser welding*
S-6	SLO-1 SLO-2	*Formation and Relieving*	*Submerged arc welding*	*Soldering and Brazing: Capillary and welding action*	*Gas welding ,fuel gases and flames*	*Electron beam welding -types of electron gun*
S-7	SLO-1 SLO-2	*Types of weld joints*	*Electro slag welding*	*Soldering and Brazing-Temperature Range*	*Torches, Filler metal and Fluxes*	*Electron beam welding- spot size beam power*
S-8	SLO-1 SLO-2	*Edge preparation, cleaning of edges*	*Arc welding applications*	*Filler Metals and Fluxes*	*Backward and Forward welding and filler rod diameter*	*Operating voltage, pulse technique, deep penetration and applications*
S-9	SLO-1 SLO-2	*Tack welding*	*Arc welding advantages and disadvantages*	*Processes and application, Design and strength of joints*	*Thermit welding*	*Other Joining Techniques for automotive applications*

Learning Resources	1. *Nadkarni. S. V, "Modern Arc Welding Technology", Ador Welding Ltd. Oxford and IBH Publishing, 2008.* 2. *William A. Bowditch, Kevin E. Bowditch, Mark A. Bowditch, "Welding Technology Fundamentals", Goodheart-Willcox Publisher, 4 edition, 2009*	3. *Richard L. Little, "Welding and welding Technology", TATA McGraw Hill Publishing Company Ltd, 1973.* 4. *Parmar. R. S, "Welding Engineering And Technology", Khanna Publishers, 2004*

Learning Assessment

	Bloom's Level of Thinking	Continuous Learning Assessment (50% weightage)								Final Examination (50% weightage)	
		CLA – 1 (10%)		CLA – 2 (15%)		CLA – 3 (15%)		CLA – 4 (10%)#			
		Theory	Practice	Theory	Practice	Theory	Practice	Theory	Practice	Theory	Practice
Level 1	Remember Understand	*60%*		*50%*		*40%*		*15%*		*50%*	
Level 2	Apply Analyze	*40%*		*50%*		*60%*		*20%*		*50%*	
Level 3	Evaluate Create	-		-		-		*15%*		-	
	Total	100 %		100 %		100 %		100 %		100%	

CLA – 4 can be from any combination of these: Assignments, Seminars, Tech Talks, Mini-Projects, Case-Studies, Self-Study, MOOCs, Certifications, Conf. Paper etc.,

Course Designers

Experts from Industry	Experts from Higher Technical Institutions	Internal Experts
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Course Code	18AUE323T	Course Name	AUTOMOTIVE SURFACE ENGINEERING	Course Category	E	PROFESSIONAL ELECTIVE	L	T	P	C
							3	0	0	3

Pre-requisite Courses	Nil	Co-requisite Courses	Nil	Progressive Courses	Nil
Course Offering Department	Automobile Engineering	Data Book / Codes/Standards	Nil		

Course Learning Rationale (CLR):	*The purpose of learning this course is to:*
CLR-1 :	*Describe the surface preparation techniques*
CLR-2 :	*Interpret the knowledge on thermal spraying technology for surface coating applications*
CLR-3 :	*Understand the process of Hot dip and diffusion coating*
CLR-4 :	*Illustrate the testing procedure for surface coating*
CLR-5 :	*Understand the testing and selection of coating*

Course Learning Outcomes (CLO):	*At the end of this course, learners will be able to:*	Learning 1 Level of Thinking (Bloom)	2 Expected Proficiency (%)	3 Expected Attainment (%)	PLO 1 Engineering Knowledge	2 Problem Analysis	3 Design & Development	4 Analysis, Design, Research	5 Modern Tool Usage	6 Society & Culture	7 Environment & Sustainability	8 Ethics	9 Individual & Team Work	10 Communication	11 Project Mgt. & Finance	12 Life Long Learning	13 PSO - 1	14 PSO - 2	15 PSO – 3
CLO-1 :	*Select the various techniques of surface preparation*	3	90	85	H	M	H	M	L	L	H	M	M	M	L	M	M	M	L
CLO-2 :	*Identify the thermal spraying process and electrodeposited coating*	1	80	75	H	M	M	M	M	L	M	-	M	M	-	M	M	M	H
CLO-3 :	*Distinguish the process of Hot dip and diffusion coating*	2	85	80	H	M	M	M	M	M	M	L	M	M	M	M	H	M	H
CLO-4 :	*Perform the testing procedure for surface coating*	2	85	80	H	H	M	H	M	L	L	L	M	M	-	M	M	M	M
CLO-5 :	*Analyze and select the coating for application*	1	90	85	H	M	M	M	M	H	H	H	M	M	L	M	M	M	H

		Metal Cleaning and Surface Treatment	Thermal Spraying Processes	Coatings	Non-Metallic coating oxide and Corrosion	Testing and Selection of coatings
Duration (hour)		09	09	09	09	09
S-1	SLO-1	*Need and relevance of surface engineering*	*Classification of Thermal spraying*	*Principles – surface preparation batch coating*	*Plating coating*	*The quality plan, Design*
	SLO-2	*Pre-treatment of coating*	*Thermal barrier and Thermal conductive coatings*	*Continuous coating process*	*Lacquers*	*Testing and inspection of thickness measurement*
S-2	SLO-1	*General cleaning process for ferrous metals*	*Thermal spraying – flame*	*Properties of Coatings*	*Rubbers*	*Adhesion*
	SLO-2	*General cleaning process for non-ferrous metals*	*Arc spraying method*	*Applications of coatings*	*Elastomers*	*Resistance*
S-3	SLO-1	*Selection of cleaning process*	*Plasma Processes*	*surface treatments in wear*	*Vitreous enamels*	*Porosity measurement*
	SLO-2	*Alkaline cleaning*	*HVOF processes*	*Friction control*	*Anodizing phosphating and chromating*	*Selection of coatings*
S-4	SLO-1	*Emulsion cleaning*	*PLV process*	*Thick coatings*	*Application to Aluminium, Magnesium, Tin, Zinc, Cadmium Copper and Silver*	*Industrial applications of engineering coatings*
	SLO-2	*Ultrasonic cleaning*	*Coating production*	*Principles of cementation*	*Phosphating primers*	*Basic mechanisms of wear*
S-5	SLO-1	*Acid bath descaling*	*Spray consumables*	*Cladding*	*Principle of Corrosion*	*Abrasive Wear*
	SLO-2	*Pickling salt bath descaling*	*Principles of electroplating*	*Diffusion coating of C.N. Al, Si, Cr and B*	*Classification of corrosion*	*adhesive wear*
S-6	SLO-1	*Abrasive bath cleaning*	*Technologies used in electroplating systems*	*Corrosion resistant coatings*	*Types of corrosion*	*contact fatigue*
	SLO-2	*Surface treatment of gears*	*Factors affecting the electroplating process*	*Properties of diffusion coatings*	*Factors influencing corrosion*	*fretting corrosion*
S-7	SLO-1	*Short peening*	*Properties and Faraday's Law*	*Application of diffusion coatings*	*Corrosion protection of ferrous and non-ferrous components*	*Salt spray test*
	SLO-2	*Blasting*	*Factors affecting throwing power*	*Nano-engineered coatings*	*Testing and Prevention of Corrosion*	*Humidity test*
S-8	SLO-1	*Machining*	*Electroplating*	*Wear resistant coatings*	*Material selection*	*Porosity test*
	SLO-2	*Boronizing*	*Applications of electroplating*	*Characteristics of Wear resistant coatings*	*Alteration of environment*	*Susceptibility tests for intergranular corrosion Stress*

S-9	SLO-1	*Carbonitriding*	*Non-aqueous*	*Physical vapor deposition*	*surface treatments on Gears*	*Corrosion test*
	SLO-2	*Aluminising*	*Electroless deposition*	*Chemical vapor deposition*	*Corrosion inhibitors*	*Testing wear resistance practical diagnosis of wear*

Learning Resources	1. *George Dieter "Mechanical Metallurgy", McGraw Hill Education; 2012* 2. *Rabinowicz.E, "Friction and Wear of materials", Second Edition: John Willey &Sons, UK, 2013.* 3. *DeGarmo's "Materials and Processes in Manufacturing" J.T. Black, Ronald A. Kohser, Wiley, 2011.* 4. *S.K.Basu, S.N.Sengupta & B.B.Ahuja ,"Fundamentals of Tribology", Prentice –Hall of India Pvt Ltd, New Delhi, 2005*	5. *G.W.Stachowiak& A.W .Batchelor , "Engineering Tribology", Butterworth-Heinemann, UK, 2005* 6. *Stand Grainger engineering coatings – design and application jaico publishing House, 1994.* 7. *Parthasarathy. N.V., Electroplating Handbooks, Prentice Hall, 1992*

Learning Assessment

	Bloom's Level of Thinking	Continuous Learning Assessment (50% weightage)								Final Examination (50% weightage)	
		CLA – 1 (10%)		CLA – 2 (15%)		CLA – 3 (15%)		CLA – 4 (10%)#			
		Theory	Practice	Theory	Practice	Theory	Practice	Theory	Practice	Theory	Practice
Level 1	Remember Understand	*40 %*	-	*30 %*	-	*30 %*	-	*30 %*	-	*30%*	-
Level 2	Apply Analyze	*40 %*	-	*40 %*	-	*40 %*	-	*40 %*	-	*40%*	-
Level 3	Evaluate Create	*20 %*	-	*30 %*	-	*30 %*	-	*30 %*	-	*30%*	-
	Total	100 %		100 %		100 %		100 %		100 %	

CLA – 4 can be from any combination of these: Assignments, Seminars, Tech Talks, Mini-Projects, Case-Studies, Self-Study, MOOCs, Certifications, Conf. Paper etc.,

Course Designers

Experts from Industry	Experts from Higher Technical Institutions	Internal Experts
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Course Code	18AUE324T	Course Name	AGILE MANUFACTURING	Course Category	E	Professional Elective	L	T	P	C
							3	0	0	3

Pre-requisite Courses	Nil	Co-requisite Courses	Nil	Progressive Courses	Nil
Course Offering Department	Automobile Engineering	Data Book / Codes/Standards	Nil		

Course Learning Rationale (CLR):	*The purpose of learning this course is to:*
CLR-1 :	*Understand the manufacturing system and operation in terms of economic and technology.*
CLR-2 :	*Learn the manufacturing categories, material handling and manufacturing product*
CLR-3 :	*Expertise in industrial automation levels and its functional requirement*

Course Learning Outcomes (CLO):	*At the end of this course, learners will be able to:*	Learning 1: Level of Thinking (Bloom)	Learning 2: Expected Proficiency (%)	Learning 3: Expected Attainment (%)	PLO 1: Engineering Knowledge	PLO 2: Problem Analysis	PLO 3: Design & Development	PLO 4: Analysis, Design, Research	PLO 5: Modern Tool Usage	PLO 6: Society & Culture	PLO 7: Environment & Sustainability	PLO 8: Ethics	PLO 9: Individual & Team Work	PLO 10: Communication	PLO 11: Project Mgt. & Finance	PLO 12: Life Long Learning	PLO 13: PSO - 1	PLO 14: PSO - 2	PLO 15: PSO – 3
CLO-1 :	*Identify the lean manufacturing tools and their potential applications.*	*1*	*85*	*80*	*H*	*H*	*L*	*M*	*L*	*L*	*L*	*L*	*H*	*L*	*M*	*H*	*H*	*M*	*H*
CLO-2 :	*Summarize the usage of visual management, TPM and lean practices*	*2*	*80*	*75*	*H*	*H*	*M*	*H*	*M*	*M*	*M*	*M*	*H*	*L*	*H*	*H*	*H*	*L*	*H*
CLO-3 :	*Compare the technology drivers of agile manufacturing*	*2*	*85*	*80*	*H*	*M*	*H*	*M*	*H*	*H*	*M*	*H*	*H*	*L*	*H*	*H*	*H*	*M*	*M*
CLO-4 :	*Demonstrate the lean manufacturing principles to find and eliminate wastes*	*2*	*90*	*85*	*H*	*H*	*M*	*H*	*H*	*L*	*L*	*M*	*H*	*L*	*H*	*H*	*H*	*H*	*L*
CLO-5 :	*Explain the technology drivers of agile manufacturing*	*2*	*85*	*80*	*H*	*H*	*H*	*H*	*H*	*M*	*L*	*M*	*H*	*L*	*H*	*H*	*H*	*H*	*M*

		Introduction to Manufacturing Operations	Manufacturing System	Supply Chain Management, Production Planning & Control System	Lean Production : JIT, Value Added & Waste Elimination	Agile Manufacturing
Duration (hour)		09	09	09	09	09
S-1	SLO-1	*Introduction to Manufacturing Operations*	*Manufacturing System- Definition*	*Supply Chain Management*	*Introduction to various manufacturing techniques*	*Agile Manufacturing*
	SLO-2	*Definition of Manufacturing*	*Material Handling- Definition*	*Importance of supply chain-Definition*	*Introduction to lean production-importance*	*Introduction-Definition-Organize to master change*
S-2	SLO-1	*Alternate Definition of Manufacturing system as Technological*	*Human Resource Manufacturing system in large production system*	*competitive industrial revolution*	*Components of lean production*	*leverage the impact of People & information*
	SLO-2	*Economic Process Comments - Remarks*	*Components of a manufacturing system*	*Relying on Suppliers-downside and upside*	*Minimizing waste, perfect first time quality*	*cooperate to enhance competitiveness-enrich the customers*
S-3	SLO-1	*Manufacturing Industries & Products Manufacturing Categories –Primary – Secondary – Territory*	*Various components- Production machines*	*Supply chain management-Physical supply chain*	*flexible production line, continuous improvement*	*Market force & agility*
	SLO-2	*Continuous & Batch Production – Discrete manufacturing industry. Manufacturing Products – Materials, Typical Product*	*Tools, fixtures & material handling system*	*management philosophy*	*Definitions, Functions, & Principles.*	*Intensifying competition-fragmentation of mass market*
S-4	SLO-1	*Manufacturing Operation-Processing & Assembly operations-Material handling*	*Computer systems to coordinate the manufacturing system*	*Purchasing-changing roles*	*Smart inventory waste minimization*	*cooperative business relationship*
	SLO-2	*Inspection & testing-Coordination & testing-Process, Objective, Working & Stages of operations*	*Human Workers*	*requirement specifications*	*JIT- Concept*	*Changing customer expectation*
S-5	SLO-1	*Product & Production Relationship*	*Classification of Manufacturing systems*	*suppliers, assessment, selection & contracting*	*waste of over production*	*Reorganizing the production system for agility-design*
	SLO-2	*Production quantity & product variety*	*Factors – Types of operation performed*	*managing supplier relationship*	*waste of waiting*	*Reorganizing the production system for agility-product*

S-6	SLO-1	*Complexity of assembled products-Complexity of individual parts*	*number of work stations & layout*	*Material Requirement Planning (MRP) inputs to MRP, Bill of materials,*	*waste of transportation, waste of processing*	*Reorganizing the production system for agility-marketing*
	SLO-2	*Operations, functions, capabilities, limitation & examples*	*level of automation- product variety.*	*Product Structure, working- Examples, output & benefits of MRP*	*waste of motion*	*Reorganizing the production system for agility production operation*
S-7	SLO-1	*Production Concept & Mathematical Models-Production rate*	*Overview of Classification of manufacturing systems*	*Capacity Planning*	*waste of making defective parts*	*Agility versus Mass production*
	SLO-2	*Production capacity-utilization & availability of facility*	*single station*	*Shop Floor Control- order release, scheduling & Progress. Data collection.*	*Objectives of JIT*	*Agility versus Mass production*
S-8	SLO-1	*Manufacturing Lead time-Work in Process*	*Multi station*	*Inventory Control- Order point inventory system*	*Ingredients of JIT*	*Comparison of Lean & agile production*
	SLO-2	*objective, Operations, Functions & examples*	*production lines*	*work in process (WIP) inventory cost*	*Quality & Quantity principles of JIT*	*Comparison of Lean & agile production*
S-9	SLO-1	*Costs of Manufacturing Operations-Fixed & variable cost- Definition, cost equation & application-Direct Labor- Definition, Equation, Application & Examples*	*Learning curves of manufacturing progress-Definition*	*Manufacturing Resource Planning II (MRP II)*	*Primary quantity JIT principles*	*implementation of agile manufacturing*
	SLO-2	*Material & overhead- Factory & cooperate.- Estimating manufacturing Cost & establishing selling price-Cost of Equipment*	*learning rates for typical operations*	*Definition, structure, working & application*	*JIT implementation*	*implementation of agile manufacturing*

Learning Resources	*1. Mikell P. Groover "Automation, Production System & Computer Integrated Manufacturing ", Prentice Hall; 3 edition (August 3, 2007)* *2. John M. Nicholas "Competitive Manufacturing Management" 9th Edition, TATA McGraw Hill editions*	*3. S.R.K. Prasad, R. Prabhakar, S. Dhandapani, V. Selladurai " Intelligent Flexible Autonomous Manufacturing Systems", TATA McGraw- Hill Publishing Company Limited, 2010* *4. M. P. Chowdiah, Gopinath Gargesa, V. Arun Kumar, "Agile Manufacturing:, TATA McGraw- Hill Publishing Company Limited, 2006*

Learning Assessment

	Bloom's Level of Thinking	Continuous Learning Assessment (50% weightage)								Final Examination (50% weightage)	
		CLA – 1 (10%)		CLA – 2 (15%)		CLA – 3 (15%)		CLA – 4 (10%)#			
		Theory	Practice	Theory	Practice	Theory	Practice	Theory	Practice	Theory	Practice
Level 1	Remember Understand	*40 %*	-	*30 %*	-	*30 %*	-	*30 %*	-	*30%*	-
Level 2	Apply Analyze	*40 %*	-	*40 %*	-	*40 %*	-	*40 %*	-	*40%*	-
Level 3	Evaluate Create	*20 %*	-	*30 %*	-	*30 %*	-	*30 %*	-	*30%*	-
	Total	100 %		100 %		100 %		100 %		100 %	

CLA – 4 can be from any combination of these: Assignments, Seminars, Tech Talks, Mini-Projects, Case-Studies, Self-Study, MOOCs, Certifications, Conf. Paper etc.,

Course Designers		
Experts from Industry	Experts from Higher Technical Institutions	Internal Experts
1. Dr K Venkateswaran, Bimetal Bearings Limited, drvenki@bimite.co.in	*1. Dr.R.Elansezhian, Pondicherry Engineering College,elansezhianr@gmail.com*	*1. Dr. R.Rajendran, SRMIST, rajendrr@srmist.edu.in*
2. Dr.G.Saravanan Caterpillar, gsaravanan@cat.com	*2. Mr. N.Ravikumar, Crescent Institute of Science and Technology, ravikumar@crescent.education*	*2.Mr. S.Madhan Kumar, SRMIST, madhanks@srmist.edu.in*

Course Code	18AUE325T	Course Name	MANUFACTURING SYSTEMS AND SIMULATION	Course Category	E	Professional Elective	L	T	P	C
							3	0	0	3

Pre-requisite Courses	18AUC201J	Co-requisite Courses	Nil	Progressive Courses	Nil
Course Offering Department	Automobile Engineering	Data Book / Codes/Standards	Nil		

Course Learning Rationale (CLR):	*The purpose of learning this course is to:*
CLR-1 :	*Provide an insight into how simulation modelling can aid in effective decision-making.*
CLR-2 :	*Create Simulation model building aspects of discrete systems (such as Queuing, Inventory and manufacturing) in detail.*
CLR-3 :	*Demonstrate how computer simulation can be used to successfully model, analyze and improve systems under study.*
CLR-4 :	*Perform the statistical analysis of simulation model output.*
CLR-5 :	*Selection of the appropriate simulation software for the different cases.*

Course Learning Outcomes (CLO):	*At the end of this course, learners will be able to:*	Learning			Program Learning Outcomes (PLO)														
		1	2	3	1	2	3	4	5	6	7	8	9	10	11	12	13	14	15
		Level of Thinking (Bloom)	Expected Proficiency (%)	Expected Attainment (%)	Engineering Knowledge	Problem Analysis	Design & Development	Analysis, Design, Research	Modern Tool Usage	Society & Culture	Environment & Sustainability	Ethics	Individual & Team Work	Communication	Project Mgt. & Finance	Life Long Learning	PSO - 1	PSO - 2	PSO – 3
CLO-1 :	*Learn the basic concepts of simulation.*	*1,2*	*90*	*85*	*H*	*M*	*L*	*L*	*L*	*L*	*L*	*M*	*L*	*M*	*M*	*H*	*H*	*H*	*M*
CLO-2 :	*Develop and analyze complex models for industrial engineering problems using commercially available discrete event simulation software*	*2*	*90*	*80*	*H*	*H*	*H*	*H*	*H*	*L*	*M*	*H*	*H*	*H*	*M*	*H*	*H*	*H*	*H*
CLO-3 :	*Interpret simulation output using valid statistical methods and make appropriate recommendations.*	*2*	*90*	*80*	*H*	*M*	*M*	*M*	*M*	*L*	*M*	*H*	*M*	*H*	*M*	*H*	*M*	*M*	*H*
CLO-4 :	*Analyze data to determine appropriate input distributions using valid statistical methods.*	*2*	*90*	*80*	*H*	*H*	*M*	*H*	*M*	*L*	*M*	*H*	*M*	*H*	*M*	*M*	*H*	*M*	*H*
CLO-5:	*Apply the simulation software for various manufacturing system/process*	*2*	*90*	*80*	*H*	*H*	*M*	*H*	*H*	*L*	*L*	*M*	*H*	*H*	*M*	*H*	*H*	*H*	*M*

		Introduction to Manufacturing Systems	Manufacturing System Modeling and Simulation	Random Number Generation	Evaluation of Simulation Experiments	Simulation software and Examples
Duration (hour)		9	9	9	9	9
S-1	SLO-1	*Basic concepts and problems concerning systems*	*Basic concepts ofprobability-*	*Properties of random numbers*	*Input modeling, Data collection*	*Programming for discrete event system simulation in GPSS-*
	SLO-2	*Components of Manufacturing systems*	*Discrete versus Continuous Variables*		*Histograms, Selecting the family distribution,*	
S-2	SLO-1	*Systems design: Decision making procedures*	*Probability distribution for discrete variables*	*Techniques for generating random numbers- Linear Congruential Method*	*Selecting input distributions with data*	*GPSS- Single Server Queue simulation*
	SLO-2	*Classifications of Manufacturing systems*	*Probability distribution for continuous variables*		*Quantile-Quantile plots*	
S-3	SLO-1	*Structural, Transformational and procedural aspects of manufacturing*	*Binominal Distribution- to test hypothesis*	*Techniques for generating random numbers- Combined Linear Congruential Generator.*	*Parameter estimation- sample mean and sample variance*	*Simulation of Production systems- Models of Material Handling system.*
	SLO-2				*Suggested estimators*	
S-4	SLO-1	*Modes of production- Batch Production, Cellular, Flexible Manufacturing.*	*Statistical Models- Queueing Systems, Inventory and Supply chain system*	*Techniques for generating random numbers- Random- Number streams*	*Goodness-of-fit tests Chi-square test*	*Simulation of Production systems- Models of Material Handling Equipment.*
	SLO-2		*Reliability and Maintainability*		*Chi-square test with equal probabilities*	
S-5	SLO-1	*Process systems for manufacturing*	*Spread Sheet simulations*	*Tests for random numbers- Frequency Test.*	*Kolmogorov-smirnov goodness of fit test*	*Queueing Systems- Characteristics*
	SLO-2				*p-value and best fits*	
S-6	SLO-1	*Logistic systems- Product-Production Relationship*	*Queueing simulation in a spread sheet*	*Tests for random numbers- Test for Autocorrelation.*	*Selecting input models without data*	*Queueing Systems- Notations*
	SLO-2		*Waiting line models*			
S-7	SLO-1	*Material flow & technological information flow*	*Simulating a single server queue*	*Direct transformation for acceptance and rejection techniques- Poisson Distribution*	*Multivariate and time series input models*	*Project networks*
	SLO-2		*Simulating a queue with two servers*	*Nonstationary Poisson process & Gamma Distribution.*	*Covariance and correlation*	

S-8	SLO-1	*Management and information systems for manufacturing*	*Discrete and Continuous Systems*	*Inverse Transform Techniques- Exponential Distribution, Uniform Distribution*	*Time-series input models*	*Maintenance and replacement systems*
	SLO-2		Discrete- Event system simulation	*Inverse Transform Techniques- Weibull Distribution, Triangular Distribution*		
S-9	SLO-1	*Managerial information flow in manufacturing systems*	*Concepts in Discrete- Event system simulation*	*Inverse Transform Techniques- Emphatical continuous distributions.*	*experimental layout and validation*	*Investment Analysis*
	SLO-2			*Inverse Transform Techniques- Discrete distribution.*		

Learning Resources	1. *Jerry Banks and John S Carson, Barry L Nelson, David M Nicol, 'Discrete event system simulation',5th editionPearson Education, 2017, ISBN 13: 9789332518759.* 2. *David Bedworth& James Bailey, Integrated production control system management, analysis & design, 2nd ed., John Wiley & Sons Ltd, 1987, ISBN 13: 9780471821793*	3. *Carrle A, "Simulation of Manufacturing Systems", John Wiley and Sons Inc., New York, 2007, ISBN 13: 9780471915744* 4. *Gordon G, "Systems Simulation", Pearson Education, 2002.ISBN 13: 9788120301405* 5. *Narsingh Deo, "System Simulation with Digital Computer", Prentice Hall of India, New Delhi, 2001.ISBN 13: 9780138817893*

Learning Assessment											
	Bloom's Level of Thinking	Continuous Learning Assessment (50% weightage)								Final Examination (50% weightage)	
		CLA – 1 (10%)		CLA – 2 (15%)		CLA – 3 (15%)		CLA – 4 (10%)#			
		Theory	Practice	Theory	Practice	Theory	Practice	Theory	Practice	Theory	Practice
Level 1	Remember Understand	*60%*		*50%*		*40%*		*15%*		*50%*	
Level 2	Apply Analyze	*40%*		*50%*		*60%*		*20%*		*50%*	
Level 3	Evaluate Create	-		-		-		*15%*		-	
	Total	100 %		100 %		100 %		100 %		100%	

CLA – 4 can be from any combination of these: Assignments, Seminars, Tech Talks, Mini-Projects, Case-Studies, Self-Study, MOOCs, Certifications, Conf. Paper etc.,

Course Designers		
Experts from Industry	Experts from Higher Technical Institutions	Internal Experts
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Course Code	18AUE421T	Course Name	ADVANCED MANUFACTURING PROCESS	Course Category	E	Professional Elective	L	T	P	C
							3	0	0	3

Pre-requisite Courses	18AUC201J	Co-requisite Courses	Nil	Progressive Courses	Nil
Course Offering Department	Automobile Engineering	Data Book / Codes/Standards	Nil		

Course Learning Rationale (CLR):	*The purpose of learning this course is to:*
CLR-1 :	*Acquire knowledge of various advanced manufacturing processes used in industries*
CLR-2 :	*Understand the various manufacturing process of composite, plastics and glass.*
CLR-3 :	*Acquaint students with the concept of Additive Manufacturing (AM), various AM technologies, selection of materials for AM, modeling of AM processes, and their applications in various fields*

Course Learning Outcomes (CLO):	*At the end of this course, learners will be able to:*
CLO-1 :	*Identify the advanced metal forming process and its current role in the industries.*
CLO-2 :	*Choose the manufacturing process for the fabrication of composite, plastics and glass depending on the applications.*
CLO-3 :	*Integrate microelectronic device for Automotive application*
CLO-4 :	*List the low temperature joining and surface treatment process.*
CLO-5 :	*Select economically viable manufacturing process of highly complex parts alternative to conventional manufacturing technologies*

	Learning			Program Learning Outcomes (PLO)														
	1	2	3	1	2	3	4	5	6	7	8	9	10	11	12	13	14	15
	Level of Thinking (Bloom)	Expected Proficiency (%)	Expected Attainment (%)	Engineering Knowledge	Problem Analysis	Design & Development	Analysis, Design, Research	Modern Tool Usage	Society & Culture	Environment & Sustainability	Ethics	Individual & Team Work	Communication	Project Mgt. & Finance	Life Long Learning	PSO - 1	PSO - 2	PSO – 3
CLO-1	*1*	*85*	*75*	*H*	*M*	*M*	*M*	*H*	*M*	*M*	*M*	*M*	*M*	*L*	*M*	*H*	*H*	*H*
CLO-2	*3*	*80*	*75*	*H*	*M*	*M*	*H*	*M*	*M*	*M*	*M*	*M*	*M*	*L*	*M*	*H*	*H*	*H*
CLO-3	*3*	*85*	*80*	*H*	*M*	*H*	*M*	*M*	*M*	*M*	*M*	*M*	*L*	*M*	*L*	*H*	*H*	*H*
CLO-4	*1*	*85*	*80*	*H*	*M*	*M*	*M*	*H*	*M*	*H*	*H*	*M*	*H*	*L*	*L*	*H*	*H*	*H*
CLO-5	*3*	*80*	*75*	*H*	*M*	*H*	*M*	*L*	*L*	*L*	*M*	*M*	*L*	*M*	*M*	*H*	*H*	*H*

		Advanced Metal Forming Process	Composites, Plastics & Glass: Forming, Shaping & Equipment	Fabrication of Microelectronic Devices	Low Temperature Joining Process & Surface Technology	Additive Manufacturing
Duration (hour)		9	9	9	9	9
S-1	SLO-1	*Introduction – why do we need advanced manufacturing process?*	*Introduction to Composites*	*Role of Electronics in Industrial Revolution.*	*Introduction to joining process*	*Introduction to additive manufacturing.*
	SLO-2	*Introduction to powder metallurgy technique.*	*Composites properties and structures.*	*Integration of Electronics in Automotive Industry.*	*Brazing & Soldering methods- torch, furnace, induction, resistance, dip, infrared and applications.*	*Importance of Rapid prototyping.*
S-2	SLO-1	*Need and role of powder metallurgy in Automotive industry.*	*Processing of Polymer Matrix composites- Compression molding, injection molding , hand lay-up method , filament winding*	*Semiconductors & Silicon- Structure, Physical Properties.*	*Adhesion bonding – types of adhesives and adhesives system – Applications*	*RPT – classification based on materials, Advantages*
	SLO-2	*Powder Metallurgy Applications – Automotive parts and components.*	*Processing of Metal Matrix composites. Stir casting process , squeeze casting process/ infiltration , diffusion bonding, powder metallurgy*	*Semiconductors – working and types.*	*Joining of Plastics*	*Liquid based techniques-overview*
S-3	SLO-1	*Production and properties of metal powders.*	*Processing of Ceramic Matrix Composites Chemical vapor infiltration, Sol-gel Process*	*Semiconductors – advantages.*	*Joining of ceramics Joining of glass.*	*Stereo lithography.*
	SLO-2	*Particle size, distribution and shape of metal powders.*	*Composites in Automotive applications.*	*Wafer Formation & preparation*	*Surface Treatment- need, surface structure.*	*Solid Ground Curing technique.*
S-4	SLO-1	*Blending of metal powders and purpose.*	*Shaping of plastics*	*Single Crystal growing Techniques.*	*Mechanical surface treatment – shot peening, laser shot peening*	*Multi Jet Modeling,*
	SLO-2	*Hazards in Blending, Compaction of Metal powders.*	*Injection Molding process.*	*Slicing of wafers Geometry of wafers.*	*Water jet peening,*	*Ballistic particle.*
S-5	SLO-1	*Purpose of Isotactic pressing.*	*Blow Molding process*	*Film Deposition & Oxidation techniques.*	*Ultrasonic peening*	*Shape deposition Manufacturing*
	SLO-2	*Hot & Cold Shaping Process.*	*Rotational Molding process.*	*Physical Vapor Deposition*	*surface rolling - operation*	*Powder based techniques-overview*

S-6	SLO-1	*Metal injection molding, Spray Deposition.*	*Thermoforming process.*	*Chemical Vapor Deposition*	*explosive hardening - operation*	*Selective laser sintering.*
	SLO-2	*Sintering – process, Coining, Forging.*	*Compression molding process*	*Photolithography – Principle and Process.*	*Cladding - process & working*	*Laser engineered net shaping.*
S-7	SLO-1	*Mechanism and Properties of Sintered Parts Secondary & Finishing Operations.*	*Transfer Molding process.*	*Photolithography - Types & working*	*Case hardening - process & working*	*3D printing – introduction*
	SLO-2	*Heat treating, Impregnation, Infiltration & Plating.*	*Economics of Processing Plastics & Composites.*	*Etching – Need, Types, Principle.*	*Hard facing - objective, process & working.*	*3D printing- working and application*
S-8	SLO-1	*Dent Resistance of Sheet metals – dent formation &automotive application.*	*Forming & shaping of Glass- piece ware glass-spinning , pressing , press and blow , blow & blow and casting*	*Etching - Process & Working*	*Spark hardening - objective, process & working*	*Solid based technique-overview*
	SLO-2	*Fabrication of Honey Comb Structure for Catalytic Convertor.*	*Flat and tubular glass- float process , rolling of flat plate , Danner process*	*Diffusion- Principle, Process & Working*	*Thermal spraying – need, materials*	*Fused Deposition Modeling*
S-9	SLO-1	*Super plastic Forming – Super plasticity process, advantages and Properties.*	*Forming of glass fiber- centrifugal spraying, drawing*	*Ion Implantation - Principle, Process & Working*	*Thermal spraying – types*	*Paper Lamination Technology*
	SLO-2	*Diffusion bonding – process – advantages.*	*Strengthening Techniques for Glass*	*A brief outline of Wire Bonding, Packaging, Yield, Reliability*	*Thermal spraying –process- combustion , electrical and cold spraying*	*Laminated object modeling – process*

Learning Resources	1. *SeropeKalpakjian, "Manufacturing Engineering and Technology", 6th Edition, Addison-Wesley Publishing Co., Boston, 2014.* 2. *Mikell P. Groover "Fundamentals of Modern Manufacturing", 4thEdition, John Wiley & Sons Inc, 2015.*	3. *Helmi A Youssef, Hassan E El-Holfy, Mahmoud H Ahmed, "Manufacturing Technology", CRC Press. 2010*

Learning Assessment

	Bloom's Level of Thinking	Continuous Learning Assessment (50% weightage)								Final Examination (50% weightage)	
		CLA – 1 (10%)		CLA – 2 (15%)		CLA – 3 (15%)		CLA – 4 (10%)#			
		Theory	Practice	Theory	Practice	Theory	Practice	Theory	Practice	Theory	Practice
Level 1	Remember Understand	*40 %*	-	*30 %*	-	*30 %*	-	*30 %*	-	*30%*	-
Level 2	Apply Analyze	*40 %*	-	*40 %*	-	*40 %*	-	*40 %*	-	*40%*	-
Level 3	Evaluate Create	*20 %*	-	*30 %*	-	*30 %*	-	*30 %*	-	*30%*	-
	Total	100 %		100 %		100 %		100 %		100 %	

CLA – 4 can be from any combination of these: Assignments, Seminars, Tech Talks, Mini-Projects, Case-Studies, Self-Study, MOOCs, Certifications, Conf. Paper etc.,

Course Designers

Experts from Industry	Experts from Higher Technical Institutions	Internal Experts
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2. Mr.S. Senthil Kumar, Deputy Manager, Renault Nissan Technology & Business Centre India, senthilkumar.subramanian@rntbci.com	2. Dr.P.Jawahar, Assistant Professor, NIT Agartala, drjawahar.me@nita.ac.in	2. Mr.S.Palanisamy,SRMIST, palaniss@srmist.edu.in

Course Code	18AUE422T	Course Name	COMPUTER INTEGRATED MANUFACTURING	Course Category	E	Professional Elective	L	T	P	C
							3	0	0	3

Pre-requisite Courses	Nil	Co-requisite Courses	Nil	Progressive Courses	Nil
Course Offering Department	Automobile Engineering	Data Book / Codes/Standards	Nil		

Course Learning Rationale (CLR):	*The purpose of learning this course is to:*	Learning			Program Learning Outcomes (PLO)														
		1	2	3	1	2	3	4	5	6	7	8	9	10	11	12	13	14	15
CLR-1 :	*Develop capability in students to understand and use CIM in fabrication industry*																		
CLR-2 :	*Prepare planning and scheduling of process equipment fabrication using various CAPP*																		
CLR-3 :	*Demonstrate and use automated assembly lines, FMS and Industrial Robots*																		
Course Learning Outcomes (CLO):	*At the end of this course, learners will be able to:*	Level of Thinking (Bloom)	Expected Proficiency (%)	Expected Attainment (%)	Engineering Knowledge	Problem Analysis	Design & Development	Analysis, Design, Research	Modern Tool Usage	Society & Culture	Environment & Sustainability	Ethics	Individual & Team Work	Communication	Project Mgt. & Finance	Life Long Learning	PSO - 1	PSO - 2	PSO – 3
CLO-1 :	*Discuss the basic components of CIM.*	*1*	*90*	*85*	*H*	*H*	*M*	*M*	*H*	*L*	*L*	*M*	*H*	*L*	*L*	*M*	*H*	*H*	*M*
CLO-2 :	*Enable knowledge in CAPP and MRP.*	*2*	*85*	*80*	*H*	*H*	*H*	*L*	*H*	*L*	*M*	*M*	*M*	*L*	*M*	*H*	*H*	*H*	*L*
CLO-3 :	*Explain about Group Technology and Cellular Manufacturing*	*2*	*90*	*85*	*H*	*H*	*H*	*M*	*H*	*L*	*M*	*M*	*L*	*L*	*H*	*H*	*H*	*H*	*L*
CLO-4 :	*Equip themselves familiar with FMS and AGVs*	*2*	*80*	*75*	*H*	*H*	*M*	*M*	*H*	*L*	*L*	*M*	*M*	*L*	*H*	*M*	*H*	*H*	*L*
CLO-5 :	*Exposed to the concept of Industrial Robots*	*2*	*90*	*85*	*H*	*H*	*M*	*M*	*H*	*L*	*M*	*M*	*H*	*L*	*M*	*M*	*H*	*H*	*M*

		Introduction to CIM	Production Planning And Control And Computerised Process Planning	Cellular Manufacturing Group Technology(Gt)	Flexible Manufacturing System(Fms) And Automated Guided Vehicle System (Agvs)	Industrial Robotics
Duration (hour)		9	9	9	9	9
S-1	SLO-1	*Brief introduction to CAD and CAM*	*Process planning – Computer Aided Process Planning (CAPP)*	*Part families*	*Types of Flexibility*	*Robot Anatomy*
	SLO-2	*Manufacturing Planning, Manufacturing control*				*Related Attributes*
S-2	SLO-1	*Concurrent Engineering*	*Retrieval Computer Aided Process Planning*	*Parts Classification*	*Flexible Manufacturing System*	*Classification of Robots*
	SLO-2	*CIM concepts*	*Generative Computer Aided Process Planning*	*Parts coding*	*FMS Components*	*Robot Control systems*
S-3	SLO-1	*Computerized elements of CIM system*	*Aggregate Production Planning*	*Opitz Part Coding system*	*FMS Application*	*End Effectors*
	SLO-2	*Types of production*	*Aggregate Plan Strategies*	*Form Code in Opitz Part Coding system*	*FMS Benefits*	*Sensors in Robotics*
S-4	SLO-1	*Manufacturing models and Metrics*	*Master Production Schedule*	*Model problems I*	*FMS Planning*	*Industrial Robot Applications*
	SLO-2	*Mathematical models of Production Performance*	*Main Functions of Master Production Scheduling*	*Model problems II*	*FMS Control*	*Material Handling Applications*
S-5	SLO-1	*Model problems I*	*Material Requirement planning*	*Production flow Analysis*	*Quantitative analysis in FMS*	*Process Operations*
	SLO-2	*Model problems II*	*Demand driven MRP*	*Cellular Manufacturing*	*Bottelneck model*	*Assembly and Inspection*
S-6	SLO-1	*Marketing engineering*	*Capacity Planning*	*Composite part concept*	*Model problems I*	*Robot Programming*
	SLO-2	*Problems I*	*Control Systems*	*Individual features of Composite part concept*	*Model problems II*	*Leadthrough Programming*
S-7	SLO-1	*Problems II*	*Shop Floor Control*	*Machine cell design*	*Automated Guided Vehicle System*	*Motion Programming languages*
	SLO-2	*Basic Elements of an Automated system*	*Inventory Control*	*Machine cell layout*	*AGV System management*	*Robot Programming languages*
S-8	SLO-1	*Levels of Automation*	*Introdution on Manufacturing Resource Planning-II (MRP-II)*	*Quantitative analysis in Cellular Manufacturing*	*AGVS Application*	*Simulation and Off line programming*
	SLO-2	*Five Levels of Automation*	*Enterprise Resource Planning (ERP)*	*Rank Order Clustering Method*	*Vehicle Guidance technology*	*Robot Accuracy*
S-9	SLO-1	*Lean Production*	*Problems I*	*Arranging Machines in a GT cell*	*Vehicle Guidance technology benefits*	*Repeatability*
	SLO-2	*Just-In-Time Production*	*Problems II*	*Applications of GT*	*Vehicle Management & Safety*	*Problems*

Learning Resources	*1. Mikell.P.Groover "Automation, Production Systems and computer integrated manufacturing", 4th edition Pearson Education 2016.* *2. Kant Vajpayee. S., 'Principles of Computer Integrated Manufacturing', Prentice Hall of India, 2009*	*4. Roger Hanman "Computer Intergrated Manufacturing", Addison – Wesley, 1997* *5. Mikell.P.Groover and Emory Zimmers Jr., "CAD/CAM", Prentice Hall of India Pvt. Ltd., New Delhi-1, 2008*

Learning Assessment

	Bloom's Level of Thinking	Continuous Learning Assessment (50% weightage)								Final Examination (50% weightage)	
		CLA – 1 (10%)		CLA – 2 (15%)		CLA – 3 (15%)		CLA – 4 (10%)#			
		Theory	Practice	Theory	Practice	Theory	Practice	Theory	Practice	Theory	Practice
Level 1	Remember Understand	*40 %*	-	*30 %*	-	*30 %*	-	*30 %*	-	*30%*	-
Level 2	Apply Analyze	*40 %*	-	*40 %*	-	*40 %*	-	*40 %*	-	*40%*	-
Level 3	Evaluate Create	*20 %*	-	*30 %*	-	*30 %*	-	*30 %*	-	*30%*	-
	Total	100 %		100 %		100 %		100 %		100 %	

CLA – 4 can be from any combination of these: Assignments, Seminars, Tech Talks, Mini-Projects, Case-Studies, Self-Study, MOOCs, Certifications, Conf. Paper etc.,

Course Designers

Experts from Industry	Experts from Higher Technical Institutions	Internal Experts
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Course Code	18AUE423T	Course Name	PROCESS PLANNING AND COST ESTIMATION	Course Category	E	Professional Core	L	T	P	C
							3	0	0	3

Pre-requisite Courses	Nil	Co-requisite Courses	Nil	Progressive Courses	Nil
Course Offering Department	Automobile Engineering	Data Book / Codes/Standards	Nil		

Course Learning Rationale (CLR):	*The purpose of learning this course is to:*
CLR-1 :	*Impart basic knowledge about process planning and cost estimation*
CLR-2 :	*Retrieve the basic idea to estimate different cost*
CLR-3 :	*Acquaint knowledge to estimate machining time and cost*

Course Learning Outcomes (CLO):	*At the end of this course, learners will be able to:*	Learning 1: Level of Thinking (Bloom)	Learning 2: Expected Proficiency (%)	Learning 3: Expected Attainment (%)	PLO 1: Engineering Knowledge	PLO 2: Problem Analysis	PLO 3: Design & Development	PLO 4: Analysis, Design, Research	PLO 5: Modern Tool Usage	PLO 6: Society & Culture	PLO 7: Environment & Sustainability	PLO 8: Ethics	PLO 9: Individual & Team Work	PLO 10: Communication	PLO 11: Project Mgt. & Finance	PLO 12: Life Long Learning	PLO 13: PSO - 1	PLO 14: PSO - 2	PLO 15: PSO – 3
CLO-1 :	*Interpreting knowledge about work study and ergonomics.*	*1*	*85*	*80*	*M*	*L*	*L*	*M*	*M*	*M*	*M*	*M*	*M*	*M*	*H*	*M*	*H*	*M*	*H*
CLO-2 :	*Execute the process planning concepts*	*1*	*85*	*80*	*M*	*M*	*M*	*M*	*H*	*M*	*M*	*M*	*M*	*M*	*H*	*M*	*H*	*M*	*H*
CLO-3 :	*Predict various cost estimation*	*2*	*85*	*80*	*M*	*M*	*M*	*M*	*H*	*M*	*M*	*M*	*M*	*M*	*H*	*M*	*H*	*M*	*H*
CLO-4 :	*Calculate the production cost*	*2*	*80*	*75*	*M*	*M*	*H*	*M*	*H*	*M*	*M*	*M*	*M*	*M*	*H*	*M*	*H*	*M*	*H*
CLO-5 :	*Solve machining time and cost*	*3*	*80*	*75*	*M*	*M*	*H*	*M*	*H*	*M*	*M*	*M*	*M*	*M*	*H*	*M*	*H*	*M*	*H*

		Work Study and Ergonomics	Introduction to Process Planning	Cost Estimation	Production Cost Estimation	Estimation of Machining Times & Cost
Duration (hour)		9	9	9	9	9
S-1	SLO-1	*Objectives- Work study, Method study*	*Introduction to manufacturing system-Fundamental Concept and Basic Manufacturing process*	*Objectives of cost estimation*	*Estimation of material cost*	*Machine shop operations-Lathe, Drilling*
	SLO-2			*Types of cost estimation*		
S-2	SLO-1	*Basic Procedure for Method Study (Select, Record, Examine, Develop, Define, Install and Maintain)*	*Process planning-Basic concepts, Process selection and analysis*	*Fundamentals of costing and cost accounting methods,*	*Estimation of labor cost*	*Machine shop operations- Milling and Grinding*
	SLO-2					
S-3	SLO-1	*Recording Techniques used in Method Study*	*Details of process plan, process charts and route sheets*	*Components of a Cost Estimate*	*Estimation of Overhead cost*	*Estimation of machining time for basic lathe operation-Turning and Facing*
	SLO-2					
S-4	SLO-1	*Work Measurements, Objectives of work Measurements*	*Process planning methods- manual and computer aided process planning & its approaches*	*Classification of Costing*	*Foundry basics, Methods of casting, Casting tools and accessories*	*Estimation of machining time for Threading and Chamfering*
	SLO-2					
S-5	SLO-1	*Work Sampling, Analytical Estimating*	*Manual process planning-Basic procedure, merits & demerits, applications and comparisons*	*Elements of Cost, Cost of Product*	*Cost estimation in foundry shop- pattern cost, casting cost*	*Estimation of machining time for drilling–sample problems*
	SLO-2					
S-6	SLO-1	*Ergonomics*	*Case study-Preparation of manual process plan for four stroke petrol engine assembly*	*Methods of Cost Estimates*	*Welding, Types of weld joints, Gas welding*	*Estimation of machining time for boring operations –sample problems*
	SLO-2					
S-7	SLO-1	*Ergonomics Principles Applied to Instrument Design and Control*	*Computer aided process planning-Types, Basic procedure, merits, demerits and applications*	*Data Requirements and Sources of information*	*Estimation of Gas welding cost, Gas cutting*	*Estimation of machining time for milling operation-Sample problems*
	SLO-2					
S-8	SLO-1	*Ergonomics Principles Applied to Machines and Controls*	*Process analysis-Break even analysis & It's objectives*	*Types of Cost Estimates, Allowances in Estimation (of Standard Time)*	*Arc welding: Equipments, Cost Estimation*	*Estimation of machining time for Grinding operation-sample problems*
	SLO-2					
S-9	SLO-1	*Ergonomics Principles Applied to Layout of a Work place*	*Statistical process control-Process capability analysis using process control charts*	*Cost Estimation Procedure*	*Cost estimation in Welding shop*	*Case studies: Estimation of cost for a product*
	SLO-2					

Learning Resources	1. Chitale, A.K., and Gupta, R.C., *"Product Design and Manufacturing", Prentice Hall of India, New Delhi, 2011.* 2. *Adithan,M, "Process planning and cost estimation", New Age International(P) Limited,2011*	3. *Nanua Singh, "System Approach to computer Integrated Design and manufacturing", John Wiley & Sons, New York, 1996.* 4. *Sinha.B.P., "Mechanical Estimation and Costing", Tata McGraw-Hill, Publishing Co.,1995* 5. *Narang, G.B.S. and Kumar. "Production and planning", Khana Publishers, New Delhi,1995.*

Learning Assessment											
	Bloom's Level of Thinking	Continuous Learning Assessment (50% weightage)								Final Examination (50% weightage)	
		CLA – 1 (10%)		CLA – 2 (15%)		CLA – 3 (15%)		CLA – 4 (10%)#			
		Theory	Practice	Theory	Practice	Theory	Practice	Theory	Practice	Theory	Practice
Level 1	Remember Understand	40 %	-	30 %	-	30 %	-	30 %	-	30%	-
Level 2	Apply Analyze	40 %	-	40 %	-	40 %	-	40 %	-	40%	-
Level 3	Evaluate Create	20 %	-	30 %	-	30 %	-	30 %	-	30%	-
	Total	100 %		100 %		100 %		100 %		100 %	

CLA – 4 can be from any combination of these: Assignments, Seminars, Tech Talks, Mini-Projects, Case-Studies, Self-Study, MOOCs, Certifications, Conf. Paper etc.,

Course Designers		
Experts from Industry	Experts from Higher Technical Institutions	Internal Experts
1. Mr. Silambarasan Ramadoss, Renault Nissan Technology & Business Centre India, silambarasan.ramadoss@rntbci.com	*1. Dr. A.Siddharthan, Madras Institute of Technology, sidharth@mitindia.edu*	*1. Dr. J.Chandradass, SRMIST, chandraj@srmist.edu.in*
2.Mr. Prasad Arun Kumar, Mahindra Research Valley, prasad.arunkumar@mahindra.com	*2. Dr. S. Renold Elsen, Vellore Institute of Technology, renoldelsen.s@vit.ac.in*	*2. Mr. M.Palanivendhan, SRMIST, palanivm@srmist.edu.in*

Course Code	18AUE424T	Course Name	AUTOMOTIVE QUALITY SYSTEMS	Course Category	E	Professional Elective	L	T	P	C
							3	0	0	3

Pre-requisite Courses	Nil	Co-requisite Courses	Nil	Progressive Courses	Nil
Course Offering Department	Automobile Engineering	Data Book / Codes/Standards	Nil		

Course Learning Rationale (CLR):	*The purpose of learning this course is to:*
CLR-1 :	*Impart the knowledge of quality concepts and quality management systems*
CLR-2 :	*Implement the knowledge of tool and techniques in automotive industries.*
CLR-3 :	*Integrate the idea to work with professional cost accountants to obtain realistic cost estimates*
CLR-4 :	*Collaborate on international quality systems and modern management systems for quality.*

Course Learning Outcomes (CLO):	*At the end of this course, learners will be able to:*	Learning 1	Learning 2	Learning 3	PLO 1	PLO 2	PLO 3	PLO 4	PLO 5	PLO 6	PLO 7	PLO 8	PLO 9	PLO 10	PLO 11	PLO 12	PLO 13	PLO 14	PLO 15
		Level of Thinking (Bloom)	Expected Proficiency (%)	Expected Attainment (%)	Engineering Knowledge	Problem Analysis	Design & Development	Analysis, Design, Research	Modern Tool Usage	Society & Culture	Environment & Sustainability	Ethics	Individual & Team Work	Communication	Project Mgt. & Finance	Life Long Learning	PSO - 1	PSO - 2	PSO – 3
CLO-1 :	*Relate the quality concepts and quality production*	*1*	*80*	*75*	*M*	*M*	*M*	*M*	*M*	*H*	*M*	*H*	*M*	*H*	*H*	*H*	*M*	*H*	*H*
CLO-2 :	*Explain quality Management system and different dimensions of quality*	*2*	*85*	*80*	*M*	*H*	*L*	*H*	*M*	*H*	*M*	*H*	*M*	*H*	*H*	*H*	*M*	*H*	*H*
CLO-3 :	*Implement the application of management tools and techniques for process improvement*	*2*	*85*	*80*	*M*	*H*	*H*	*L*	*H*	*H*	*M*	*H*	*M*	*H*	*H*	*H*	*M*	*H*	*H*
CLO-4 :	*Assess Automotive TS16949 quality system practices*	*3*	*85*	*80*	*M*	*H*	*H*	*H*	*H*	*H*	*M*	*H*	*M*	*H*	*H*	*H*	*M*	*H*	*H*
CLO-5 :	*Validate various system analysis measurement and data collection*	*3*	*90*	*85*	*M*	*H*	*H*	*H*	*H*	*H*	*M*	*H*	*M*	*H*	*H*	*H*	*M*	*H*	*H*

Duration (hour)		9	9	9	9	9
S-1	SLO-1 / SLO-2	*Basic Concepts of Quality. Quality, classification of quality and services*	*Quality Management Systems-Introduction*	*Modern Management Tools and Techniques*	*ISO TS16949 Scope, application and quality management system*	*Quality Tools and Measurement Systems Analysis*
S-2	SLO-1 / SLO-2	*Quality systems overview*	*Quality Management – A conceptual Frame Work*	*Introduction to Modern Management Techniques*	*Requirements of quality management system*	*Concepts of SPC detection vs. prevention*
S-3	SLO-1 / SLO-2	*Product Quality design*	*Dimensions of Quality*	*5s concepts*	*Advanced Product Quality Planning (APQP)-Focus and benefits*	*Data collection methods*
S-4	SLO-1 / SLO-2	*Quality engineering in design of production processes*	*Costs of Quality*	*Kaizen techniques*	*Advanced Product Quality Planning (APQP)- Different Phases*	*Statistical Tools*
S-5	SLO-1 / SLO-2	*Quality characteristics*	*Quality System Standards*	*Six sigma methodologies*	*Design of Failure Mode Effects Analysis - Types*	*Understanding of measurement systems*
S-6	SLO-1 / SLO-2	*Reliability*	*ISO 9000 clauses*	*Quality circles*	*Design of Failure Mode Effects Analysis-Advantages and Limitations*	*Variable Gauge R&R*
S-7	SLO-1 / SLO-2	*Safety*	*ISO 9000 interpretations*	*Taguchi loss function-Theory*	*Process Failure Mode Effects Analysis*	*Introduction to Hypothesis Testing*
S-8	SLO-1 / SLO-2	*Quality engineering in production*	*ISO TS16949 clauses*	*Taguchi loss function-Applications*	*Production Part Approval Process (PPAP)*	*ANOVA*
S-9	SLO-1 / SLO-2	*Quality engineering in service*	*ISO TS16949 interpretation*	*POKE –YOKE Techniques*	*Single and Multiple Regression*	*Correlation Analysis*

Learning Resources	
	1. *David Hoyle, "Automotive quality system Handbook" , Butterworth – Heinemann ltd, second edition,oxford,2005* 2. *William M Feld, "Lean Manufacturing: Tools, Techniques and How to Use Them" , APICS, 2010* 3. *Montgomery Douglas C, "Introduction to Statistical Quality Control", John Wiley and Sons, New Delhi, 2009.* 4. *Logo Thetis N, "Managing for Total Quality – From Deming to Taguchi and SPC", Prentice Hall of India Private Limited, New Delhi, 1997.* 5. *" Advanced product quality planning and control plan" 2 nd Edition ,Standards media (2008)*

Learning Assessment											
	Bloom's Level of Thinking	Continuous Learning Assessment (50% weightage)								Final Examination (50% weightage)	
		CLA – 1 (10%)		CLA – 2 (15%)		CLA – 3 (15%)		CLA – 4 (10%)#			
		Theory	Practice	Theory	Practice	Theory	Practice	Theory	Practice	Theory	Practice
Level 1	Remember Understand	*40 %*	-	*30 %*	-	*30 %*	-	*30 %*	-	*30%*	-
Level 2	Apply Analyze	*40 %*	-	*40 %*	-	*40 %*	-	*40 %*	-	*40%*	-
Level 3	Evaluate Create	*20 %*	-	*30 %*	-	*30 %*	-	*30 %*	-	*30%*	-
	Total	100 %		100 %		100 %		100 %		100 %	

CLA – 4 can be from any combination of these: Assignments, Seminars, Tech Talks, Mini-Projects, Case-Studies, Self-Study, MOOCs, Certifications, Conf. Paper etc.,

Course Designers		
Experts from Industry	Experts from Higher Technical Institutions	Internal Experts
1. Mr. Silambarasan Ramadoss, Renault Nissan Technology & Business Centre India, silambarasan.ramadoss@rntbci.com	*1. Dr. A.Siddharthan, Madras Institute of Technology, sidharth@mitindia.edu*	*1. Dr. J.Chandradass, SRMIST, chandraj@srmist.edu.in*
2.Mr. Prasad Arun Kumar, Mahindra Research Valley, prasad.arunkumar@mahindra.com	*2. Dr. S. Renold Elsen, Vellore Institute of Technology, renoldelsen.s@vit.ac.in*	*2. Mr.M.Palanivendhan,SRMIST, palanivm@srmist.edu.in*

Course Code	18AUE425T	Course Name	INDUSTRIAL ENGINEERING AND OPERATIONAL RESEARCH	Course Category	E	Professional Elective	L	T	P	C
							3	0	0	3

Pre-requisite Courses	Nil	Co-requisite Courses	Nil	Progressive Courses	Nil
Course Offering Department	Automobile Engineering	Data Book / Codes/Standards	Nil		

Course Learning Rationale (CLR):	*The purpose of learning this course is to:*
CLR-1 :	*Provide an insight into the concepts of industrial engineering and organization*
CLR-2 :	*Develop a diverse group of professionals and leaders in industrial engineering*
CLR-3 :	*Enhance the scientific awareness of the society in the field of operation research.*

Course Learning Outcomes (CLO):	*At the end of this course, learners will be able to:*	Learning 1: Level of Thinking (Bloom)	2: Expected Proficiency (%)	3: Expected Attainment (%)	PLO 1: Engineering Knowledge	2: Problem Analysis	3: Design & Development	4: Analysis, Design, Research	5: Modern Tool Usage	6: Society & Culture	7: Environment & Sustainability	8: Ethics	9: Individual & Team Work	10: Communication	11: Project Mgt. & Finance	12: Life Long Learning	13: PSO - 1	14: PSO - 2	15: PSO – 3
CLO-1 :	*Understand the impact of industrial engineering solutions in a global and social context*	1	85	80	H	M	L	M	L	L	L	L	H	L	M	L	H	M	H
CLO-2 :	*Use the knowledge and skills of industrial engineering to model and analyze problems*	2	80	75	H	H	M	H	M	M	L	M	H	L	H	H	H	L	M
CLO-3 :	*Investigate Effective utilization of men, equipment and space*	2	85	80	H	M	H	M	H	H	L	H	H	L	H	H	H	M	M
CLO-4 :	*Ensure optimal use of resources with modern technology to create a place of higher learning in the fields of Operation Research*	2	90	85	H	H	M	H	H	L	L	M	H	L	H	H	H	M	L
CLO-5 :	*Apply the PERT/CPM for a constraint based problem of service/manufacturing.*	2	85	80	H	H	M	H	H	M	L	M	H	L	H	H	H	H	M

		Industrial Engineering and Management Science	Production And Productivity	Plant Location and Layout	Work Study	Operational Research
Duration (hour)		9	9	9	9	9
S-1	SLO-1 / SLO-2	*Introduction to Industrial Engineering, Concepts*	*Production Concept*	*Factors Governing on plant location*	*Definition concept and need for work study*	*Operational Research concept and defination*
S-2	SLO-1	*History and Development of Industrial Engineering*	*Production function*	*Locational Economics*	*Method Study*	*Methods of Operational Research*
	SLO-2	*Scientific management*	*Production system*	*Rural V/S Urban plant sites*	*Method Study Procedure*	*Linear Programming*
S-3	SLO-1	*Roles of an Industrial Engineer*	*Analysis of Production system*	*Plant layout*	*Process chart symbols*	*Graphical method*
	SLO-2	*Applications of Industrial Engineer*	*Input output model*	*Principles of Plant layout*	*Flow process charts*	*Model problem in Graphical method*
S-4	SLO-1	*Functions of Industrial Engineering department and its organization*	*Productivity*	*Process layout*	*Process charts types*	*Transportation problem*
	SLO-2	*Production Management*	*Productivity model problem*	*Process layout Merits and demerits*	*Flow diagram*	*Transportation problem types*
S-5	SLO-1	*Production Management Versus Industrial Engineer*	*Factors affecting productivity*	*Product layout*	*Steps in flow diagram*	*Vogels approximate method*
	SLO-2	*Operations Management*	*Product design*	*Product layout Merits and demerits*	*Man type flow process chart*	*Model problem in Vogels approximate method*
S-6	SLO-1	*Management science*	*Increasing productivity of Resources*	*Combination layout*	*String diagram*	*North west corner method*
	SLO-2	*Historical Development*	*Work productivity*	*Fixed position layout*	*String diagram construction*	*Model problem I*
S-7	SLO-1	*Tools of management science*	*Model Problem I*	*Flow pattern layout*	*Multiple Activity chart*	*Cost matrix*
	SLO-2	*Simulation model*	*Model Problem II*	*Flow pattern layout types*	*Multiple Activity chart Construction*	*Profit matrix*
S-8	SLO-1	*Managerial economics*	*Productivity measures*	*Work station*	*Operational analysis*	*Profit matrix with equal supply and demand*
	SLO-2	*Managerial Techniques*	*Development of Productivity Measures*	*Work station design*	*Example Operational chart*	*Profit matrix with unequal supply and demand*
S-9	SLO-1	*Managerial Accounting*	*Productivity Measurement system*	*Model Problem I*	*Analysis of motion*	*Degeneracy*
	SLO-2	*Analysis and performance*	*Components of Productivity Measurement system*	*Model Problem II*	*Steps in motion analysis*	*Degeneracy Problem*

Learning Resources	1. O.P. Khanna, *"Industrial Engineering and management", 17th Edition, Dhanpat Rai Publishing Co Pvt Ltd, 2018.* 2. Martand Telsang, *"Industrial Engineering and Production management", 2nd edition, S. Chand publisher, 2014.*	3. Hamdy A Taha , *"Operations Research : An Introduction" 10th Edition,* Pearson, *2016.*

Learning Assessment

	Bloom's Level of Thinking	Continuous Learning Assessment (50% weightage)								Final Examination (50% weightage)	
		CLA – 1 (10%)		CLA – 2 (15%)		CLA – 3 (15%)		CLA – 4 (10%)#			
		Theory	Practice	Theory	Practice	Theory	Practice	Theory	Practice	Theory	Practice
Level 1	Remember Understand	*40 %*	-	*30 %*	-	*30 %*	-	*30 %*	-	*30%*	-
Level 2	Apply Analyze	*40 %*	-	*40 %*	-	*40 %*	-	*40 %*	-	*40%*	-
Level 3	Evaluate Create	*20 %*	-	*30 %*	-	*30 %*	-	*30 %*	-	*30%*	-
	Total	100 %		100 %		100 %		100 %		100 %	

CLA – 4 can be from any combination of these: Assignments, Seminars, Tech Talks, Mini-Projects, Case-Studies, Self-Study, MOOCs, Certifications, Conf. Paper etc.,

Course Designers

Experts from Industry	Experts from Higher Technical Institutions	Internal Experts
1. Mr.N.Vijayakumar, Head Test labs, Mahindra and Mahindra, vijayakumar.n@mahindra.com.	*1. Prof. M.Balasubramanian, Professor, IIT Madras, mbala@iitm.ac.in*	*1.Dr.J.Chandradass,SRMIST, chandraj@srmist.edu.in*
2. Mr.S. Senthil Kumar, Deputy Manager, Renault Nissan Technology & Business Centre India, senthilkumar.subramanian@rntbci.com	*2. Dr.P.Jawahar, Assistant Professor, NIT Agartala, drjawahar.me@nita.ac.in*	*2.Mr.S.MadhanKumar,SRMIST, madhanks@srmist.edu.in*

Course Code	18AUE331T	Course Name	HEAT VENTILATION AND AIR CONDITIONING	Course Category	E	Professional Elective	L	T	P	C
							3	0	0	3

Pre-requisite Courses	18AUC203T	Co-requisite Courses	Nil	Progressive Courses	Nil
Course Offering Department	Automobile Engineering	Data Book / Codes/Standards	Nil		

Course Learning Rationale (CLR):	*The purpose of learning this course is to:*
CLR-1 :	*Describe the working of Refrigeration system*
CLR-2 :	*Interpret the knowledge on Psychrometry process*
CLR-3 :	*Understand the refrigerant properties*
CLR-4 :	*Illustrate the Load calculation*
CLR-5 :	*Understand the function of air distribution system*

Course Learning Outcomes (CLO):	*At the end of this course, learners will be able to:*	Learning 1	Learning 2	Learning 3	PLO 1	2	3	4	5	6	7	8	9	10	11	12	13	14	15
		Level of Thinking (Bloom)	Expected Proficiency (%)	Expected Attainment (%)	Engineering Knowledge	Problem Analysis	Design & Development	Analysis, Design, Research	Modern Tool Usage	Society & Culture	Environment & Sustainability	Ethics	Individual & Team Work	Communication	Project Mgt. & Finance	Life Long Learning	PSO - 1	PSO - 2	PSO – 3
CLO-1 :	*Select the various Refrigeration system*	*3*	*90*	*85*	*H*	*M*	*H*	*M*	*L*	*L*	*H*	*M*	*M*	*M*	*L*	*M*	*M*	*M*	*L*
CLO-2 :	*Identify the thermal condition of Psychrometry process*	*1*	*80*	*75*	*H*	*M*	*M*	*M*	*M*	*L*	*M*	*L*	*M*	*M*	*L*	*M*	*M*	*M*	*H*
CLO-3 :	*Distinguish the refrigerant properties*	*2*	*85*	*80*	*H*	*M*	*M*	*M*	*M*	*M*	*M*	*L*	*M*	*M*	*M*	*M*	*H*	*M*	*H*
CLO-4 :	*Perform the Load calculation*	*2*	*85*	*80*	*H*	*H*	*M*	*H*	*M*	*L*	*L*	*L*	*M*	*M*	*L*	*M*	*M*	*M*	*M*
CLO-5 :	*Analyze and select the air distribution system*	*1*	*90*	*85*	*H*	*M*	*M*	*M*	*M*	*H*	*H*	*H*	*M*	*M*	*L*	*M*	*M*	*M*	*H*

		Air Conditioning Fundamentals	Psychrometry	Refrigerant	Fans and Air Distribution	Load Calculation and Applied Psychrometrics
Duration (hour)		09	09	09	09	09
S-1	SLO-1	*Introduction to Air Conditioning System*	*Mixing Process*	*Working of Refrigerant in refrigeration system*	*Fan Characteristics*	*Preliminary Considerations*
	SLO-2	*Location of Air Conditioning system In a Car*	*Properties of Moist Air*	*Containers Handling Refrigerants*	*Centrifugal Fans*	*Internal Heat gains*
S-2	SLO-1	*Schematic layout of Refrigeration System*	*Dalton's Law of Partial Pressure*	*Desirable Properties Of Refrigerant*	*Axial Fans*	*Occupancy Load*
	SLO-2	*Mode of heat transfer*	*Psychrometric Properties*	*Selection of Refrigerants*	*Fan Arrangements*	*Lighting Load*
S-3	SLO-1	*Refrigeration cycle*	*Dry Bulb Temperature*	*Thermodynamic Requirements*	*Fan in Series*	*Appliances Load*
	SLO-2	*Terminologies In HVAC: TR, COP*	*Wet Bulb Temperature*	*Freezing Point*	*Fan in parallel*	*Product Load*
S-4	SLO-1	*EER, SEER*	*Specific Humidity*	*Critical Temperature and Pressure*	*Types of Ducts*	*System Heat Gains*
	SLO-2	*Heat Exchanger And Its Types*	*Dew Point Temperature*	*Chemical Requirements*	*Air Flow Through Simple Duct System*	*Supply air duct heat gain and Leakage loss*
S-5	SLO-1	*Direct-Contact Heat Exchangers*	*Relative Humidity*	*Flammability*	*Duct Fittings*	*Heat gain from Air Conditioning fan*
	SLO-2	*Storage Type Exchangers*	*Psychrometric Processes*	*Toxicity*	*Friction Loss In Duct*	*Return air duct heat and Leakage gain*
S-6	SLO-1	*Tubular Heat Exchangers*	*Sensible cooling*	*Action of Refrigerant with water*	*Dynamic Loss In Ducts*	*Safety factor*
	SLO-2	*Shell-and-Tube Exchangers*	*Sensible heating*	*Action of Refrigerant with oil*	*Dampers*	*Cooling Load Estimate*
S-7	SLO-1	*Double-Pipe Heat Exchangers*	*Humidifying*	*Binary Mixtures*	*Indoor Air Distribution*	*Room Sensible Heat*
	SLO-2	*Spiral Tube Heat Exchangers*	*Dehumidifying*	*Classification of Refrigerant Mixtures*	*Static And Velocity Pressures*	*Room Latent Heat*
S-8	SLO-1	*Air Conditioning Components*	*Heating and Humidifying*	*Lubricant in Refrigeration system*	*Fixed Velocity Method*	*Grand total load on Air conditioning system*
	SLO-2	*Compressor*	*Cooling and Dehumidifying*	*Tapping Into The Refrigerant Container*	*Equal Friction Method*	*Heat Balance Method*
S-9	SLO-1	*Condenser*	*Cooling and Humidifying*	*Ambient Conditions Affecting System Pressures*	*Static Regain Method*	*Heat Load Calculation*
	SLO-2	*Evaporator Expansion Valve*	*Heating and Dehumidifying*	*Secondary Refrigerant*	*Static Pressure Calculation*	*Tutorials*

Learning Resources	1. *C. P. Arora "Refrigeration and Air conditioning" – McGraw Hill Education (India) Private Limited, New Delhi,2010* 2. *Roy J. Dossat, "Principles of Refrigeration", 4th edition, Pearson Education Asia, 2009* 3. *William H. Crouse and Donald I. Anglin - "Automotive Air conditioning" - McGraw Hill, 2000*	4. *Paul Weiser - "Automotive Air Conditioning" - Reston Publishing Co., Inc., - 1990* 5. *MacDonald, K.I., "Automotive Air Conditioning" - Theodore Audel series - 1978*

Learning Assessment

	Bloom's Level of Thinking	Continuous Learning Assessment (50% weightage)								Final Examination (50% weightage)	
		CLA – 1 (10%)		CLA – 2 (15%)		CLA – 3 (15%)		CLA – 4 (10%)#			
		Theory	Practice	Theory	Practice	Theory	Practice	Theory	Practice	Theory	Practice
Level 1	Remember Understand	*40 %*	-	*30 %*	-	*30 %*	-	*30 %*	-	*30%*	-
Level 2	Apply Analyze	*40 %*	-	*40 %*	-	*40 %*	-	*40 %*	-	*40%*	-
Level 3	Evaluate Create	*20 %*	-	*30 %*	-	*30 %*	-	*30 %*	-	*30%*	-
	Total	100 %		100 %		100 %		100 %		100 %	

CLA – 4 can be from any combination of these: Assignments, Seminars, Tech Talks, Mini-Projects, Case-Studies, Self-Study, MOOCs, Certifications, Conf. Paper etc.,

Course Designers

Experts from Industry	Experts from Higher Technical Institutions	Internal Experts
1. Mr D Rajasekaran, Freeze India Manufacturing Pvt Limited, rajakd@fim.com	*1. Dr A Baskaran, P. A. College of Engineering and Technology, boss120367@gmail.com*	*1., Dr. S. Thiyagarajan, SRMIST*
2. Mr S Ashok, ETA, ashoks@eta-engg.com	*2. Dr G Venkatesan, Pondicherry Engineering College, rvenkirm@pec.com*	*2. Mr. S. Logeshwaran, SRMIST*

Course Code	18AUE332T	Course Name	ENGINE TESTING AND VALIDATION	Course Category	E	Professional Elective	L	T	P	C
							3	0	0	3

Pre-requisite Courses	18AUC301J	Co-requisite Courses	Nil	Progressive Courses	Nil
Course Offering Department	Automobile Engineering	Data Book / Codes/Standards	Nil		

Course Learning Rationale (CLR):	*The purpose of learning this course is to:*
CLR-1 :	*Analyze the various engine operating parameters*
CLR-2 :	*Employ various instruments for measuring engine parameters*
CLR-3 :	*Evaluate the working principle of measuring instruments*
CLR-4 :	*Create insight on the fundamental considerations for engine test facility*
CLR-5 :	*Analyze the data acquired from the engine*
CLR-6 :	*Validate the data acquired from the engine*

Course Learning Outcomes (CLO):	*At the end of this course, learners will be able to:*	Learning 1: Level of Thinking (Bloom)	Learning 2: Expected Proficiency (%)	Learning 3: Expected Attainment (%)	PLO 1: Engineering Knowledge	PLO 2: Problem Analysis	PLO 3: Design & Development	PLO 4: Analysis, Design, Research	PLO 5: Modern Tool Usage	PLO 6: Society & Culture	PLO 7: Environment & Sustainability	PLO 8: Ethics	PLO 9: Individual & Team Work	PLO 10: Communication	PLO 11: Project Mgt. & Finance	PLO 12: Life Long Learning	PLO 13: PSO - 1	PLO 14: PSO - 2	PLO 15: PSO – 3
CLO-1 :	*Evaluate the performance parameters in IC engines*	*2*	*80*	*75*	*H*	*M*	*M*	*M*	*H*	*M*	*M*	*M*	*H*	*H*	*M*	*M*	*H*	*M*	*L*
CLO-2 :	*Measure the various engine operating parameters of I.C engine*	*2*	*85*	*80*	*H*	*M*	*M*	*M*	*M*	*L*	*M*	*L*	*M*	*M*	*M*	*M*	*H*	*M*	*L*
CLO-3 :	*Apply the knowledge of basic principle of measuring instruments*	*1*	*80*	*75*	*H*	*M*	*H*	*M*	*L*	*L*	*M*	*M*	*M*	*M*	*L*	*L*	*H*	*M*	*L*
CLO-4 :	*Develop an engine test rig with necessary instrumentation*	*1*	*80*	*75*	*M*	*H*	*M*	*H*	*M*	*M*	*M*	*M*	*H*	*H*	*M*	*M*	*H*	*M*	*L*
CLO-5 :	*Analyze and validate various engine test results*	*2*	*85*	*80*	*H*	*M*	*M*	*M*	*M*	*M*	*M*	*M*	*H*	*M*	*M*	*M*	*H*	*M*	*M*

		Performance Parameters	Measurements	Instrumentation	Test facility layout	Data analysis
Duration (hour)		9	9	9	9	9
S-1	SLO-1	*Engine performance parameters - Introduction*	*Indicated power measurement*	*Instrumentation and data acquisition - Introduction*	*Test facility layout considerations- fundamentals*	*Validation of data and test results - Introduction*
	SLO-2	*Engine performance parameters - Explanation*	*Frictional power measurement*	*Pressure measurement*	*Test cell - thermodynamic system*	*General principles for data validation in engine testing*
S-2	SLO-1	*Brake power - Calculation*	*Tutorial session*	*The Hall-effect sensor*	*Basics of test cell and control room design*	*Error types*
	SLO-2	*Torque Output - Calculation*	*Tutorial session*	*Shielded-field sensor*	*Ventilation and air conditioning*	*Error Sources*
S-3	SLO-1	*Tutorial session*	*Brake power measurements*	*Crankshaft position sensor*	*Vibration control*	*Combination of errors*
	SLO-2	*Tutorial session*	*Torque and speed measurements*	*Types*	*Test cell noise control*	*Experiment repeatability*
S-4	SLO-1	*Mean effective pressure - Calculation*	*Dynamometer - Introduction*	*Throttle position sensor*	*Cooling circuit requirements*	*Instrument sensitivity*
	SLO-2	*Mechanical efficiency Calculation*	*Mechanical Dynamometer*	*Temperature sensors*	*Installation*	*Experimental precision*
S-5	SLO-1	*Tutorial session*	*Electrical Dynamometer*	*Coolant sensors*	*Exhaust gas system*	*Absolute and relative accuracy*
	SLO-2	*Tutorial session*	*Eddy Current Dynamometer*	*Sensors for Feedback control*	*Installation*	*Traceability*
S-6	SLO-1	*Volumetric efficiency and Fuel-air ratio calculation*	*Measurement of speed*	*Exhaust gas oxygen sensor*	*Electrical system considerations*	*Uncertainty- calibration –definition, importance*
	SLO-2	*Specific fuel consumption calculation*	*Fuel consumption measurement*	*EGO characteristics*	*Layout*	*Calibration - definition*
S-7	SLO-1	*Tutorial session*	*Air consumption measurement*	*Switching characteristics*	*Fuel storage requirements*	*Calibration - importance*
	SLO-2	*Tutorial session*	*Smoke and particulate measurement*	*Knock sensor*	*Fuel supply requirements*	*Calibration techniques for pressure*
S-8	SLO-1	*Heat Balance - Calculation*	*Measurement of exhaust emissions – HC, CO, NOx and* CO_2	*Pressure sensor*	*Fuel treatment systems*	*Calibration techniques for temperature*
	SLO-2	*Brake thermal efficiency - calculation*	*Tutorial session*	*Data Acquisition, Data collection and control systems (EDACS)*	*Input parameters for engine testing*	*Gaussian distribution as a statistical tool*
S-9	SLO-1	*Tutorial session*	*Tutorial session*	*Post processing of data*	*Maintenance of engine test facility*	*Error analysis*
	SLO-2	*Tutorial session*	*Tutorial session*	*Tutorial session*	*Troubleshooting of engine instruments*	*Tutorial session*

Learning Resources	1. *A.J.Martyr, M.A. Plint, Engine Testing and Theory and Practice,3rd edition,-SAE International, 2007* 2. *Dietrich,C.F. "Uncertainty, Calibration and Probability", Adam Hilger, London.1973*	3. *Jyotindra S. Killedar, Dynamometer: Theory and application to engine testing, Xlibris Corporation LLC, 2012* 4. *A.J.Martyr, M.A. Plint, Engine testing: The design, building, modification and use of powertrain test facilities, 4th edition,- Elsevier, 2012*

Learning Assessment

	Bloom's Level of Thinking	Continuous Learning Assessment (50% weightage)								Final Examination (50% weightage)	
		CLA – 1 (10%)		CLA – 2 (15%)		CLA – 3 (15%)		CLA – 4 (10%)#			
		Theory	Practice	Theory	Practice	Theory	Practice	Theory	Practice	Theory	Practice
Level 1	Remember Understand	*40 %*	-	*30 %*	-	*30 %*	-	*30 %*	-	*30%*	-
Level 2	Apply Analyze	*40 %*	-	*40 %*	-	*40 %*	-	*40 %*	-	*40%*	-
Level 3	Evaluate Create	*20 %*	-	*30 %*	-	*30 %*	-	*30 %*	-	*30%*	-
	Total	100 %		100 %		100 %		100 %		100 %	

CLA – 4 can be from any combination of these: Assignments, Seminars, Tech Talks, Mini-Projects, Case-Studies, Self-Study, MOOCs, Certifications, Conf. Paper etc.,

Course Designers

Experts from Industry	Experts from Higher Technical Institutions	Internal Experts
1. Mr.ShanmugaSundaram, Renault Nissan, sankaran@rntbci.com	*1. Dr.V.Karthickeyan, Sri Krishna College of Engineering, karthickeyanv@skcet.ac.in*	*1. Dr. V. Edwin Geo, SRMIST*
2. Mr S Ashok, ETA, ashoks@eta-engg.com	*2. Dr.P.Nanthakumar, Amrita School of Engineering, p_nanthakumar@cb.amrita.edu*	*2. Dr. S. Thiyagarajan, SRMIST*

Course Code	18AUE333T	Course Name	FUEL TESTING AND STANDARDS	Course Category	E	Professional Elective	L	T	P	C
							3	0	0	3

Pre-requisite Courses	18AUC301J	Co-requisite Courses	NIL	Progressive Courses	
Course Offering Department	Automobile Engineering	Data Book / Codes/Standards	Nil		

Course Learning Rationale (CLR):	The purpose of learning this course is to:
CLR-1 :	*Learn the sources, composition and properties of automotive fuels*
CLR-2 :	*Gain knowledge on reference and commercial fuels and road map to quality improvement*
CLR-3 :	*Acquire knowledge on the significance of different fuel properties with respect to engine application*
CLR-4 :	*Understand and become familiar with BIS testing standards for gasoline and diesel*
CLR-5 :	*Conceive idea on the testing methods for LPG, CNG and biodiesels*

Course Learning Outcomes (CLO):	*At the end of this course, learners will be able to:*	Learning 1 Level of Thinking (Bloom)	2 Expected Proficiency (%)	3 Expected Attainment (%)	PLO 1 Engineering Knowledge	2 Problem Analysis	3 Design & Development	4 Analysis, Design, Research	5 Modern Tool Usage	6 Society & Culture	7 Environment & Sustainability	8 Ethics	9 Individual & Team Work	10 Communication	11 Project Mgt. & Finance	12 Life Long Learning	13 PSO - 1	14 PSO - 2	15 PSO – 3
CLO-1 :	*Understand the sources, composition and properties of automotive fuels and significance of testing fuels*	2	80	75	M	M	L	M	L	H	H	H	M	L	L	M	M	H	H
CLO-2 :	*Acquire knowledge on the specification of reference fuels for testing vehicles, road map and bottle necks in quality improvement*	2	80	75	M	M	L	M	L	H	H	H	M	L	L	M	M	H	H
CLO-3 :	*Learn the significant fuel properties and its implication in engine application*	2	80	75	M	M	L	M	L	H	H	H	M	L	L	M	M	H	H
CLO-4 :	*Gain knowledge on commercial gasoline and diesel fuel testing as specified in BIS*	1	80	75	M	M	L	M	L	H	H	H	M	L	L	M	M	H	H
CLO-5 :	*Gain knowledge on CNG, LPG and biodiesel testing*	1	80	75	M	M	L	M	L	H	H	H	M	L	L	M	M	H	H

		Automotive fuels	Reference and commercial fuels	Fuel Properties	Commercial Gasoline and Diesel fuel testing as specified in BIS	CNG, LPG and Biodiesels testing
Duration (hour)		9	9	9	9	9
S-1	SLO1	*Petroleum - sources and composition*	*Technical specification of fuels - significance*	*Properties of different fuels-Volatility*	*Method to determine Distillation temperatures*	*Method to determine methane and Ethane content*
	SLO2	*Gasoline, Diesel- sources and composition*	*Technical Specification of Reference fuel for testing vehicles -Gasoline*	*Properties of different fuels- Oxidation stability*	*Research Octane Number (RON), Motor Octane Number (MON)*	*C_3 and C_4 content*
S-2	SLO1	*CNG- sources and composition*	*Technical Specification of Reference fuel for testing vehicles - Diesel*	*Properties of different fuels- Octane rating*	*Calorific value, Oxidation Stability*	*Motor Octane number*
	SLO2	*LPG –sources and composition*	*Technical Specification of Reference fuel for testing vehicles -CNG*	*Properties of different fuels- Cetane rating*	*Sulphur content*	*Hydrogen sulphide content(LPG)*
S-3	SLO1	*Alcohols –sources and composition*	*Technical Specification of Reference fuel for testing vehicles - LPG*	*Properties of different fuels- Cetane rating*	*Reid Vapour Pressure*	*Odour, Copper strip corrosion*
	SLO2	*Alcohols –sources and composition*	*Technical Specification of Reference fuel for testing vehicles - Blended fuels*	*Calorific Value*	*Benzene, Aromatic*	*Wobbe Index(CNG)*
S-4	SLO1	*Biodiesels –sources and composition*	*Comparison of the specification of Commercial Gasoline and commercial diesel for different Bharat stage norms,*	*Density*	*Olefin and oxygen content*	*Oxidation Stability*
	SLO2	*Biodiesels –sources and composition*	*Comparison of the specification of Commercial Gasoline and commercial diesel for different Bharat stage norms,*	*Viscosity*	*Method to determine Ash content*	*Low temperature flow properties*
S-5	SLO1	*Reformulated fuels -Types and Use*	*Fuel quality improvement accomplished in India*	*Carbon Residue Etc.*	*Carbon residue*	*Kinematic viscosity*
	SLO2	*Reformulated fuels -Types and Use*	*Fuel quality improvement accomplished in India*	*Characteristic requirements of different fuels in IC engines- Availability*	*Cetane number and Index*	*Cetane number, Copper strip corrosion*
S-6	SLO1	*Additives-Types and Use*	*Fuel quality compliance issues*	*Characteristic requirements of different fuels in IC engines- Fuel economy*	*Distillation temperature*	*Ester content, Mono, Di and Tri-glycerides*

	SLO2	*Hydrogen as IC engine fuel*	*Fuel quality compliance issues*	*Characteristic requirements of different fuels in IC engines- Performance*	*Flash point, Kinematic viscosity*	*Density, Iodine Number*
S-7	SLO1	*Comparison of LPG. CNG, Hydrogen*	*Fuel testing*	*Gasoline quality effects on vehicle emissions,*	*Density, calorific value*	*Structure indices*
	SLO2	*Comparison of LPG. CNG, Hydrogen*	*Presumptive liability*	*Diesel quality effects on vehicle emissions*	*Test for sulphur and water content, sulphated ash*	*Liquid chromatography technique*
S-8	SLO1	*Importance of fuel testing*	*Fuel registration and tracking-A comparison in India, USA and Japan*	*Ultra low sulphur fuels*	*Cold filter plug point ,Cloud point*	*Gas chromatography*
	SLO2	*Need for fuel testing Standards*	*Fuel registration and tracking-A comparison in India, USA and Japan*	*Lubricity characteristics*	*Copper strip corrosion*	*Mass Spectrometry analysis*
S-9	SLO1	*An overview of the different standards available for fuel testing-EN, ASTM, ISO, JIS BIS*	*Inhibiting factors in fuel quality improvement in India*	*Flame characteristics- burning velocity, flame temperature and flammability limit*	*Oxidative stability*	*Photo spectrometry analysis*
	SLO2	*An overview of the different standards available for fuel testing-EN, ASTM, ISO, JIS BIS*	*Inhibiting factors in fuel quality improvement in India*	*Flame characteristics- burning velocity, flame temperature and flammability limit*	*Polycyclic Aromatic Hydrocarbon*	*Photo spectrometry analysis*

Learning Resources	1. *Automotive Fuels Reference Book-Keith Owen, Trevor Coley, Second Edition, Society of Automotive Engineers Inc.,1995* 2. *ALTERNATIVE FUELS Concepts, Technologies and Developments S.S. Thipse, Jaico Publishing House* 3. *Practical Handbook on Fuel Properties and Testing by SajidZaman, Lambert Academic Publishing, 2014.*	4. *Motor Vehicles Act ,2009,India* 5. *ARAI Tap Document –Document on Test Method, Testing Equipments and Related Procedures for Testing Type approval and Conformity of Production (COP),Ministry of Road Transport and High ways* 6. *Biodiesel Production and Properties by AmitSarin, RSC Publishing ,2012*

Learning Assessment

	Bloom's Level of Thinking	Continuous Learning Assessment (50% weightage)								Final Examination (50% weightage)	
		CLA – 1 (10%)		CLA – 2 (15%)		CLA – 3 (15%)		CLA – 4 (10%)#			
		Theory	Practice	Theory	Practice	Theory	Practice	Theory	Practice	Theory	Practice
Level 1	Remember Understand	40%	-	40%	-	40%	-	40%	-	40%	-
Level 2	Apply Analyze	40%	-	40%	-	40%	-	40%	-	40%	-
Level 3	Evaluate Create	20%	-	20%	-	20%	-	20%	-	20%	-
	Total	100 %		100 %		100 %		100 %		100%-	

CLA – 4 can be from any combination of these: Assignments, Seminars, Tech Talks, Mini-Projects, Case-Studies, Self-Study, MOOCs, Certifications, Conf. Paper etc.,

Course Designers

Experts from Industry	Experts from Higher Technical Institutions	Internal Experts
1. Dr.Gunabalan,Manager, R&D Turbo Energy ,Chennai,	*1.Dr.M.Arul Prakasajothi, Associate Professor, Mechanical Engineering, VelTech , Deemed to be university ,Email :arulprakasajothi@veltech.edu.in*	*1. Dr. S. Thiyagarajan. SRMIST*
2. Mr.Shantha Kumar, Lead Engineer, Royal Enfield	*2.Dr.S.Natrajan, Assistant Professor(Senior Grade),Mechanical Engineering, Sri Venkateswara College of Engineering, Email: natraj@svce.ac.in*	*2.Mr. C. Prabhu, SRMIST*

Course Code	18AUE334T	Course Name	AUTOMOTIVE EXHAUST SYSTEM DEVELOPMENT	Course Category	E	Professional Elective	L	T	P	C
							3	0	0	3

Pre-requisite Courses	18AUC301J	Co-requisite Courses	Nil	Progressive Courses	Nil
Course Offering Department	Automobile Engineering	Data Book / Codes/Standards	Nil		

Course Learning Rationale (CLR):	*The purpose of learning this course is to:*
CLR-1 :	*Gain knowledge about Various exhaust systems.*
CLR-2 :	*Understand various emission norms and control methods*
CLR-3 :	*Gain knowledge about noise pollutions and control methods*
CLR-4 :	*Enlighten the knowledge in Computational analysis.*

Course Learning Outcomes (CLO):	*At the end of this course, learners will be able to:*	Learning 1: Level of Thinking (Bloom)	Learning 2: Expected Proficiency (%)	Learning 3: Expected Attainment (%)	PLO 1: Engineering Knowledge	PLO 2: Problem Analysis	PLO 3: Design & Development	PLO 4: Analysis, Design, Research	PLO 5: Modern Tool Usage	PLO 6: Society & Culture	PLO 7: Environment & Sustainability	PLO 8: Ethics	PLO 9: Individual & Team Work	PLO 10: Communication	PLO 11: Project Mgt. & Finance	PLO 12: Life Long Learning	PLO 13: PSO - 1	PLO 14: PSO - 2	PLO 15: PSO – 3
CLO-1 :	*Understand the History and evolution of Automobile Exhaust System*	1	85	80	H	M	M	H	M	M	H	H	H	M	H	M	H	M	M
CLO-2 :	*Gain familiarity on the emission norms and emission reduction techniques*	1	85	80	H	H	M	M	L	L	M	H	H	M	M	M	H	M	M
CLO-3 :	*Get familiarized with the basics of acoustics, muffler types and characteristic design of mufflers*	2	80	75	H	H	H	H	M	M	M	M	M	H	H	H	H	M	M
CLO-4 :	*Understand the procedures and fundamentals involved in computational fluid dynamic, thermal and structural analysis of vehicle exhaust system*	2	80	75	H	H	H	H	M	M	H	M	H	M	H	H	H	L	H
CLO-5 :	*Understand the fundamentals involved in testing and validation of automotive exhaust system*	2	80	75	H	H	H	H	M	M	M	M	H	H	H	H	H	M	H

		History of Automobile Exhaust Systems	Hot End	Cold End	Computational Analysis (CFD and FEA)	Testing and Validation
Duration (hour)		09	09	09	09	09
S-1	SLO-1	*History and evolution of automobile exhaust system*	*Gasoline engine out pollutants*	*Basics of acoustics, fundamentals of sound, terminologies, noise cancellation.*	*CFD for vehicle exhaust system, governing equation of fluid flow and heat transfer*	*Vehicle noise measurement*
	SLO-2	*History and evolution of automobile exhaust system*	*Diesel engine out pollutants*	*Destructive & constructive interferences*	*CFD for vehicle exhaust system, governing equation of fluid flow and heat transfer*	*Vehicle noise measurement*
S-2	SLO-1	*Basics of exhaust system*	*Emission norms*	*Engine noise introduction, gasoline & diesel engine operation*	*Flow uniformity, pressure loss through exhaust system*	*Operational vibration analysis, experimental modal analysis*
	SLO-2	*Exhaust system from engine head face to tail pipe*	*Converter hot end components*	*Exhaust noise characteristics, vehicle pass by noise, exhaust noise measurement standards*	*Exhaust system, flow eccentricity, hego index, conjugate heat transfer analysis*	*Air leak test, thermal shock tests, thermal fatigue test*
S-3	SLO-1	*Layout of exhaust system*	*Three way catalytic converter, manifold – cone profiles.*	*Types of exhaust noises, pulsation noises, flow noises, booming noises*	*Introduction to finite element analysis*	*Back pressure measurement test*
	SLO-2	*Different components of exhaust system*	*Substrate*	*Shell radiation noises, passive noise reduction techniques*	*Present, past, future features*	*Hot end system*
S-4	SLO-1	*Introduction about air pollution and noise pollution*	*Types of substrate*	*Types of mufflers, reflective, absorptive, hybrid mufflers*	*Introduction to preprocessing 1d, 2d, 3d elements*	*Hot vibration test, cold vibration test*
	SLO-2	*Air pollution and noise control requirements in automobiles*	*Wash coat, mat, types of mats, shell*	*Muffler design constrains, muffler internal design, tri flow muffler, straight through muffler*	*Meshing and processing techniques*	*Flow noise measurement*
S-5	SLO-1	*Hot end components of exhaust system*	*Canning and types of canning*	*Helmholtz resonator, internal resonators*	*Statics of strength of materials*	*Shell deformation test, cold end: biaxial fatigue test*
	SLO-2	*Cold end components of exhaust system*	*Controlled canning, gbd (gab bulk density)*	*Baffle plates, perforations, shells, end plates, pipe diameters*	*Types of analysis*	*Uniaxial fatigue test, salt spray test, condensate water noise test*

S-6	SLO-1	*Manufacturing of exhaust components*	*Temperature sensor, oxygen sensor*	*Absorptive materials, development methodologies, muffler performance parameters, sound transmission loss, insertion loss*	*Modal analysis*	*Transmission loss measurement*
	SLO-2	*Exhaust manifold manufacturing process*	*Thermal management, insulators, heat shields (gasoline \ diesel).*	*Noise reduction, tail pipe noise level, back pressure, vehicle interior noise levels, advanced muffler technologies, cat con integrated muffler*	*Linear static analysis*	*Shell stiffness measurement , glass wool endurance test*
S-7	SLO-1	*Silencer manufacturing process*	*Advancement in substrates, Technology for gasoline engine*	*Variable flow muffler, twin mufflers, active noise cancellation, sporty sound mufflers*	*Introduction to non-linear analysis*	*Resonance frequency measurement*
	SLO-2	*Exhaust system integration*	*Gasoline particulate filter(gpf)*	*Sound engineering, off road, on road, non-road muffler applications examples, manufacturing types & process*	*Dynamic analysis*	*Shell radiation noise measurement*
S-8	SLO-1	*Service of exhaust system*	*Lean NOx trap (INT), Technology for diesel engine*	*Roll and spot welding, lock seaming.*	*Thermal analysis*	*Tail pipe noise measurement*
	SLO-2	*Service of exhaust system*	*Exhaust gas recirculation (EGR)*	*Double seaming, web forming.*	*RLDA & fatigue analysis*	*Tail pipe noise measurement*
S-9	SLO-1	*Replacing of exhaust system*	*Diesel oxidation catalyst (DOC), partial flow filter (PFF), diesel particulate filter (DPF)*	*Clinching, cold metal transfer, hydro forming.*	*Post processing techniques of different analysis*	*Water drainage ability test*
	SLO-2	*Replacing of exhaust system*	*Selective catalytic reduction (SCR), selective catalytic reduction filter (SCRF), global regulations and testing protocols*	*Piercing, stamping, muffler examples.*	*Process flows and targets, case study 1-2-3.*	*Water drainage ability test*

Learning Resources	1. *Philip ii smith and John Morrison "The scientific design of exhaust and intake systems engineering and performance"., 3rd edition, publisher : Bentley (Robert) inc., USA*	2. *Istvan I. Ver and leol.Beranek "Noise and vibration control engineering (principles and applications)"., 2 ndedition 2006, publisher : john wiley& sons inc.* 3. *M.Imunjal "Acoustics of ducts and mufflers with applications to exhaust and ventilation system design"., 2nd edition, publisher : wiley- inter science*

Learning Assessment											
	Bloom's Level of Thinking	Continuous Learning Assessment (50% weightage)								Final Examination (50% weightage)	
		CLA – 1 (10%)		CLA – 2 (15%)		CLA – 3 (15%)		CLA – 4 (10%)#			
		Theory	Practice	Theory	Practice	Theory	Practice	Theory	Practice	Theory	Practice
Level 1	Remember Understand	*40 %*	-	*30 %*	-	*30 %*	-	*30 %*	-	*30%*	-
Level 2	Apply Analyze	*40 %*	-	*40 %*	-	*40 %*	-	*40 %*	-	*40%*	-
Level 3	Evaluate Create	*20 %*	-	*30 %*	-	*30 %*	-	*30 %*	-	*30%*	-
	Total	100 %		100 %		100 %		100 %		100 %	

CLA – 4 can be from any combination of these: Assignments, Seminars, Tech Talks, Mini-Projects, Case-Studies, Self-Study, MOOCs, Certifications, Conf. Paper etc.,

Course Designers		
Experts from Industry	Experts from Higher Technical Institutions	Internal Experts
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2. Mr. Ram Prasanth A, Caterpillar India Pvt Ltd, anjaneyulu_ram_p@cat.com	*2. Dr.Parthasarathy M,Vel Tech RangarajanDr.Sagunthala R&D Institute of Science and Technology, nparthasararhy@veltech.edu.in.*	*2. Mr.D. Boopathi, SRMIST*

Course Code	18AUE335T	Course Name	ENGINE AUXILARY SYSTEMS	Course Category	E	Professional Elective	L	T	P	C
							3	0	0	3

Pre-requisite Courses	18AUC301J	Co-requisite Courses	Nil	Progressive Courses	Nil
Course Offering Department	Automobile Engineering	Data Book / Codes/Standards	Nil		

Course Learning Rationale (CLR):	*The purpose of learning this course is to:*
CLR-1 :	*Impart knowledge about Super charging & Turbocharging their mapping procedure and thermodynamic issues related to their operation.*
CLR-2 :	*Provide a fundamental knowledge on Engine Thermal Management*

Course Learning Outcomes (CLO):	*At the end of this course, learners will be able to:*	Learning 1: Level of Thinking (Bloom)	2: Expected Proficiency (%)	3: Expected Attainment (%)	PLO 1: Engineering Knowledge	2: Problem Analysis	3: Design & Development	4: Analysis, Design, Research	5: Modern Tool Usage	6: Society & Culture	7: Environment & Sustainability	8: Ethics	9: Individual & Team Work	10: Communication	11: Project Mgt. & Finance	12: Life Long Learning	13: PSO - 1	14: PSO - 2	15: PSO – 3
CLO-1 :	*Acquire knowledge about Supercharging and compressor mapping.*	2	90	90	H	H	M	H	L	L	M	L	H	M	M	M	H	M	H
CLO-2 :	*Gain knowledge about Flow maps of supercharging systems.*	2	90	90	H	M	M	M	M	L	L	M	H	M	M	M	H	M	H
CLO-3 :	*Analyze Thermodynamic issues with Turbocharging.*	2	90	90	H	M	H	H	M	H	L	L	H	M	H	M	H	M	H
CLO-4 :	*Understand the Modern design features of exhaust turbocharger features.*	2	90	90	M	H	M	M	H	M	H	H	M	L	H	M	H	M	H
CLO-5 :	*Acquire knowledge about Engine thermal management.*	2	90	90	H	H	M	H	L	H	M	L	L	H	M	M	H	M	H

		Introduction	Super charging and turbo charging	Performance characteristics	Feature characteristics	Heat management
Duration (hour)		9	9	9	9	9
S-1	SLO1	*Introduction to super charging*	*Introduction to flow maps of supercharging systems*	*Introduction to thermodynamic issues with turbocharging*	*Introduction to particular features of exhaust turbocharging*	*Charge boosting, exhaust pre-release, turbo-cooling*
	SLO2	*Introduction to compressor mapping*	*Two stroke engines*	*Cylinder release temperature*	*Exhaust manifold arrangements for various firing sequences of engines.*	*miller, two stage, complex, hyper-bar, rotor designs*
S-2	SLO1	*Definitions, survey of supercharging methods,*	*Four stroke engines*	*Mean exhaust temperature*	*Exhaust manifold arrangements for various firing sequences of engines.*	*Types of impellers, bearing arrangements,*
	SLO2	*Petrol engines*	*Interaction between turbocharger and engine.*	*Theoretical aspects of complete extraction of work*	*Constant pressure vs pulse turbocharging*	*types and lubrication on bearings*
S-3	SLO1	*Diesel engines*	*Mechanical supercharging,*	*Expanding from release pressure to ambient pressure*	*Constant pressure vs pulse turbocharging.*	*Examples of supercharged engines of road vehicles (cases),*
	SLO2	*Exhaust turbo charging.*	*Mechanical supercharging,*	*Complete conversion into kinetic energy at ambient pressure.*	*Modified forms of pulse turbocharging.*	*introduction to engine cooling systems, engine coolants,*
S-4	SLO1	*Fundamentals of compressor matching,*	*Exhaust turbo charging*	*Complete conversion into kinetic energy at ambient pressure.*	*Transient response.*	*Heat exchangers, in-vehicle installation, performance curves.*
	SLO2	*compressor power*	*Exhaust turbo charging -operational differences.*	*Compressor power in terms of mean piston pressure*	*Transient response*	*Pressurized engine cooling systems: filling, de- aeration & drawdown accessories.*
S-5	SLO1	*Air consumption*	*Equivalent nozzle area of turbine*	*Compressor power in terms of mean piston pressure*	*Torque characteristics of engines with exhaust turbochargers*	*On-highway cooling system test code, engine cooling systems field test (air-to-boil)*
	SLO2	*Types of compressors*	*Equivalent nozzle area of turbine*	*Numerical -compressor power in terms of mean piston pressure*	*Torque characteristics of engines with exhaust turbochargers.*	*Heat exchanger thermal & pressure cycle durability. Cooling fans*
S-6	SLO1	*Compressor characteristics*	*Pulse turbocharging*	*Numerical problem -compressor power in terms of mean piston pressure*	*Measures to improve acceleration*	*Fan laws, fan characteristics, and system resistance curve*

	SLO2	*Relationship between air consumption and power*	*Pulse turbocharging*	*Difference in fuel consumption between mechanical and exhaust superchargers.*	*Measures to improve acceleration*	*Cooling flow measurement techniques.*
S-7	SLO1	*Numerical problems-calculate air consumption and power*	*Diagram for determination of operating condition of a single stage turbocharger system.*	*Difference in fuel consumption between mechanical and exhaust superchargers.*	*Measures to improve torque characteristics of exhaust turbocharged engines.*	*Cooling system inspection, trouble diagnosis & service.*
	SLO2	*Numerical problems- calculate air consumption and power*	*Diagram for determination of operating condition of a single stage turbocharger system.*	*Effect of cooling the charge air.*	*Measures to improve torque characteristics of exhaust turbocharged engines.*	*Radiator field failures. Introduction to EGR (exhaust gas recirculation) coolers*
S-8	SLO1	*Volumetric efficiency of supercharged four stroke engines.*	*Examples of computed results*	*Effect of cooling the charge air.*	*Altitude de-rating*	*its significance in reduction of vehicle emissions.*
	SLO2	*Numerical problems-calculate volumetric efficiency*	*Examples of computed results*	*Exhaust turbocharger as a means to increase efficiency*	*Altitude de-rating*	*Cycle test-I*
S-9	SLO1	*Computations of gas exchange process*	*Examples of computed results*	*Numerical problem-Exhaust turbocharger as a means to increase efficiency.*	*Effect of supercharging on exhaust emissions of SI engines*	*Cycle test-II*
	SLO2	*Computations of gas exchange process*	*Tutorials onsupercharging systems*	*Numerical problem-Exhaust turbocharger as a means to increase efficiency.*	*Effect of supercharging on exhaust emissions of CI engines*	*Surprise test*

Learning Resources	1. *Zinner, K, "Auxillary Engine Systems by Supercharging of Internal Combustion Engines"., Springer, 1978.* 2. *N. Watson and M.S. Janota, "Turbocharging the Internal Combustion Engines", Macmillan Press, London 1982* 3. *BOSCH, "Automotive Handbook", 8 th Edition, Bentley Robert Incorporated, 2011* 4. *Lilly, L.C.R, "Diesel Engine Reference Book", Butterworths, London, 1984*	5. *Benson, R.S, Whitehouse N.D, "Internal Combustion Engines", Vol 1 and 2, Pergamon Press Ltd. Oxford UK.1980* 6. *Tom Birch, "Automotive Heating & Air Conditioning", 6th edition, Prentice Hall PTR, 2011* 7. *Hermann Hiereth, Peter Prenninger, "Charging the Internal Combustion Engine", Springer, 2010.*

Learning Assessment

	Bloom's Level of Thinking	Continuous Learning Assessment (50% weightage)								Final Examination (50% weightage)	
		CLA – 1 (10%)		CLA – 2 (15%)		CLA – 3 (15%)		CLA – 4 (10%)#			
		Theory	Practice	Theory	Practice	Theory	Practice	Theory	Practice	Theory	Practice
Level 1	Remember Understand	*20%*	*20%*	*15%*	*15%*	*15%*	*15%*	*15%*	*15%*	*15%*	*15%*
Level 2	Apply Analyze	*20%*	*20%*	*20%*	*20%*	*20%*	*20%*	*20%*	*20%*	*20%*	*20%*
Level 3	Evaluate Create	*10%*	*10%*	*15%*	*15%*	*15%*	*15%*	*15%*	*15%*	*15%*	*15%*
	Total	100 %		100 %		100 %		100 %		100%	

CLA – 4 can be from any combination of these: Assignments, Seminars, Tech Talks, Mini-Projects, Case-Studies, Self-Study, MOOCs, Certifications, Conf. Paper etc.,

Course Designers		
Experts from Industry	Experts from Higher Technical Institutions	Internal Experts
1. Mr.Jayaraman.R,BLG Logistics,jayaraman.r@blgparekh.com	*1. Dr.S. Ramkumar, Vel Tech, drsramkumar@veltech.edu*	*1. Dr. V. Edwin Geo, SRMIST*
2. Mr. ShanmugaSundaram, Renault Nissan, sankaran@rntbci.com	*2. Mr.R. Sakthivel, Sri Venkateswara College of Engineering, rsakthivel@svce.ac.in*	*2. Mr. T.Prakash, SRMIST*

Course Code	18AUE431T	Course Name	DESIGN OF AUTOMOTIVE THERMAL SYSTEMS	Course Category	E	Professional Elective	L	T	P	C
							3	0	0	3

Pre-requisite Courses	18AUC203T	Co-requisite Courses	Nil	Progressive Courses	Nil
Course Offering Department	Automobile Engineering	Data Book / Codes/Standards	Psychometric chart, Heat and Mass transfer data book, Refrigerant table		

Course Learning Rationale (CLR):	*The purpose of learning this course is to:*
CLR-1 :	*Understand various thermal systems and its functions*
CLR-2 :	*Solve cooling load calculations and to select different types of fans.*
CLR-3 :	*Understand various types of compressors*
CLR-4 :	*Familiarize with the applications of different fluid systems.*
CLR-5 :	*Understand the concepts to design heat exchangers*

Course Learning Outcomes (CLO):	*At the end of this course, learners will be able to:*	Learning 1 Level of Thinking (Bloom)	2 Expected Proficiency (%)	3 Expected Attainment (%)	PLO 1 Engineering Knowledge	2 Problem Analysis	3 Design & Development	4 Analysis, Design, Research	5 Modern Tool Usage	6 Society & Culture	7 Environment & Sustainability	8 Ethics	9 Individual & Team Work	10 Communication	11 Project Mgt. & Finance	12 Life Long Learning	13 PSO - 1	14 PSO - 2	15 PSO – 3
CLO-1 :	*Understand the methodology of a thermal system.*	1	90	85	H	H	M	M	M	L	L	L	L	L	L	M	H	H	H
CLO-2 :	*Analyze a refrigeration problem to carryout necessary calculation*	1	90	85	H	M	M	M	M	L	M	L	M	L	L	H	M	M	M
CLO-3 :	*Identify different air compressor systems and its applications and able to calculate its efficiencies*	1	90	85	H	H	H	H	M	L	M	L	L	L	L	H	M	M	M
CLO-4 :	*List the basic components and analyze the working of fluid transport system*	2	90	85	H	M	H	H	H	L	L	L	L	L	L	M	M	H	M
CLO-5 :	*Able to identify parts of heat exchanger systems and design heat exchangers based on various criteria's*	2	90	85	H	M	H	H	M	L	M	L	L	L	L	H	M	M	H
CLO-6 :	*Apply the design concepts of automotive thermal systems*	2	90	85	H	H	H	H	H	L	L	L	L	L	L	H	H	H	H

Duration (hour)		6	10	10	10	9
S-1	SLO-1	*Introduction to Thermal Systems*	*Introduction to Automotive Air Conditioning*	*Introduction to Air Compressors*	*Introduction to Fluid Transport*	*Introduction to Heat Exchangers*
	SLO-2	*Introduction to Thermal Systems*	*Introduction to Automotive Air Conditioning*	*Introduction to Air Compressors*	*Introduction to Fluid Transport*	*Introduction to Heat Exchangers*
S-2	SLO-1	*System, boundary and surroundings, heat transfer, fluid flow*	*Psychrometric properties*	*Types and classification of compressors*	*Incompressibility and expansion of fluids*	*Functions of radiator, compressor*
	SLO-2	*System, boundary and surroundings, heat transfer, fluid flow*	*Psychrometric properties*	*Types and classification of compressors*	*Incompressibility and expansion of fluids*	*Functions of radiator, compressor*
S-3	SLO-1	*Heat engines – Functions, components, working*	*Use of psychrometric chart*	*Working principle*	*Transmission of forces through fluids, multiplication of forces Fluid power*	*Functions of condenser, evaporator, expansion valve*
	SLO-2	*Heat engines – Functions, components, working*	*Use of psychrometric chart*	*Working principle*	*Transmission of forces through fluids, multiplication of forces Fluid power*	*Functions of condenser, evaporator, expansion valve*
S-4	SLO-1	*Cooling , properties of coolant*	*Refrigerants – Types of refrigerants*	*Reciprocating compressors*	*Applications of fluid power – power brakes, power steering, shock absorber*	*Classification of heat exchangers – According to transfer process*
	SLO-2	*Cooling , properties of coolant*	*Refrigerants – Types of refrigerants*	*Reciprocating compressors*	*Applications of fluid power – power brakes, power steering, shock absorber*	*Classification of heat exchangers – According to transfer process*
S-5	SLO-1	*Coolant recirculation systems*	*Properties and Selection of refrigerants*	*Single and multistage compressors*	*Components of hydraulic and pneumatic systems*	*Number of fluids, surface compactness*
	SLO-2	*Coolant recirculation systems*	*Properties and Selection of refrigerants*	*Single and multistage compressors*	*Components of hydraulic and pneumatic systems*	*Number of fluids, surface compactness*
S-6	SLO-1	*Coolant lubrication systems*	*Factors affecting the air flow*	*Compressors - compression with and without clearance*	*Reservoir, pumps, strainers, filters, valve types, actuators, motors*	*Construction features, flow arrangements, heat transfer mechanisms.*
	SLO-2	*Coolant lubrication systems*	*Factors affecting the air flow*	*Compressors - compression with and without clearance*	*Reservoir, pumps, strainers, filters, valve types, actuators, motors*	*Construction features, flow arrangements, heat transfer mechanisms.*
S-7	SLO-1		*Types of fans*	*Calculations - volumetric, isothermal and isentropic efficiency*	*Accumulators, oil coolers, cooling fan, tubing, piping, hose*	*Selection and design of heat exchangers based on – Types, heat transfer rate*

	SLO-2		*Types of fans*	*Calculations - volumetric, isothermal and isentropic efficiency*	*Accumulators, oil coolers, cooling fan, tubing, piping, hose*	*Selection and design of heat exchangers based on – Types, heat transfer rate*
S-8	SLO-1		*Axial and Centrifugal fans*	*Rotary compressors*	*Fluid transport and power systems*	*Selection and design of heat exchangers based on – cost, pumping power*
	SLO-2		*Axial and Centrifugal fans*	*Rotary compressors*	*Fluid transport and power systems*	*Selection and design of heat exchangers based on – cost, pumping power*
S-9	SLO-1		*Load calculations*	*Comparison between reciprocating and rotary compressors*	*Applications of pneumatic and hydraulic systems*	*Selection and design of heat exchangers based on – size and weight materials*
	SLO-2		*Load calculations*	*Comparison between reciprocating and rotary compressors*	*Applications of pneumatic and hydraulic systems*	*Selection and design of heat exchangers based on – size and weight materials*
S-10	SLO-1		*Winter air conditioning*	*Comparison between centrifugal and axial compressors*	*Advantage and disadvantages of hydraulic systems*	
	SLO-2		*Winter air conditioning*	*Comparison between centrifugal and axial compressors*	*Advantage and disadvantages of hydraulic systems*	

Learning Resources	1. *Rajput R.K, "Thermal Engineering", Laxmi Publications, 8th Edition, New Delhi, 2010* 2. *R. C. Sachdeva, "Fundamentals of Engineering Heat and Mass Transfer", New Age Science Ltd., NewDelhi, 2009* 3. *C.P Arora "Refrigeration and Air conditioning", 3rd edition., McGraw Hill Education (india) privateLimited.2014*	4. *Holman, J P, "Heat transfer", McGraw – Hill, New york, 1968* 5. *Yunus A Cengel, Afshin J Ghajar, "Heat and Mass Transfer"., Tat McGraw Hill Education Private Limited,New Delhi,2013* 6. *Andrew parr, "Hydraulics and Pneumatics"., second edition, Butterworth Heinemann*

Learning Assessment

	Bloom's Level of Thinking	Continuous Learning Assessment (50% weightage)								Final Examination (50% weightage)	
		CLA – 1 (10%)		CLA – 2 (15%)		CLA – 3 (15%)		CLA – 4 (10%)#			
		Theory	Practice	Theory	Practice	Theory	Practice	Theory	Practice	Theory	Practice
Level 1	Remember Understand	*40 %*	-	*30 %*	-	*30 %*	-	*30 %*	-	*30%*	-
Level 2	Apply Analyze	*40 %*	-	*40 %*	-	*40 %*	-	*40 %*	-	*40%*	-
Level 3	Evaluate Create	*20 %*	-	*30 %*	-	*30 %*	-	*30 %*	-	*30%*	-
	Total	100 %		100 %		100 %		100 %		100 %	

CLA – 4 can be from any combination of these: Assignments, Seminars, Tech Talks, Mini-Projects, Case-Studies, Self-Study, MOOCs, Certifications, Conf. Paper etc.,

Course Designers

Experts from Industry	Experts from Higher Technical Institutions	Internal Experts
1. Mr.ShanmugaSundaram, Renault Nissan, sankaran@rntbci.com	*1. Dr.S. Premnath, Sri Venkateswara College if Engineering, prem@svce.ac.in*	*1. Dr. S. Thiyagarajan, SRMIST*
2. Mr.Jayaraman.R,BLG Logistics,jayaraman.r@blgparekh.com	*2. Dr.V. Karthickeyan, Sri Krishna College of Engineering and Technology, karthickeyanv@skcet.ac.in*	*2. Dr. A. Prabu, SRMIST*

Course Code	18AUE432T	Course Name	SIMULATION OF IC ENGINES	Course Category	E	Professional Elective	L	T	P	C
							3	0	0	3

Pre-requisite Courses	18AUC301J	Co-requisite Courses	Nil	Progressive Courses	Nil
Course Offering Department	Automobile Engineering	Data Book / Codes/Standards	Nil		

Course Learning Rationale (CLR):	*The purpose of learning this course is to:*
CLR-1 :	*Gain Knowledge about various engine design parameters.*
CLR-2 :	*Understand engine numerical modeling.*
CLR-3 :	*Enlighten the knowledge about simulation of various performance parameters for different type engine.*

Course Learning Outcomes (CLO):	*At the end of this course, learners will be able to:*	Learning 1 Level of Thinking (Bloom)	2 Expected Proficiency (%)	3 Expected Attainment (%)	Program Learning Outcomes (PLO) 1 Engineering Knowledge	2 Problem Analysis	3 Design & Development	4 Analysis, Design, Research	5 Modern Tool Usage	6 Society & Culture	7 Environment & Sustainability	8 Ethics	9 Individual & Team Work	10 Communication	11 Project Mgt. & Finance	12 Life Long Learning	13 PSO - 1	14 PSO - 2	15 PSO – 3
CLO-1 :	*Understand the Various Combustion Parameters.*	*1*	*90*	*85*	*H*	*H*	*M*	*H*	*H*	*L*	*M*	*L*	*L*	*L*	*M*	*L*	*L*	*M*	*M*
CLO-2 :	*Analyze the various idle cycles*	*1*	*90*	*85*	*H*	*H*	*M*	*M*	*H*	*L*	*M*	*L*	*L*	*L*	*L*	*L*	*L*	*M*	*M*
CLO-3 :	*Understand Various Combustion Simulations*	*2*	*90*	*85*	*H*	*H*	*M*	*M*	*H*	*L*	*M*	*L*	*L*	*L*	*M*	*L*	*L*	*M*	*M*
CLO-4 :	*Gain knowledge about two Stroke engine simulations*	*2*	*90*	*85*	*H*	*M*	*L*	*M*	*H*	*L*	*L*	*L*	*L*	*L*	*M*	*L*	*L*	*M*	*M*
CLO-5 :	*Understand Diesel engine numerical modeling*	*2*	*90*	*85*	*H*	*H*	*L*	*M*	*H*	*L*	*L*	*L*	*L*	*L*	*M*	*M*	*L*	*M*	*M*

		Introduction to Combustion	SI Engine Simulation With Air as Working Medium	Progressive Combustion	Simulation of 2-Stroke SI Engine	Diesel Engine Simulation
		9	9	9	9	9
S-1	SLO-1	*Introduction to combustion*	*Ideal Cycles in SI Engine*	*SI Engines Simulation With Progressive Combustion*	*Simulate The Performance Of 2 Stroke SI Engine*	*Multi Zone Model For Diesel Combustion*
	SLO-2	*Heat of reaction*	*Ideal Cycles in SI Engine*	*SI Engines Simulation With Progressive Combustion*	*Simulate The Performance Of 2 Stroke SI Engine*	*Multi Zone Model For Diesel Combustion*
S-2	SLO-1	*Measurement of URP*	*Actual working cycle in SI Engine*	*SI Engines Simulation With Gas Exchange*	*Simulate The Performance Of 2 Stroke SI Engine*	*Multi Zone Model For Diesel Combustion*
	SLO-2	*Measurement of URP*	*Actual working cycle in SI Engine*	*SI Engines Simulation With Gas Exchange*	*Simulate The Performance Of 2 Stroke SI Engine*	*Multi Zone Model For Diesel Combustion*
S-3	SLO-1	*Measurement of HRP*	*Deviation Between Actual And Ideal Cycle – Problems*	*Heat Transfer Process*	*Simulate The Performance Of 2 Stroke SI Engine*	*Multi Zone Model For Diesel Combustion*
	SLO-2	*Measurement of HRP*	*Deviation Between Actual And Ideal Cycle – Problems*	*Heat Transfer Process*	*Simulate The Performance Of 2 Stroke SI Engine*	*Multi Zone Model For Diesel Combustion*
S-4	SLO-1	*Adiabatic flame temperature*	*SI Engine Simulation With Adiabatic Combustion*	*Friction Calculation*	*Simulate The Performance Of 2 Stroke SI Engine*	*Different Heat Transfer Models For Diesel Engine Simulation*
	SLO-2	*Adiabatic flame temperature*	*SI Engine Simulation With Adiabatic Combustion*	*Friction Calculation*	*Simulate The Performance Of 2 Stroke SI Engine*	*Different Heat Transfer Models For Diesel Engine Simulation*
S-5	SLO-1	*Complete combustion in C/H/O/N Systems*	*SI Engine Temperature Drop Due To Fuel Vaporization*	*Compression Of Simulated Values*	*Simulate The Performance Of 2 Stroke SI Engine*	*Different Heat Transfer Models For Diesel Engine Simulation*
	SLO-2	*Complete combustion in C/H/O/N Systems*	*SI Engine Temperature Drop Due To Fuel Vaporization*	*Compression Of Simulated Values*	*Simulate The Performance Of 2 Stroke SI Engine*	*Different Heat Transfer Models For Diesel Engine Simulation*
S-6	SLO-1	*Constant volume adiabatic combustion*	*Full Throttle Operation - Efficiency Calculation*	*Validation Of The Computer Code*	*Simulation Of Unbalanced Forces On Two Stroke Engine*	*Diesel Engine Equilibrium Calculations*
	SLO-2	*Constant volume adiabatic combustion*	*Full Throttle Operation - Efficiency Calculation*	*Validation Of The Computer Code*	*Simulation Of Unbalanced Forces On Two Stroke Engine*	*Diesel Engine Equilibrium Calculations*

S-7	SLO-1	*Constant pressure adiabatic combustion*	*SI Engine Part-Throttle Operation*	*Engine Performance Simulation*	*Simulation Of Unbalanced Forces On Two Stroke Engine*	*Diesel Engine Equilibrium Calculations*
	SLO-2	*Constant pressure adiabatic combustion*	*SI Engine Part-Throttle Operation*	*Engine Performance Simulation*	*Simulation Of Unbalanced Forces On Two Stroke Engine*	*Diesel Engine Equilibrium Calculations*
S-8	SLO-1	*Calculation of adiabatic flame temperature*	*SI Engine Part-Throttle Efficiency Calculation*	*Pressure Crank Angle Diagram*	*Simulation Of Unbalanced Forces On Two Stroke Engine*	*Simulation Of Diesel Engine Performance*
	SLO-2	*Calculation of adiabatic flame temperature*	*SI Engine Part-Throttle Efficiency Calculation*	*Pressure Crank Angle Diagram*	*Simulation Of Unbalanced Forces On Two Stroke Engine*	*Simulation Of Diesel Engine Performance*
S-9	SLO-1	*Isentropic changes of state*	*Super Charged Operation*	*Other Engine Performance*	*Simulation Of Unbalanced Forces On Two Stroke Engine*	*Diesel Engine Simulation For Pollution Estimation*
	SLO-2	*Isentropic changes of state*	*Super Charged Operation*	*Other Engine Performance*	*Simulation Of Unbalanced Forces On Two Stroke Engine*	*Diesel Engine Simulation For Pollution Estimation*

Learning Resources	1. *Ganesan. V. "Computer Simulation of spark ignition engine process"., Universities Press (I) Ltd, Hyderabad, 1996.* 2. *Ganesan.V, "Computer Simulation of Compression Ignition Engines"., Orient Longman, 2000*	3. *Ramoss. A. L, "Modelling of Internal Combustion Engines Processes"., McGraw Hill Publishing Co., 1992* 4. *Ashley Campbel, "Thermodynamic Analysis of Combustion Engines"., John Wiley & Sons, New York, 1986*

Learning Assessment											
	Bloom's Level of Thinking	Continuous Learning Assessment (50% weightage)								Final Examination (50% weightage)	
		CLA – 1 (10%)		CLA – 2 (15%)		CLA – 3 (15%)		CLA – 4 (10%)#			
		Theory	Practice	Theory	Practice	Theory	Practice	Theory	Practice	Theory	Practice
Level 1	Remember Understand	*40 %*	-	*30 %*	-	*30 %*	-	*30 %*	-	*30%*	-
Level 2	Apply Analyze	*40 %*	-	*40 %*	-	*40 %*	-	*40 %*	-	*40%*	-
Level 3	Evaluate Create	*20 %*	-	*30 %*	-	*30 %*	-	*30 %*	-	*30%*	-
	Total	100 %		100 %		100 %		100 %		100 %	

CLA – 4 can be from any combination of these: Assignments, Seminars, Tech Talks, Mini-Projects, Case-Studies, Self-Study, MOOCs, Certifications, Conf. Paper etc.,

Course Designers		
Experts from Industry	Experts from Higher Technical Institutions	Internal Experts
1. Mr.KrishnamoorthyNallappan, Renault Nissan Technology and Business Centre, krishnamoorthy.nallappan @rntbci.com	*1. Dr.J.Venkatesan, S Sri Venkateswara College of Engineering, jvenkat@svce.ac.in*	*1. Dr. V. Edwin Geo, SRMIST*
2. Mr.P.MohamedAzarudeen,Renault Nissan Technology and Business Centre, mohamedazarudeen.pakkirmohideen@rntbci.com	*2. Dr.S.RamKumar, Vel Tech RangarajanDr.Sagunthala R&D Institute of Science and Technology , drsramkumar@veltech.edu.in*	*2. Mr. D. Boopathi, SRMIST*

Course Code	18AUE433T	Course Name	AUTOMOTIVE EMISSION FORMATION AND CONTROLS	Course Category	E	Professional Elective	L	T	P	C
							3	0	0	3

Pre-requisite Courses	18AUC301J	Co-requisite Courses	Nil	Progressive Courses	Nil
Course Offering Department	Automobile Engineering	Data Book / Codes/Standards	Nil		

Course Learning Rationale (CLR):	*The purpose of learning this course is to:*
CLR-1 :	*Learn about SI engine emission formation*
CLR-2 :	*Provide an insight CI engine emission formation*
CLR-3 :	*Familiarize with the basics of noise pollution*
CLR-4 :	*Create insight on emission measuring instruments*
CLR-5 :	*Learn about noise and vibration measurement*

Course Learning Outcomes (CLO):	*At the end of this course, learners will be able to:*	Learning 1: Level of Thinking (Bloom)	Learning 2: Expected Proficiency (%)	Learning 3: Expected Attainment (%)	PLO 1: Engineering Knowledge	PLO 2: Problem Analysis	PLO 3: Design & Development	PLO 4: Analysis, Design, Research	PLO 5: Modern Tool Usage	PLO 6: Society & Culture	PLO 7: Environment & Sustainability	PLO 8: Ethics	PLO 9: Individual & Team Work	PLO 10: Communication	PLO 11: Project Mgt. & Finance	PLO 12: Life Long Learning	PLO 13: PSO - 1	PLO 14: PSO - 2	PLO 15: PSO – 3
CLO-1 :	*Comprehend the various emissions from SI engine and its control techniques*	1	80	75	M	M	M	H	H	L	L	M	M	H	H	M	H	H	M
CLO-2 :	*Match the emission reduction techniques from CI engine*	1	85	80	H	M	M	H	M	M	H	M	L	M	H	M	H	H	M
CLO-3 :	*Evaluate the noise pollution formation*	2	80	75	M	H	H	M	H	M	L	H	M	M	M	L	H	M	M
CLO-4 :	*Apply the knowledge on measuring emissions through instruments*	2	80	75	H	H	M	M	H	H	M	M	L	H	M	H	H	M	L
CLO-5 :	*Cognize the noise and vibration measurement*	1	85	80	M	H	H	M	H	M	L	H	M	H	M	L	H	M	L

		SI engine emission	CI engine emission	Noise Pollution	Emission Measurement	Noise measurement
Duration (hour)		9	9	9	9	9
S-1	SLO-1	*Emission formation in SI engines (CO, HC)*	*Emission formation in CI engines (HC, CO)*	*Basics of acoustics–fundamentals of sound – terminologies–*	*Principle of operation of emission measuring instruments used in SI and CI engines.*	*Vehicle noise measurement*
	SLO-2	*Emission formation in SI engines (CO, HC)*	*Emission formation in CI engines (HC, CO)*	*Noise cancellation– destructive & constructive interferences*	*Principle of operation of emission measuring instruments used in SI and CI engines.*	*Operational vibration analysis*
S-2	SLO-1	*Emission formation in SI engines (NOx).*	*Emission formation in CI engines (NOx, aldehydes)*	*Engine noise introduction–gasoline & diesel engine operation.*	*Measurement of CO2 and CO by NDIR*	*Experimental modal analysis – air leak test*
	SLO-2	*Emission formation in SI engines (NOx).*	*Emission formation in CI engines (NOx, aldehydes)*	*Exhaust noise characteristics –vehicle pass by noise – exhaust noise measurement standards*	*Measurement of CO2 and CO by NDIR*	*Experimental modal analysis – air leak test*
S-3	SLO-1	*Effect of design variables on emission formation in SI engines*	*Emission formation in CI engines (smoke and particulates)*	*Types of exhaust noises– pulsation noises– flow noises–booming noises*	*Hydrocarbon emission by FID*	*Thermal shock tests – thermal fatigue test*
	SLO-2	*Effect of design variables on emission formation in SI engines*	*Emission formation in CI engines (smoke and particulates)*	*Shell radiation noises–passive noise reduction techniques*	*Hydrocarbon emission by FID*	*Thermal shock tests – thermal fatigue test*
S-4	SLO-1	*Effect of operating variables on emission formation in SI engines*	*Effect of design variables on emission formation in CI engines*	*Types of mufflers –reflective–absorptive – hybrid mufflers –muffler design constrains*	*Chemiluminescentanalyser for NOx*	*Back pressure measurement test–hot end system*
	SLO-2	*Effect of operating variables on emission formation in SI engines*	*Effect of design variables on emission formation in CI engines*	*Muffler internal design–tri flow muffler –straight though muffler*	*Chemiluminescentanalyser for NOx*	*Back pressure measurement test–hot end system*
S-5	SLO-1	*Control techniques -Thermal reactor,*	*Effect of operating variables on emission formation in CI engines*	*Helmholtz resonator – internal resonators – baffle plates– perforations*	*Gas Chromatograph*	*Hot vibration test – cold vibration test*
	SLO-2	*Control techniques -Thermal reactor,*	*Effect of operating variables on emission formation in CI engines*	*shells –end plates–pipe diameters*	*Gas Chromatograph*	*flow noise measurement*
S-6	SLO-1	*Control techniques - exhaust gas recirculation*	*Control techniques, exhaust gas recirculation*	*Absorptive materials –development methodologies*	*Spot sampling*	*Salt spray test – condensate water noise test*
	SLO-2	*Control techniques - exhaust gas recirculation*	*Control techniques, exhaust gas recirculation*	*muffler performance parameters– sound transmission loss –insertion loss*	*Spot sampling*	*Salt spray test – condensate water noise test*

S-7	SLO-1	*Three way catalytic convertor*	*NOx selective catalytic reduction*	*Noise reduction–tail pipe noise level –back pressure –vehicle interior noise levels*	*Continuous indication type smoke meters (Bosch, AVL and Hartridge smoke meters)*	*Transmission loss measurement – shell stiffness measurement – glass wool endurance test*
	SLO-2	*Three way catalytic convertor*	*NOx selective catalytic reduction*	*Advanced muffler technologies–cat con integrated muffler*	*Continuous indication type smoke meters (Bosch, AVL and Hartridge smoke meters)*	*Transmission loss measurement – shell stiffness measurement – glass wool endurance test*
S-8	SLO-1	*Charcoal canister control for evaporative emission*	*Diesel oxidation catalyst catalytic convertor*	*Variable flow muffler –twin mufflers–active noise cancellation–sporty sound mufflers–sound engineering*	*Emission test procedures – FTP*	*Resonance frequency measurement – shell radiation noise measurement*
	SLO-2	*Charcoal canister control for evaporative emission*	*Diesel oxidation catalyst catalytic convertor*	*Off road – on road –non road muffler applications examples –manufacturing types & process*	*Emission test procedures – FTP*	*Resonance frequency measurement – shell radiation noise measurement*
S-9	SLO-1	*Positive crank case ventilation for blow by gas control*	*Diesel particulate filter*	*Roll and spot welding–lock seaming–double seaming –web forming–clinching–cold metal transfer*	*Euro and Bharat norms*	*Tail pipe noise measurement – water drainage ability test.*
	SLO-2	*Positive crank case ventilation for blow by gas control*	*NOx versus particulates –trade off*	*Hydro forming –piercing– stamping–muffler examples*	*Euro and Bharat norms*	*Tail pipe noise measurement – water drainage ability test.*

Learning Resources	1. *Ganesan V, "Internal combustion engines"., 4th edition, Tata McGraw Hill Education, 2012*	2. *John B Heywood. "Internal Combustion Engine Fundamentals". , Tata McGraw-Hill 1988.*

Learning Assessment

	Bloom's Level of Thinking	Continuous Learning Assessment (50% weightage)								Final Examination (50% weightage)	
		CLA – 1 (10%)		CLA – 2 (15%)		CLA – 3 (15%)		CLA – 4 (10%)#			
		Theory	Practice	Theory	Practice	Theory	Practice	Theory	Practice	Theory	Practice
Level 1	Remember Understand	*40 %*	-	*30 %*	-	*30 %*	-	*30 %*	-	*30%*	-
Level 2	Apply Analyze	*40 %*	-	*40 %*	-	*40 %*	-	*40 %*	-	*40%*	-
Level 3	Evaluate Create	*20 %*	-	*30 %*	-	*30 %*	-	*30 %*	-	*30%*	-
	Total	100 %		100 %		100 %		100 %		100 %	

CLA – 4 can be from any combination of these: Assignments, Seminars, Tech Talks, Mini-Projects, Case-Studies, Self-Study, MOOCs, Certifications, Conf. Paper etc.,

Course Designers

Experts from Industry	Experts from Higher Technical Institutions	Internal Experts
1. Mr.SarathRamakannan, Aston Martin, sharath.ramakrishnan@astonmartin.com	*1. Dr. N. Balaji, Sri Krishna College of Engineering, balajin@skcet.ac.in*	*1. Dr. V. Edwin Geo, SRMIST*
2. Mr.ShanmugaSundaram, Renault Nissan, sankaran@rntbci.com	*2. Dr.R.Sakthivel, Sri Venkateswara College of Engineering, rsakthivel@svce.ac.in*	*2. Dr. S. Thiyagarajan, SRMIST*

Course Code	18AUE434T	Course Name	ALTERNATIVE FUELS AND ENERGY SYSTEMS	Course Category	E	Professional Elective	L	T	P	C
							3	0	0	3

Pre-requisite Courses	18AUC301J	Co-requisite Courses	Nil	Progressive Courses	Nil
Course Offering Department	Automobile Engineering	Data Book / Codes/Standards	Nil		

Course Learning Rationale (CLR):	*The purpose of learning this course is to:*
CLR-1 :	*Evaluate the use of alcohol in SI and CI engine*
CLR-2 :	*Create insight on use of vegetable oil as fuel in CI engine*
CLR-3 :	*Evaluate the use of hydrogen as fuel in SI and CI engine*
CLR-4 :	*Analyze the other gaseous fuels utilization in SI and CI engine*
CLR-5 :	*Create insight on hybrid, solar and electric based vehicles*

Course Learning Outcomes (CLO):	*At the end of this course, learners will be able to:*	Learning 1: Level of Thinking (Bloom)	Learning 2: Expected Proficiency (%)	Learning 3: Expected Attainment (%)	PLO 1: Engineering Knowledge	PLO 2: Problem Analysis	PLO 3: Design & Development	PLO 4: Analysis, Design, Research	PLO 5: Modern Tool Usage	PLO 6: Society & Culture	PLO 7: Environment & Sustainability	PLO 8: Ethics	PLO 9: Individual & Team Work	PLO 10: Communication	PLO 11: Project Mgt. & Finance	PLO 12: Life Long Learning	PLO 13: PSO - 1	PLO 14: PSO - 2	PLO 15: PSO – 3
CLO-1 :	*Apply the knowledge of using alcohol as fuel*	1	90	85	H	L	L	M	M	H	H	L	L	M	L	H	H	M	L
CLO-2 :	*List the techniques employed to use vegetable oil in CI engine*	1	90	85	H	L	L	M	M	H	H	L	L	M	L	H	H	M	L
CLO-3 :	*Develop system for using hydrogen in engines*	2	90	85	H	M	M	M	H	H	H	L	M	M	L	H	H	M	M
CLO-4 :	*Understand the concepts of biogas, LPG and CNG as fuels in IC engines*	1	90	85	H	L	M	M	M	H	H	L	L	M	L	H	M	H	L
CLO-5 :	*Demonstrate the working of hybrid, solar and electric vehicles*	2	90	85	H	L	M	M	M	H	H	L	L	M	L	H	M	M	M

		Alcohol Fuels	Vegetable Oil	Hydrogen based fuels	Other Gaseous Fuels	Hybrid, solar and Electric vehicles
Duration (hour)		9	9	9	9	9
S-1	SLO-1	*Need for Alternate Fuel*	*Various vegetable oils and its properties*	*Hydrogen as fuel in IC engine, hydrogen properties*	*Biogas – Introduction, sources*	*Layout of Electric vehicles, Advantages and limitations*
	SLO-2	*Need for Alternate Fuel*	*Various vegetable oils and its properties*	*Hydrogen as fuel in IC engine, hydrogen properties*	*Biogas – Introduction, sources*	*Layout of Electric vehicles, Advantages and limitations*
S-2	SLO-1	*Properties of alcohol as IC engine fuel*	*Problems of using vegetable oil in CI engine and techniques to overcome*	*Hydrogen production and storage*	*Biogas production*	*System components, Electronic controlled system*
	SLO-2	*Properties of alcohol as IC engine fuel*	*Problems of using vegetable oil in CI engine and techniques to overcome*	*Hydrogen production and storage*	*Biogas production*	*System components, Electronic controlled system*
S-3	SLO-1	*Alcohol use in SI engine – Performance and emission*	*Trans-esterification – Reaction, Process optimization, fuel property variations*	*Problems associated with hydrogen as fuel and its solution*	*Factors affecting biogas production*	*High energy and power density batteries*
	SLO-2	*Alcohol use in SI engine – Performance and emission*	*Trans-esterification – Reaction, Process optimization, fuel property variations*	*Problems associated with hydrogen as fuel and its solution*	*Factors affecting biogas production*	*High energy and power density batteries*
S-4	SLO-1	*Gasohol, Flexible Fuel system, Reformed Alcohol*	*Blending – Diesel, ether based fuels*	*Different methods of using hydrogen in SI and CI engine*	*Biogas usage in CI and SI engine*	*Types of hybrid vehicles*
	SLO-2	*Gasohol, Flexible Fuel system, Reformed Alcohol*	*Blending – Diesel, ether based fuels*	*Different methods of using hydrogen in SI and CI engine*	*Biogas usage in CI and SI engine*	*Types of hybrid vehicles*
S-5	SLO-1	*Alcohol use in SI engine – Performance and emission*	*Fuel Preheating – electric based and waste exhaust heat , emulsification*	*Performance, emission and combustion characteristics*	*Properties of LPG and CNG as fuel in IC engine*	*Hybrid vehicle configuration*
	SLO-2	*Alcohol use in SI engine – Performance and emission*	*Fuel Preheating – electric based and waste exhaust heat , emulsification*	*Performance, emission and combustion characteristics*	*Properties of LPG and CNG as fuel in IC engine*	*Hybrid vehicle configuration*
S-6	SLO-1	*Dual fuel combustion*	*Waste to energy – Waste plastic and tires to fuel*	*Liquid hydrogen and metal hydrides for cars*	*Fuel metering system*	*Solar cell for energy collection*
	SLO-2	*Dual fuel combustion*	*Waste to energy – Waste plastic and tires to fuel*	*Liquid hydrogen and metal hydrides for cars*	*Fuel metering system*	*Solar cell for energy collection*

S-7	SLO-1	*Spark assisted diesel engine*	*Various techniques for conversion of waste solid to fuel*	*Fuel cell : Concept with hydrogen and methanol*	*Combustion characteristics*	*Storage batteries*
	SLO-2	*Spark assisted diesel engine*	*Various techniques for conversion of waste solid to fuel*	*Fuel cell : Concept with hydrogen and methanol*	*Combustion characteristics*	*Storage batteries*
S-8	SLO-1	*Surface ignition, ignition accelerators*	*Performance and emission comparison of vegetable oil and biodiesel*	*Power rating, performance and heat dissipation*	*Effect on performance and emission characteristics*	*Layout of solar powered vehicles*
	SLO-2	*Surface ignition, ignition accelerators*	*Performance and emission comparison of vegetable oil and biodiesel*	*Power rating, performance and heat dissipation*	*Effect on performance and emission characteristics*	*Layout of solar powered vehicles*
S-9	SLO-1	*Alcohol production techniques*	*First to fifth generation biofuels*	*Layout of fuel cell vehicle*	*LPG and CNG vehicle layout*	*Advantages and limitations*
	SLO-2	*Alcohol production techniques*	*First to fifth generation biofuels*	*Layout of fuel cell vehicle*	*LPG and CNG vehicle layout*	*Advantages and limitations*

Learning Resources	1. *M.K. GajendraBabu &K.A. Subramanian, Alternate Transportation Fuels: Utilization in combustion engine, CRC press, 2017*	2. *Richard L.Bechtold, Automotive Fuels Guide Book, SAE Publications, 1997*

Learning Assessment											
	Bloom's Level of Thinking	Continuous Learning Assessment (50% weightage)								Final Examination (50% weightage)	
		CLA – 1 (10%)		CLA – 2 (15%)		CLA – 3 (15%)		CLA – 4 (10%)#			
		Theory	Practice	Theory	Practice	Theory	Practice	Theory	Practice	Theory	Practice
Level 1	Remember Understand	*40 %*	-	*30 %*	-	*30 %*	-	*30 %*	-	*30%*	-
Level 2	Apply Analyze	*40 %*	-	*40 %*	-	*40 %*	-	*40 %*	-	*40%*	-
Level 3	Evaluate Create	*20 %*	-	*30 %*	-	*30 %*	-	*30 %*	-	*30%*	-
	Total	100 %		100 %		100 %		100 %		100 %	

CLA – 4 can be from any combination of these: Assignments, Seminars, Tech Talks, Mini-Projects, Case-Studies, Self-Study, MOOCs, Certifications, Conf. Paper etc.,

Course Designers		
Experts from Industry	Experts from Higher Technical Institutions	Internal Experts
1. Mr. S. Sivaramakrishnan, Volvo Cars, sivaramakrishnan.swaminathan@volvocars.com	*1. Dr. K. Balasubramanian, Sri Krishna College of Engineering, balasubramanian@skcet.ac.in*	*1. Dr. V. Edwin Geo, SRMIST*
2. Mr.SarathRamakannan, Aston Martin, sharath.ramakrishnan@astonmartin.com	*2. Dr. S. Premnath, Sri Venkateswara College of Engineering, prem@svcce.ac.in*	*2. Dr. S. Thiyagarajan, SRMIST*

Course Code	18AUE341T	Course Name	AUTOMOTIVE DRIVELINE DESIGN	Course Category	E	Professional Elective	L	T	P	C
							3	0	0	3

Pre-requisite Courses	Nil	Co-requisite Courses	Nil	Progressive Courses	Nil
Course Offering Department	Automobile Engineering	Data Book / Codes/Standards	Nil		

Course Learning Rationale (CLR):	The purpose of learning this course is to:
CLR-1 :	*Design the driveline systems and its components*
CLR-2 :	*Distinguish the design of various flywheel and clutches*
CLR-3 :	*Analyze the stresses and design various gears*
CLR-4 :	*Compare and design different gearboxes*
CLR-5 :	*Design the different braking systems and axles.*

Course Learning Outcomes (CLO):	At the end of this course, learners will be able to:	Learning 1: Level of Thinking (Bloom)	Learning 2: Expected Proficiency (%)	Learning 3: Expected Attainment (%)	1: Engineering Knowledge	2: Problem Analysis	3: Design & Development	4: Analysis, Design, Research	5: Modern Tool Usage	6: Society & Culture	7: Environment & Sustainability	8: Ethics	9: Individual & Team Work	10: Communication	11: Project Mgt. & Finance	12: Life Long Learning	13: PSO - 1	14: PSO - 2	15: PSO – 3
CLO-1 :	*Identify the different types power transmission drives*	1,3	90	85	H	M	H	H	M	L	L	L	M	M	L	M	H	H	H
CLO-2 :	*Infer the design of various flywheel and clutches*	1,2	90	85	H	H	H	H	M	M	L	L	M	M	L	M	H	H	H
CLO-3 :	*Classify and design different gears used in transmission systems*	1,3	90	80	H	H	H	H	H	L	L	L	M	M	L	L	H	H	H
CLO-4 :	*Categorize and design different gearbox and shafts*	1,3	80	75	H	H	H	H	H	M	L	L	M	M	L	L	H	H	H
CLO-5 :	*Interpret the design of various braking systems and axles.*	1,4	90	85	H	H	H	H	M	L	L	L	M	M	L	M	H	H	H

Program Learning Outcomes (PLO)

		Design of flexible drives	Design of flywheel and clutches	Design of Spur gear and Helical gear	Design of Gearbox, Propeller shaft and joints	Design of Axles and brakes
Duration (hour)		9	9	9	9	9
S-1	SLO-1	*Fllexible drives-Introduction*	*Flywheel and governor*	*Gears-Introduction*	*Gear box, components, requirements,*	*Axles-Types, materials*
	SLO-2	*Comparison of flexible drives with rigid drives*	*flywheel materials*	*Gear terminology and gear trains*	*Gear matching*	*Design requirements of front axle*
S-2	SLO-1	*Belt drives types and construction*	*Torque analysis*	*Design of spur gear, Selection of material*	*Requirements to obtain optimum design*	*Loads on axles*
	SLO-2	*Geometrical relationship*	*Stresses in Solid disc flywheel*	*Beam strength for gear tooth*	*Ray diagram, geometric progression and standard step ratio*	*Design of front axle*
S-3	SLO-1	*Analysis of belt tensions*	*Rimmed flywheel*	*Permissible bending stress*	*Kinematic layout*	*Design of rear axle*
	SLO-2	*Condition for maximum power*	*Stresses in rimmed flywheel*	*Effective load on gear tooth*	*Design of sliding mesh gearbox*	*Solving problems*
S-4	SLO-1	*Pulley design for belt drives*	*Tutorial on flywheel design*	*Estimation of module based on beam strength*	*Design of gearbox*	*Brakes design*
	SLO-2	*Tutorial on belt drives*	*Design considerations of clutches*	*Wear strength of Spur gear*	*Solving problems*	*Energy equations*
S-5	SLO-1	*Introduction of chain drives*	*Torque Transmission Capacity, uniform pressure theory*	*Solving problems*	*Constant mesh gearbox*	*Design of Block brake with short shoe*
	SLO-2	*Advantages of chain drives over belt drives*	*Uniform wear theory*	*Solving problems*	*Speed reducer unit*	*Design of block brake with long shoe*
S-6	SLO-1	*Roller chains*	*Design of single plate clutch*	*Terminology of helical gears*	*Design of propeller shaft for bending and torsion*	*Solving problems*
	SLO-2	*Geometrical relationship*	*Design of multidisc clutch*	*Force analysis of helical gears*	*Design of propeller shaft for bending and torsion*	*Pivoted block brake with long shoes*
S-7	SLO-1	*Polygonal effect*	*Friction materials*	*Force analysis of helical gears*	*Design of propeller shaft for rigidity*	*Solving problems*
	SLO-2	*Power rating for roller chains*	*Design of Cone clutches*	*Beam strength of helical gears*	*Solving problems*	*Internal expanding brakes*
S-8	SLO-1	*Design of sprocket wheels*	*Solving problems*	*Effective load on gear tooth*	*Design of universal joints and CV joints*	*Band brakes design*
	SLO-2	*Design of chain drive*	*Design of centrifugal clutches*	*Wear strength of helical gear*	*Slip joint design*	*Disc brakes design*
S-9	SLO-1	*Chain lubrication*	*Energy equation for clutches*	*Estimation of module based on wear strength*	*Design of final drive and Differential*	*Thermal considerations*
	SLO-2	*Tutorial on chain drives*	*Thermal consideration in clutch design*	*Solving problems*	*Solving problems*	*Solving problems*

Learning Resources	1. *Bhandari. V. B., "Design of Machine Elements", Tata McGraw-Hill Publishing Company Ltd, 2010.* 2. *Gian Carlo Genta, Lorenzo lorello "The Automotive Chassis system design" published by Springer,2009*	3. *Joseph E. Shigley & Larry D. Mitchell, "Mechanical Engineering Design", 10 th Edition, McGraw-Hill International book company,2014* 4. *Julian Hapian Smith, "An Introduction to Modern Vehicle Design", Society of Automotive Engineers Inc,2002*

2

Learning Assessment											
	Bloom's Level of Thinking	Continuous Learning Assessment (50% weightage)								Final Examination (50% weightage)	
		CLA – 1 (10%)		CLA – 2 (15%)		CLA – 3 (15%)		CLA – 4 (10%)			
		Theory	Practice	Theory	Practice	Theory	Practice	Theory	Practice	Theory	Practice
Level 1	Remember Understand	*40 %*	-	*30 %*	-	*30 %*	-	*30 %*	-	*30%*	-
Level 2	Apply Analyze	*40 %*	-	*40 %*	-	*40 %*	-	*40 %*	-	*40%*	-
Level 3	Evaluate Create	*20 %*	-	*30 %*	-	*30 %*	-	*30 %*	-	*30%*	-
	Total	100 %		100 %		100 %		100 %		100 %	

CLA – 4 can be from any combination of these: Assignments, Seminars, Tech Talks, Mini-Projects, Case-Studies, Self-Study, MOOCs, Certifications, Conf. Paper etc.,

Course Designers		
Experts from Industry	Experts from Higher Technical Institutions	Internal Experts
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Course Code	18AUE342T	Course Name	AUTOMOTIVE CHASSIS COMPONENT DESIGN	Course Category	E	Professional Elective	L	T	P	C
							3	0	0	3

Pre-requisite Courses	Nil	Co-requisite Courses	Nil	Progressive Courses	Nil
Course Offering Department	Automobile Engineering	Data Book / Codes/Standards	Nil		

Course Learning Rationale (CLR):	*The purpose of learning this course is to:*	Learning			Program Learning Outcomes (PLO)														
CLR-1 :	*Design the chassis and its components.*	1	2	3	1	2	3	4	5	6	7	8	9	10	11	12	13	14	15
CLR-2 :	*Design the steering and braking system and its components.*																		
CLR-3 :	*Compare and classify different transmission system.*																		
CLR-4 :	*Distinguish various suspension systems and designing it.*																		
CLR-5 :	*Gain knowledge about tire and its performance characteristics.*																		
Course Learning Outcomes (CLO):	*At the end of this course, learners will be able to:*	Level of Thinking (Bloom)	Expected Proficiency (%)	Expected Attainment (%)	Engineering Knowledge	Problem Analysis	Design & Development	Analysis, Design, Research	Modern Tool Usage	Society & Culture	Environment & Sustainability	Ethics	Individual & Team Work	Communication	Project Mgt. & Finance	Life Long Learning	PSO - 1	PSO - 2	PSO – 3
CLO-1 :	*Identify different types of frames and loads acting on it.*	*1,3*	*90*	*85*	*H*	*M*	*H*	*H*	*M*	*L*	*L*	*L*	*M*	*M*	*L*	*M*	*H*	*M*	*M*
CLO-2 :	*Interpret different steering and braking system components.*	*1,2*	*90*	*80*	*H*	*H*	*H*	*H*	*H*	*M*	*L*	*L*	*M*	*M*	*L*	*M*	*H*	*H*	*M*
CLO-3 :	*Evaluate the transmission components and their design procedures.*	*1,3*	*90*	*75*	*H*	*H*	*H*	*H*	*H*	*L*	*L*	*L*	*M*	*M*	*L*	*L*	*H*	*M*	*M*
CLO-4 :	*Classify and design different suspension system and its components.*	*1,3*	*80*	*75*	*H*	*H*	*M*	*M*	*M*	*M*	*L*	*L*	*M*	*M*	*L*	*L*	*M*	*H*	*H*
CLO-5 :	*Infer about tires and their performance characteristics.*	*1,4*	*85*	*80*	*H*	*H*	*M*	*H*	*N*	*L*	*L*	*L*	*M*	*L*	*L*	*M*	*M*	*H*	*H*

		Frames	Steering and brake system	Transmission	Suspensions	Wheels and their tires
Duration (hour)		9	9	9	9	9
S-1	SLO-1	*Study of loads Bending case*	*Introduction Steering mechanism*	*Manual Gearboxes - classification Mechanical efficiency*	*Introduction*	*Description Rim characteristics*
	SLO-2	*Torsion case Combined bending and torsion*	*Introduction Steering mechanism*	*Manual automobile gearboxes Manual gearboxes for industrial vehicles*	*Design of leaf Springs*	*Tire characteristics Wheel reference system*
S-2	SLO-1	*Lateral loading*	*Rack and pinion steering box*	*Shifting Mechanisms Internal shifting mechanisms*	*Design of Helical Springs*	*Tire operation On-road driving*
	SLO-2	*Fore and aft loading*	*Screw and sector steering box*	*Shifting Mechanisms External shifting mechanisms*	*Helical Springs in Series and Parallel and design of torsion bar*	*Off-road driving*
S-3	SLO-1	*Frame materials*	*Design Steering column*	*Start-Up Devices Friction clutch*	*Independent suspensions McPherson suspension*	*Rolling radius*
	SLO-2	*Design of frames Moment of inertia of rectangular section.*	*Design Steering column*	*Start-up devices for automatic gearboxes*	*McPherson suspensions for rear axle*	*Rolling radius*
S-4	SLO-1	*Moment of Inertia of a Hollow Rectangular Section.*	*Power steering*	*Synchronizers*	*Double wishbone suspension*	*Rolling resistance Effect of speed, material nature and structure, tread wear*
	SLO-2	*Moment of Inertia of a Hollow Rectangular Section.*	*Design and testing*	*Design criteria of Synchronizers*	*Virtual centres suspensions*	*Effect of operating temperature, inflation pressure and vertical load, tire size, road wheel sideslip angle*
S-5	SLO-1	*Moment of Inertia of a Circular Section*	*Braking system: Introduction*	*Differentials And Final Drives All wheel drive transfer boxes Outline of differential theory*	*Trailing arm suspensions- Semi-trailing arms suspension*	*Static Forces*
	SLO-2	*Moment of Inertia of a Circular Section*	*Car brakes*	*Types of self-locking differentials Differential effect on vehicle dynamics*	*Multilink suspensions*	*Static Forces*
S-6	SLO-1	*Moment of Inertia of Hollow Circular Section*	*Service and secondary systems*	*Shafts And Joints ,Propeller shafts Half shafts*	*Semi-independent suspensions*	*Longitudinal Force*
	SLO-2	*Moment of Inertia of Hollow Circular Section*	*Parking system, Disc brakes Drum brakes Control system components*	*Universal joints Constant speed joints*	*Twist beam suspension*	*Longitudinal Force*
S-7	SLO-1	*Chassis types, introduction -Ladder frames -Cruciform frames*	*Power brakes Vacuum power brake*	*Automatic Gearboxes*	*Rigid axle suspensions - Rigid axles with leaf springs*	*Cornering forces*
	SLO-2	*Torque tube backbone frames- Space frames-*	*Hydraulic power brake*	*Epi-cycloidal car gearboxes*	*Rigid guided axles*	*Interaction between longitudinal and side forces*

S-8	SLO-1	*Integral structures*	*Design and testing braking system mechanics*	*Car CVTs*	*Industrial vehicles suspensions - Pneumatic springs*	*Outline on dynamic behavior*
	SLO-2	*Underbody, Sub-frame, Industrial vehicle frames*	*Mechanical design*	*Car CVTs*	*Front suspension Rear suspensions*	*Outline on dynamic behavior*
S-9	SLO-1	*Structural tasks Structural design*	*Thermal design*	*Design and testing of Gears, Shafts Bearings*	*Design and testing*	*Testing of tires*
	SLO-2	*Structural testing*	*Thermal design*	*Lubricants, Housings and seals*	*Design and testing*	*Testing of tires*

Learning Resources	1. *The Automotive Chassis Volume 1: Components Design Genta, Giancarlo, Morello, L., Springer, Netherlands 2009.* 2. *Introduction to Modern Vehicle Design Julian Happian-Smith, Butterworth-Heinemann 2001.* 3. *Vector Mechanics for Engineers: Statics and Dynamics Beer, Johnston, McGraw Hill Education; Tenth edition 2017*	4. *Advanced Vehicle Technology Heinz Heisler, Butterworth-Heinemann; 2 edition 2002.* 5. *The Motor Vehicle Kenneth Newton , T.K. Garrett , W. Steeds, Butterworth-Heinemann 12 Revised edition 1997*

Learning Assessment

	Bloom's Level of Thinking	Continuous Learning Assessment (50% weightage)								Final Examination (50% weightage)	
		CLA – 1 (10%)		CLA – 2 (15%)		CLA – 3 (15%)		CLA – 4 (10%)#			
		Theory	Practice	Theory	Practice	Theory	Practice	Theory	Practice	Theory	Practice
Level 1	Remember Understand	*40 %*	-	*30 %*	-	*30 %*	-	*30 %*	-	*30%*	-
Level 2	Apply Analyze	*40 %*	-	*40 %*	-	*40 %*	-	*40 %*	-	*40%*	-
Level 3	Evaluate Create	*20 %*	-	*30 %*	-	*30 %*	-	*30 %*	-	*30%*	-
	Total	100 %		100 %		100 %		100 %		100 %	

Course Designers

Experts from Industry	Experts from Higher Technical Institutions	Internal Experts
1. Mr.N. Vijayakumar Mahindra & Mahindra, vijayakumar.n@mahindra.com	*1. Mr. B.Vasanthan, Madras Institute of technology, Anna University, bvasanthan@mitindia.edu*	*1.Dr. R. Rajendran, SRMIST, rajendrr@srmist.edu.in*
2. Mr..R.Srikanth, Altair, srikanth.r@altair.com	*2. Mr.N.Ravikumar,Crescent Institute of Science and Technology,ravikumar@crescent.education*	*2. Mr. T. Kaviyarasu ,SRMIST, kaviyart@srmist.edu.in*

Course Code	18AUE343T	Course Name	VEHICLE DESIGN DATA CHARACTERISTICS	Course Category	E	Professional Elective	L	T	P	C
							3	0	0	3

Pre-requisite Courses	18AUC305T	Co-requisite Courses	Nil	Progressive Courses	Nil
Course Offering Department	Automobile Engineering	Data Book / Codes/Standards	Nil		

Course Learning Rationale (CLR):	*The purpose of learning this course is to:*
CLR-1 :	*Acquire basic knowledge of the preliminary design concepts involved in designing of a vehicle.*
CLR-2 :	*Acquire the knowledge of Power requirement calculation of the vehicle*
CLR-3 :	*Inferring various characteristics of performance curves*
CLR-4 :	*Interpreting vehicle performance by various factors*
CLR-5 :	*Implementing appropriate gear requirements to meet performance of vehicle*

Course Learning Outcomes (CLO):	*At the end of this course, learners will be able to:*	Learning 1: Level of Thinking (Bloom)	Learning 2: Expected Proficiency (%)	Learning 3: Expected Attainment (%)	PLO 1: Engineering Knowledge	PLO 2: Problem Analysis	PLO 3: Design & Development	PLO 4: Analysis, Design, Research	PLO 5: Modern Tool Usage	PLO 6: Society & Culture	PLO 7: Environment & Sustainability	PLO 8: Ethics	PLO 9: Individual & Team Work	PLO 10: Communication	PLO 11: Project Mgt. & Finance	PLO 12: Life Long Learning	PLO 13: PSO - 1	PLO 14: PSO - 2	PLO 15: PSO – 3
CLO-1 :	*Understand the basic design principles of vehicle*	1	85	70	H	M	H	H	H	L	M	M	H	M	L	M	H	H	H
CLO-2 :	*Able to draw the performance curves pertaining to vehicle motion*	2	80	75	H	H	H	H	H	L	H	L	H	M	L	L	H	H	H
CLO-3 :	*Familiarize functions of several variables pertaining to vehicular design.*	3	85	70	H	H	H	H	H	L	M	L	H	M	L	M	H	H	H
CLO-4 :	*Critiquing various design variables of engine components*	2	85	65	H	H	H	H	H	L	H	L	H	M	L	H	H	H	H
CLO-5 :	*Able to measure the vehicle performance by several methods*	2	85	75	H	H	H	H	H	L	M	L	H	M	L	H	H	H	H

Duration (hour)		Introduction to Basic Concepts in Vehicular Design	Resistance to Vehicle Motion	Performance Curves – I	Performance Curves – II	Gear Ratios calculations
		09	09	09	09	09
S-1	SLO-1	*Introduction of Designing a Vehicle*	*Calculation, of Air Resistances at Various Vehicle Speeds*	*Calculation of Torque for Different Vehicle Speeds*	*Connecting Rod Length to Crank Radius Ratio*	*Gear Ratios*
	SLO-2	*Assumptions to be Made in Designing a Vehicle*	*Tabulation and Plotting of Curves for Air Resistances at Various Vehicle Speeds*	*Tabulation and Plotting of Torque for Different Vehicle Speeds*	*Calculation of Connecting Rod Length to Crank Radius Ratio*	*Determination of Gear Ratios*
S-2	SLO-1	*Gross Vehicle Weight*	*Tutorial on air resistance*	*Tutorial on torque calculation*	*Calculation of piston velocity*	*Tutorial on gear ratios*
	SLO-2	*Range of Values for Gross Vehicle Weight*	*Calculation, of Rolling Resistances at Various Vehicle Speeds*	*Calculation of Mechanical Efficiency for Different Vehicle Speeds*	*Plotting of Piston Velocity*	*Determination of Acceleration*
S-3	SLO-1	*Tutorial on gross vehicle weight calculations*	*Tabulation and Plotting of Curves for Rolling Resistances at Various Vehicle Speeds*	*Tabulation and Plotting of Mechanical Efficiency for Different Vehicle Speeds*	*Calculation of acceleration*	*Problems on Acceleration*
	SLO-2	*Frontal Area calculations*	*Tutorial on rolling resistance*	*Tutorial on mechanical efficiency calculations*	*Plotting of Acceleration Against Crank Angle*	*Gradability*
S-4	SLO-1	*Range of Values for Frontal Area*	*Calculation of Driving Force*	*Interpolation of Pressure-Volume Diagram*	*Calculation of gas pressure*	*Gradability in Different Gears*
	SLO-2	*Tutorial on frontal area calculations*	*Plotting of Driving Force*	*Pressure-Volume Diagram at various stages*	*Plotting Gas Force, Against Crank Angle*	*Determination of Gradability*
S-5	SLO-1	*Range of Values for Maximum Speed*	*Power Requirement for Different Loads*	*Frictional Mean Effective Pressure*	*Inertial force*	*Problems on Gradability*
	SLO-2	*Range of Values for Maximum Speed*	*Power Requirement for Different Loads*	*Calculation of Frictional Mean Effective Pressure*	*Calculation of inertial force*	*Problems on Gradability*
S-6	SLO-1	*Calculation on maximum speed*	*Tutorial on power requirement for different loads*	*Tutorial on Frictional Mean Effective Pressure*	*Plotting of Inertia Force Against Crank Angle*	*Influence of Gear ratio and Gradability on vehicle performance*
	SLO-2	*Range of Values for Maximum Acceleration*	*Power Requirement for Acceleration*	*Engine Cubic Capacity*	*Resultant force*	*Range of values of gear ratios*
S-7	SLO-1	*Range of Values for Maximum Acceleration*	*Tutorial on power requirement for acceleration*	*Calculation of Engine Cubic Capacity*	*Calculation of resultant force*	*Range of values of Gradability*
	SLO-2	*Calculation on maximum acceleration*	*Tutorial on power requirement for acceleration*	*Typical problems on engine cubic capacity*	*Plotting of Resultant Force Against Crank Angle*	*Determination of vehicle performance parameters*

S-8	SLO-1	*Basics of Automobile Design*	*Maximum Power Calculation*	*Typical problems on engine cubic capacity*	*Turning Moment Against Crank Angle*	*Calculation of vehicle performance*
	SLO-2	*Basics of Automobile Design*	*Maximum Power Calculation*	*Comparison between various performance parameters*	*Calculation of Turning Moment Against Crank Angle*	*Calculation of vehicle performance*
S-9	SLO-1	*Tutorial on overall design procedure of automobile*	*Tutorial on overall power requirement calculation*	*Inference from the comparison diagram*	*Side Thrust Against Crank Angle*	*Typical Problems on Vehicle Performance*
	SLO-2	*Tutorial on overall design procedure of automobile*	*Tutorial on overall power requirement calculation*	*Inference from the comparison diagram*	*Calculation of Side Thrust Against Crank Angle*	*Typical Problems on Vehicle Performance*

Learning Resources	*1. Hoag, Kevin, Don linger, Brian,"Vehicular Engine Design", 2nd Edition, springer 2016.* *2. Fenton, "Handbook of Vehicle Design Analysis", Mechanical Engineering Publications, 1996.* *3. Heldt, P.M., "High Speed Combustion Engines", Oxford and I.B.H. Publishing Co., Kolkata, 2002.*	*4. Giri. N. K., "Automotive Mechanics", Khanna Publishers, New Delhi, 2005.* *5. T. K. Garrett, K. Newton, W. Steeds, Motor Vehicle, 13th edition Butterworth-Heinemann, 2000.*

Learning Assessment

	Bloom's Level of Thinking	Continuous Learning Assessment (50% weightage)								Final Examination (50% weightage)	
		CLA – 1 (10%)		CLA – 2 (15%)		CLA – 3 (15%)		CLA – 4 (10%) #			
		Theory	Practice	Theory	Practice	Theory	Practice	Theory	Practice	Theory	Practice
Level 1	Remember Understand	*40 %*	-	*30 %*	-	*30 %*	-	*30 %*	-	*30%*	-
Level 2	Apply Analyze	*40 %*	-	*40 %*	-	*40 %*	-	*40 %*	-	*40%*	-
Level 3	Evaluate Create	*20 %*	-	*30 %*	-	*30 %*	-	*30 %*	-	*30%*	-
	Total	100 %		100 %		100 %		100 %		100 %	

CLA – 4 can be from any combination of these: Assignments, Seminars, Tech Talks, Mini-Projects, Case-Studies, Self-Study, MOOCs, Certifications, Conf. Paper etc.,

Course Designers		
Experts from Industry	Experts from Higher Technical Institutions	Internal Experts
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Course Code	18AUE344T	Course Name	CONCEPTS OF ENGINEERING DESIGN	Course Category	E	Professional Elective	L	T	P	C
							3	0	0	3

Pre-requisite Courses	Nil	Co-requisite Courses	Nil	Progressive Courses	Nil
Course Offering Department	Automobile Engineering	Data Book / Codes/Standards	Nil		

Course Learning Rationale (CLR):	*The purpose of learning this course is to:*
CLR-1 :	*Familiarize the students with the design process*
CLR-2 :	*Give insights into the various tools used in Design Methods*
CLR-3 :	*Acquaint students with material selection and design strategies*
CLR-4 :	*Familiarize the students with the Engineering statistics and reliability in design*
CLR-5 :	*Give insights into legal and ethical issues in Designing and to various tools involved in Quality Engineering*

Course Learning Outcomes (CLO):	*At the end of this course, learners will be able to:*	Learning			Program Learning Outcomes (PLO)														
		1	2	3	1	2	3	4	5	6	7	8	9	10	11	12	13	14	15
		Level of Thinking (Bloom)	Expected Proficiency (%)	Expected Attainment (%)	Engineering Knowledge	Problem Analysis	Design & Development	Analysis, Design, Research	Modern Tool Usage	Society & Culture	Environment & Sustainability	Ethics	Individual & Team Work	Communication	Project Mgt. & Finance	Life Long Learning	PSO - 1	PSO - 2	PSO – 3
CLO-1 :	*Describe various design processes*	*1*	*85*	*80*	*H*	*-*	*H*	*L*	*L*	*L*	*L*	*-*	*M*	*M*	*L*	*M*	*M*	*M*	*L*
CLO-2 :	*Demonstrate various tools used in Design Methods*	*2*	*80*	*75*	*H*	*H*	*H*	*M*	*M*	*L*	*M*	*-*	*M*	*M*	*-*	*M*	*M*	*M*	*H*
CLO-3 :	*Understand the process of material selection and can interpret various techniques involved in Design*	*1,2*	*85*	*80*	*H*	*M*	*H*	*M*	*M*	*M*	*M*	*L*	*M*	*M*	*M*	*M*	*H*	*M*	*H*
CLO-4 :	*Implement various Engineering statistics methods in design*	*2*	*80*	*75*	*H*	*H*	*H*	*H*	*M*	*L*	*L*	*L*	*M*	*M*	*-*	*M*	*M*	*M*	*M*
CLO-5 :	*Understand the legal and ethical issues in Designing and apply various tools used in Quality Engineering*	*1.2*	*85*	*80*	*H*	*M*	*H*	*M*	*M*	*H*	*H*	*H*	*M*	*M*	*L*	*M*	*M*	*M*	*H*

		Design Process	Design Methods	Material Selection Processing and Design	Engineering Statistics and Reliability	Legal and Ethical Issues in Design and Quality Engineering
Duration (hour)		9	9	9	9	9
S-1	SLO-1	*The Design Process*	*Creativity and Problem Solving, Product Design Specifications*	*Material Selection Process*	*Introduction to statistics and Reliability*	*Introduction to Ethics*
	SLO-2	*Morphology of Design, Design Drawings*	*Conceptual Design*	*Economics, Cost vs Performance*		*The Origin Of Laws*
S-2	SLO-1	*Computer Aided Engineering, Designing of Standards*	*Decision Theory, Decision Tree*	*Weighted Property Index*	*Probability*	*Contracts*
	SLO-2	*Concurrent Engineering*	*Embodiment Design*	*Value Analysis, Role of Processing in Design*		*Liability*
S-3	SLO-1	*Product Life Cycle*	*Detail Design, Mathematical Modeling*	*Classification of Manufacturing Process*	*Distributions*	*Tort Law*
	SLO-2	*Technological Forecasting*				*Product Liability*
S-4	SLO-1	*Market Identification*	*Simulation, Geometric Modeling*	*Design for Manufacture*	*Test Of Hypothesis*	*Protecting Intellectual Property*
	SLO-2					
S-5	SLO-1	*Competition Bench Marking*	*Finite Element Modeling*	*Design for Assembly*	*Design Of Experiments*	*Legal and Ethical Domains*
	SLO-2					*Codes of Ethics*
S-6	SLO-1	*Systems Engineering*	*Optimization, Search Methods*	*Designing for Castings, Forging*	*Reliability Theory*	*Solving Ethical Conflicts*
	SLO-2					
S-7	SLO-1	*Life Cycle Engineering*	*Geometric Programming*	*Designing for Metal Forming, Machining and Welding*	*Design for Reliability*	*Total Quality Concept, – Quality Assurance*
	SLO-2					*Statistics Process Control*
S-8	SLO-1	*Human Factors in Design*	*Structural Optimization*	*Residual Stresses*	*Reliability Centered Maintenance*	*Taguchi Methods*
	SLO-2					*Robust Design*
S-9	SLO-1	*Industrial Design*	*Shape Optimization*	*Fatigue, Fracture and Failure*	*Tutorial*	*Failure Mode Effect Analysis*
	SLO-2					

Learning Resources		
	1. Dieter, George E., Engineering Design - "A Materials and Processing Approach", McGraw Hill International Editions, Singapore, 4th Edition, 2008 *2. Karl T. Ulrich and Steven D. Eppinger "Product Design and Development" McGraw Hill Edition 6th edition 2015*	*3. Pahl, G, and Beitz, W.," Engineering Design: A Systematic Approach", Springer London, 2014* *4. Ray, M.S., "Elements of Engg. Design", Prentice Hall Inc. 1985.* *5. Suh, N.P., "The principles of Design", Oxford University Press, NY.1990.*

Learning Assessment											
	Bloom's Level of Thinking	Continuous Learning Assessment (50% weightage)								Final Examination (50% weightage)	
		CLA – 1 (10%)		CLA – 2 (15%)		CLA – 3 (15%)		CLA – 4 (10%)#			
		Theory	Practice	Theory	Practice	Theory	Practice	Theory	Practice	Theory	Practice
Level 1	Remember Understand	*40 %*	-	*30 %*	-	*30 %*	-	*30 %*	-	*30%*	-
Level 2	Apply Analyze	*40 %*	-	*40 %*	-	*40 %*	-	*40 %*	-	*40%*	-
Level 3	Evaluate Create	*20 %*	-	*30 %*	-	*30 %*	-	*30 %*	-	*30%*	-
	Total	100 %		100 %		100 %		100 %		100 %	

CLA – 4 can be from any combination of these: Assignments, Seminars, Tech Talks, Mini-Projects, Case-Studies, Self-Study, MOOCs, Certifications, Conf. Paper etc.,

Course Designers		
Experts from Industry	Experts from Higher Technical Institutions	Internal Experts
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2.Mr.Prasad MP AGNITO INSIGHTS, prasad@agnito.in	*2. Dr. V. Uma Maheshwar ,Osmania University mahesh.v@uceou.edu,*	*2. Mr. R. Ganesh, SRMIST, ganeshr@srmist.edu.in*

Course Code	18AUE345T	Course Name	RAPID PROTOTYPING AND TOOLING	Course Category	E	Professional Elective	L	T	P	C
							3	0	0	3

Pre-requisite Courses	Nil	Co-requisite Courses	Nil	Progressive Courses	Nil
Course Offering Department	Automobile Engineering	Data Book / Codes/Standards	Nil		

Course Learning Rationale (CLR):	*The purpose of learning this course is to:*
CLR-1 :	*Understand and use techniques for processing of CAD models for rapid prototyping.*
CLR-2 :	*Understand and apply fundamentals of rapid prototyping techniques.*
CLR-3 :	*Use appropriate tooling for rapid prototyping process.*
CLR-4 :	*Use rapid prototyping techniques for reverse engineering.*
CLR-5 :	*Examine the cases relevant to mass customization and some of the important research challenges associated with AM and its data processing tools*

		Learning			Program Learning Outcomes (PLO)														
		1	2	3	1	2	3	4	5	6	7	8	9	10	11	12	13	14	15
Course Learning Outcomes (CLO):	*At the end of this course, learners will be able to:*	Level of Thinking (Bloom)	Expected Proficiency (%)	Expected Attainment (%)	Engineering Knowledge	Problem Analysis	Design & Development	Analysis, Design, Research	Modern Tool Usage	Society & Culture	Environment & Sustainability	Ethics	Individual & Team Work	Communication	Project Mgt. & Finance	Life Long Learning	PSO - 1	PSO - 2	PSO – 3
CLO-1 :	*Understand history, concepts and terminology of additive manufacturing*	2	95	93	H	L	L	H	L	L	M	L	H	L	H	H	H	M	H
CLO-2 :	*Apply the reverse engineering concepts for design development*	2	98	96	H	L	L	H	L	L	M	L	H	L	H	H	H	M	H
CLO-3 :	*Understand the variety of additive manufacturing techniques*	2	96	95	H	L	L	H	L	L	M	L	H	L	H	H	H	M	H
CLO-4 :	*Design and develop newer tooling models*	2	98	97	H	L	L	H	L	L	M	L	H	L	H	H	H	M	H
CLO-5 :	*Analyse the cases relevant to mass customization and some of the important research challenges associated with AM and its data processing tools*	2	94	91	H	L	L	H	L	L	M	L	H	L	H	H	H	M	H

		Introduction to Rapid Prototyping	Liquid Based Additive Manufacturing System	Solid Based Additive Manufacturing System	Powder Based Additive Manufacturing System	Additive Manufacturing Application And Case Studies
Duration (hour)		9	9	9	9	9
S-1	SLO-1 SLO-2	*Overview of subtraction and additive manufacturing History*	*Methods in liquid based process and material used for fabrication*	*Introduction to solid based additive Manufacturing system*	*Methods in powder based process*	*Design for additive manufacturing method and*
S-2	SLO-1	*Need-Classification of additive manufacturing*	*Stereo lithography Apparatus (SLA)-*	*Methods in solid based process and*	*and material used for fabrication*	*special materials*
	SLO-2	*Need-Classification of additive manufacturing*	*Principle, process,*	*material used for fabrication*	*Selective Laser Sintering*	*medical and bio-additive manufacturing*
S-3	SLO-1	*The cost and effects of design changes during conceptual modeling, detail*	*advantages, disadvantages and limitations*	*fused deposition modeling(FDM)- introduction*	*Principles of SLS–process*	*Customized implants and prosthesis: Design*
	SLO-2	*designing, prototyping,*	*Digital light processing -introduction*	*fused deposition modeling(FDM)- principle*	*Process, advantages and*	*and production*
S-4	SLO-1	*manufacturing and product release*	*Digital light processing principle*	*Process*	*Applications*	*Bio-Additive Manufacturing-*
	SLO-2	*Reverse Engineering*	*Process*	*Advantages and dis advantages*	*Selective Laser Melting*	*Computer Aided Tissue Engineering (CATE)*
S-5	SLO-1	*Bench marking*	*Advantages and dis advantages*	*Limitation Limitations*	*Principles of SLS process*	*Advantages and dis advantages*
	SLO-2	*3D scanning, 3D digitizing and Data fitting*	*Limitations*	*Multi jet modelling- Principle*	*Process, advantages and applications*	*Application of RP techniques in Automotive components-*
S-6	SLO-1	*CAD for RPT: CAD model preparation*	*Solid ground curing introduction*	*process, advantages,*	*Selective heat sintering*	*3D printed brake caliper*
	SLO-2	*Part Orientation and support generation*	*Solid ground curing principle*	*disadvantages and limitations*	*Laser Engineered Net Shaping (LENS) -,*	*3D printed food- need and*
S-7	SLO-1	*Model Slicing –Tool path Generation*	*Process*	*Laminated object modeling (LOM)- Principle, process,*	*Principle, process, advantages*	*its limitation*
	SLO-2	*Materials for Additive Manufacturing Technology*	*Advantages and dis advantages*	*advantages, disadvantages and limitations*	*disadvantages and limitations*	*zero-gravity 3D printer*

S-8	SLO-1	*And its classification based on materials*	*Limitations*		*Three Dimensional Printing - Principle, process,*	*Application of RP in Art and jewelry*
	SLO-2	*RPT and its role in modern manufacturing mechanical design*	*Continuous Liquid Interface Production*	*Electron-beam freeform fabrication*	*advantages and applications-*	*Challenges in implementation of RP techniques*
S-9	SLO-1	*-Economics of RP techniques*	*Shape deposition modelling*	*Case studies*	*Electron Beam Melting- Principle, process,*	*Case Studies*
	SLO-2		*Ballistic Particle Manufacturing(BPM)*		*advantages, disadvantages and limitations*	

Learning Resources	*1. Chua, C.K., Leong K.F. and Lim C.S., "Rapid prototyping: Principles and applications", second edition, World Scientific Publishers, 2010.* *2. Gebhardt, A., "Rapid prototyping", Hanser Gardener Publications, 2003.*	*3. Gibson, I., Rosen, D.W. and Stucker, B., "Additive Manufacturing Methodologies: Rapid Prototyping to Direct Digital Manufacturing", Springer, 2010.* *4. Hilton, P.D. and Jacobs, P.F., Rapid Tooling: Technologies and Industrial Applications, CRC press, 2005.*

Learning Assessment

	Bloom's Level of Thinking	Continuous Learning Assessment (50% weightage)								Final Examination (50% weightage)	
		CLA – 1 (10%)		CLA – 2 (15%)		CLA – 3 (15%)		CLA – 4 (10%)#			
		Theory	Practice	Theory	Practice	Theory	Practice	Theory	Practice	Theory	Practice
Level 1	Remember Understand	*40 %*	-	*30 %*	-	*30 %*	-	*30 %*	-	*30%*	-
Level 2	Apply Analyze	*40 %*	-	*40 %*	-	*40 %*	-	*40 %*	-	*40%*	-
Level 3	Evaluate Create	*20 %*	-	*30 %*	-	*30 %*	-	*30 %*	-	*30%*	-
	Total	100 %		100 %		100 %		100 %		100 %	

CLA – 4 can be from any combination of these: Assignments, Seminars, Tech Talks, Mini-Projects, Case-Studies, Self-Study, MOOCs, Certifications, Conf. Paper etc.,

Course Designers

Experts from Industry	Experts from Higher Technical Institutions	Internal Experts
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Course Code	18AUE346T	Course Name	MODELING AND CONTROL OF VIBRATION IN MECHANICAL SYSTEMS	Course Category	E	Professional Elective	L	T	P	C
							3	0	0	3

Pre-requisite Courses	Nil	Co-requisite Courses	Nil	Progressive Courses	Nil
Course Offering Department	Automobile Engineering	Data Book / Codes/Standards	Nil		

Course Learning Rationale (CLR):	The purpose of learning this course is to:
CLR-1 :	*Impart knowledge on fundamentals of vibrations*
CLR-2 :	*Know the concept of two degree of freedom systems and continuous systems*
CLR-3 :	*Analyze different methods of modeling multi degree of freedom systems*
CLR-4 :	*Understand the concept of Vibration control techniques*
CLR-5 :	*Gain knowledge on vibration measurement devices*

Course Learning Outcomes (CLO):	At the end of this course, learners will be able to:	Learning 1: Level of Thinking (Bloom)	Learning 2: Expected Proficiency (%)	Learning 3: Expected Attainment (%)	PLO 1: Engineering Knowledge	PLO 2: Problem Analysis	PLO 3: Design & Development	PLO 4: Analysis, Design, Research	PLO 5: Modern Tool Usage	PLO 6: Society & Culture	PLO 7: Environment & Sustainability	PLO 8: Ethics	PLO 9: Individual & Team Work	PLO 10: Communication	PLO 11: Project Mgt. & Finance	PLO 12: Life Long Learning	PLO 13: PSO - 1	PLO 14: PSO - 2	PLO 15: PSO – 3
CLO-1 :	*Understand the fundamentals of vibration and single degree of freedom system*	1,3	90	85	H	M	H	H	M	L	L	L	M	M	L	M	H	H	H
CLO-2 :	*Implement two degree of freedom systems in any application*	1,2	90	85	H	H	H	H	M	M	L	L	M	M	L	M	H	H	H
CLO-3 :	*Classify the different modeling methods in multi degree of freedom systems*	1,3	90	80	H	H	H	H	H	L	L	L	M	M	L	L	H	H	H
CLO-4 :	*Interpret different vibration control techniques*	1,3	80	75	H	H	H	H	H	M	L	L	M	M	L	L	H	H	H
CLO-5 :	*Implement the vibration measurement devices in real time application*	1,4	90	85	H	H	H	H	M	L	L	L	M	M	L	M	H	H	H

		Fundamentals of vibration and Modelling SDOF systems	Two degree of freedom systems and continuous systems	Modelling of Multi-DegreeofFreedom Systems	Vibration control	Vibration measurement and applications
Duration (hour)		9	9	9	9	9
S-1	SLO-1, SLO-2	*Concept of vibration*	*Two DOF*	*Multi Degree Freedom System*	*Introduction to vibration control*	*Transducers*
S-2	SLO-1	*Classification of vibration*	*Modelling of Two Degree of freedom systems*	*Modeling of Continuous Systems as Multi-degreeofFreedom Systems*	*Specification of Vibration Limits*	*Transducers types and applications*
	SLO-2	*Vibration analysis procedure and elements*	*Modelling of Two Degree of freedom systems*	*Influence Coefficients*	*Static and dynamic balancing*	*Vibration pickups*
S-3	SLO-1	*Harmonic and periodic motions, vibration terminology*	*Free Vibration Analysis of an Undamped System*	*stiffness coefficients*	*Balancing of Rotating Machines*	*Vibrometer*
	SLO-2	*Modelling of single degree of freedom systems*	*Free Vibration Analysis of dampedSystem*	*Flexibility and inertia influence coefficients*	*Field balancing*	*Accelerometer*
S-4	SLO-1	*Vibration model, Equation of motion-Natural Frequency*	*Equations of Motion for ForcedVibration*	*Flexibility Matrixand Stiffness Matrix*	*Whirling of Rotating Shafts*	*Velometer*
	SLO-2	*Energy method, Rayleigh method*	*Forced Vibration with HarmonicExcitation System*	*Flexibility Matrixand Stiffness Matrix*	*Critical Speeds, Stability Analysis*	*Phase Distortion*
S-5	SLO-1	*Principle of virtual work,*	*Forced Vibration with HarmonicExcitation System*	*Eigen Values and Eigen Vectors*	*Balancing of Reciprocating Engines*	*Frequency-Measuring Instruments*
	SLO-2	*Damping models.*	*Coordinate Couplings and Principal Coordinates*	*Eigen Values and Eigen Vectors*	*Control of Natural Frequencies*	*Vibration Exciters*
S-6	SLO-1	*Viscously damped free vibration*	*Vibration of continuous systems*	*Matrix Iteration Method*	*Vibration Isolation*	*Signal Analysis*
	SLO-2	*Special cases: oscillatory, non-oscillatory and critically damped motions.*	*Vibrating string*	*ApproximateMethods*	*Vibration Isolation methods*	*Dynamic Testing of Machines and Structures*
S-7	SLO-1	*Logarithmic decrement, Experimental determination of damping coefficient.*	*Longitudinal vibration of rods*	*Dunkerley, Rayleigh's, and Holzer Method*	*Vibration Absorbers*	*Experimental Modal Analysis*
	SLO-2	*Forced harmonic vibration, Magnification factor.*	*Torsional vibration of rods*	*Geared Systems*	*Dynamic vibration absorbers*	*Measurement of Mode Shapes*

S-8	SLO-1	*Rotor unbalance, Transmissibility*	*Vibration of suspension bridges*	*Eigen Values & Eigenvectors for large system of equations using sub space*	*torsional and pendulum type absorbers*	*Machine Condition Monitoring and Diagnosis*
	SLO-2	*Vibration Isolation*	*Euler equation for beams*	*Solving problems*	*Damped vibration absorbers*	*Machine Condition Monitoring and Diagnosis*
S-9	SLO-1	*Equivalent viscous damping, Sharpness of resonance.*	*Cycle test 2*	*Cycle test 2*	*Cycle test 3*	*Cycle test 3*
	SLO-2	*Cycle test 1*	*cycle test 2*	*cycle test 2*	*Cycle test 3*	*Cycle test 3*

Learning Resources	1. *Ramamurti. V, "Mechanical Vibration Practice with Basic Theory", Narosa, New Delhi, 2010* 2. *Rao, S.S.," Mechanical Vibrations," Addison Wesley Longman, 6th Edition 2018.*	3. *S. Graham Kelly &Shashidar K. Kudari, "Mechanical Vibrations", Tata McGraw–Hill Publishing Com. Ltd New Delhi, 2007* 4. *4. Thomson, W.T. – "Theory of Vibration with Applications", CBS Publishers and Distributors, New Delhi, 2006*

Learning Assessment

	Bloom's Level of Thinking	Continuous Learning Assessment (50% weightage)								Final Examination (50% weightage)	
		CLA – 1 (10%)		CLA – 2 (15%)		CLA – 3 (15%)		CLA – 4 (10%)#			
		Theory	Practice	Theory	Practice	Theory	Practice	Theory	Practice	Theory	Practice
Level 1	Remember Understand	*40 %*	-	*30 %*	-	*30 %*	-	*30 %*	-	*30%*	-
Level 2	Apply Analyze	*40 %*	-	*40 %*	-	*40 %*	-	*40 %*	-	*40%*	-
Level 3	Evaluate Create	*20 %*	-	*30 %*	-	*30 %*	-	*30 %*	-	*30%*	-
	Total	100 %		100 %		100 %		100 %		100 %	

CLA – 4 can be from any combination of these: Assignments, Seminars, Tech Talks, Mini-Projects, Case-Studies, Self-Study, MOOCs, Certifications, Conf. Paper etc.,

Course Designers

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2. Mr.GopalDhanasekar, System Engineer, Automotive Testing System. Gopal.dhanasekar@ats_india.com	*2. Dr. R Kannan, Professor, PSNA CET Kannanjothy@gmail.com*	*2. Dr. T.Praveenkumrar, SRMIST praveent@srmist.edu.in*

Course Code	18AUE441T	Course Name	OPTIMIZATION TECHNIQUES IN ENGINEERING DESIGN	Course Category	E	Professional Elective	L	T	P	C
							3	0	0	3

Pre-requisite Courses	18MAB202T	Co-requisite Courses	Nil	Progressive Courses	Nil
Course Offering Department	Automobile Engineering	Data Book / Codes/Standards			

Course Learning Rationale (CLR):	*The purpose of learning this course is to:*
CLR-1 :	*Familiarize Unconstrained Optimization Techniques*
CLR-2 :	*Familiarize Constrained Optimization Techniques*
CLR-3 :	*Illustrate the Bio-inspired Optimization Techniques*
CLR-4 :	*Give insights into Fuzzy logic and Neural networks*
CLR-5 :	*Acquaint students with optimization in Static and Dynamic Applications*

Course Learning Outcomes (CLO):	*At the end of this course, learners will be able to:*	Learning 1 Level of Thinking (Bloom)	Learning 2 Expected Proficiency (%)	Learning 3 Expected Attainment (%)	PLO 1 Engineering Knowledge	PLO 2 Problem Analysis	PLO 3 Design & Development	PLO 4 Analysis, Design, Research	PLO 5 Modern Tool Usage	PLO 6 Society & Culture	PLO 7 Environment & Sustainability	PLO 8 Ethics	PLO 9 Individual & Team Work	PLO 10 Communication	PLO 11 Project Mgt. & Finance	PLO 12 Life Long Learning	PLO 13 PSO - 1	PLO 14 PSO - 2	PLO 15 PSO – 3
CLO-1 :	*Correlate single and multivariable optimization*	*1*	*80*	*75*	*H*	*M*	*M*	*M*	*H*	*M*	*M*	*H*	*M*	*M*	*H*	*H*	*H*	*H*	*H*
CLO-2 :	*Apply the direct and indirect methods for constrained optimization problem*	*2*	*85*	*80*	*H*	*H*	*H*	*M*	*L*	*M*	*M*	*M*	*M*	*M*	*H*	*H*	*H*	*H*	*H*
CLO-3 :	*Solve Multi objective optimization problems*	*3*	*85*	*80*	*H*	*H*	*H*	*H*	*L*	*M*	*M*	*M*	*M*	*M*	*H*	*H*	*H*	*H*	*H*
CLO-4 :	*Develop the Fuzzy logic and Neural networks*	*3*	*80*	*75*	*H*	*H*	*H*	*H*	*L*	*M*	*M*	*M*	*M*	*M*	*H*	*H*	*H*	*H*	*H*
CLO-5 :	*Apply optimization techniques in Static and Dynamic Applications*	*3*	*85*	*80*	*H*	*H*	*H*	*H*	*L*	*M*	*M*	*M*	*H*	*M*	*H*	*H*	*H*	*H*	*H*

		Unconstrained Optimization Techniques	Constrained Optimization Techniques I	Advanced Optimization Techniques	Fuzzy logic and Neural networks	Static and Dynamic Applications
Duration (hour)		9	9	9	9	9
S-1	SLO-1 SLO-2	*Unconstrained Optimization*	*Constrained Optimization*	*Advanced Optimization*	*Fuzzy logic and Neural networks*	*Static and Dynamic Applications*
S-2	SLO-1 SLO-2	*Classification of optimization problems*	*Optimization with equality constraints*	*Multi stage optimization – dynamic programming*	*Fuzzy Set Theory*	*Structural Design applications*
S-3	SLO-1 SLO-2	*General principles of optimization*	*Optimization with inequality constraints*	*Multi stage optimization –stochastic programming*	*Optimization of Fuzzy Systems*	*Design and optimization of shafts*
S-4	SLO-1 SLO-2	*Problem formulation*	*Introduction to Direct methods*	*Multi objective optimization*	*Computational Procedure and Numerical Results*	*Design and optimization of springs*
S-5	SLO-1 SLO-2	*Single variable optimization*	*Introduction to Indirect methods*	*Genetic algorithms*	*Demonstration of Fuzzy logic using Matlab*	*Introduction to Dynamic Applications*
S-6	SLO-1 SLO-2	*Multivariable optimization*	*Indirect methods using penalty functions*	*Simulated Annealing algorithm*	*Introduction to Neural networks*	*Optimum design of single, two degree of freedom systems*
S-7	SLO-1 SLO-2	*Techniques of unconstrained minimization*	*Indirect methods using Lagrange multipliers*	*Problems on Genetic algorithms and Simulated Annealing algorithm*	*Neural-Network-Based Optimization*	*Optimum design of vibration absorbers*
S-8	SLO-1 SLO-2	*Search methods*	*Geometric programming*	*Ant colony Optimization*	*Feedforward networks for Classification and Regression*	*Application of optimization in Mechanisms*
S-9	SLO-1 SLO-2	*Interpolation methods*	*Problems on Geometric programming*	*Particle Swarm Optimization*	*Demonstration of Neural network using Matlab*	*Optimum design of simple linkage mechanisms*

Learning Resources	1. *S. SingaresuRao, "Engineering Optimization – Theory & Practice", New Age International (P) Limited, New Delhi, 2016.* 2. *D.K. PratiharNarosa , "Soft Computing: Fundamentals and Applications", Publishing House, New-Delhi, 2014*	3. *Kalyanamoy Deb, "Optimization for Engineering design algorithms and Examples", Prentice Hall of India Pvt. 2012.* 4. *Goldberg, D.E., "Genetic algorithms in search, optimization and machine", Barnen, Addison- Wesley, New York, 2008.*

Learning Assessment											
	Bloom's Level of Thinking	Continuous Learning Assessment (50% weightage)								Final Examination (50% weightage)	
		CLA – 1 (10%)		CLA – 2 (15%)		CLA – 3 (15%)		CLA – 4 (10%)#			
		Theory	Practice	Theory	Practice	Theory	Practice	Theory	Practice	Theory	Practice
Level 1	Remember Understand	*40 %*	-	*30 %*	-	*30 %*	-	*30 %*	-	*30%*	-
Level 2	Apply Analyze	*40 %*	-	*40 %*	-	*40 %*	-	*40 %*	-	*40%*	-
Level 3	Evaluate Create	*20 %*	-	*30 %*	-	*30 %*	-	*30 %*	-	*30%*	-
	Total	100 %		100 %		100 %		100 %		100 %	

CLA – 4 can be from any combination of these: Assignments, Seminars, Tech Talks, Mini-Projects, Case-Studies, Self-Study, MOOCs, Certifications, Conf. Paper etc.,

Course Designers		
Experts from Industry	Experts from Higher Technical Institutions	Internal Experts
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Course Code	18AUE442T	Course Name	MULTIBODY DYNAMICS	Course Category	E	Professional Elective	L	T	P	C
							3	0	0	3

Pre-requisite Courses	18MAB202T	Co-requisite Courses	Nil	Progressive Courses	Nil
Course Offering Department	Automobile Engineering	Data Book / Codes/Standards	Nil		

Course Learning Rationale (CLR):	The purpose of learning this course is to:
CLR-1 :	*Understand the basics of multibody systems*
CLR-2 :	*Analyze kinematic parameters of multibody systems using computational approach*
CLR-3 :	*Solve for dynamics of multibody systems using computational approach*
CLR-4 :	*Model simple mechanisms and write its constraint equations*
CLR-5 :	*Simulate planar and spatial mechanisms using standard MBD package*

Course Learning Outcomes (CLO):	At the end of this course, learners will be able to:	Learning 1: Level of Thinking (Bloom)	2: Expected Proficiency (%)	3: Expected Attainment (%)	PLO 1: Engineering Knowledge	2: Problem Analysis	3: Design & Development	4: Analysis, Design, Research	5: Modern Tool Usage	6: Society & Culture	7: Environment & Sustainability	8: Ethics	9: Individual & Team Work	10: Communication	11: Project Mgt. & Finance	12: Life Long Learning	13: PSO - 1	14: PSO - 2	15: PSO – 3
CLO-1 :	*formulate a model and free body diagram of multibody systems*	1	80	70	H	H	H	H	L	L	L	M	L	M	L	H	H	M	M
CLO-2 :	*derive the equations of motion of a multibody system*	2	80	70	H	H	H	H	L	L	L	M	L	M	L	H	H	M	M
CLO-3 :	*incorporate constraints into a multibody system*	2	80	70	H	H	H	H	L	L	L	M	L	M	L	H	H	M	M
CLO-4 :	*simulate the motion of a multibody system with a computer*	3	90	80	H	H	H	H	H	L	L	M	L	M	L	H	H	M	M
CLO-5 :	*interpret and analyze the results of simulation*	3	90	80	H	H	H	H	H	L	L	M	L	M	L	H	H	M	M

		Multibody Systems Introduction	Kinemaic and Dynamic Analysis	Kinematics of Mechanical Systems	Constrained Kinematics	Applications to Simple Mechanisms
Duration (hour)		9	9	9	9	9
S-1	SLO-1 / SLO-2	*Classical approach*	*Position analysis*	*Mechanical joints*	*Kinematics of a point moving on a rigid body*	*Computer formulation of joint constraints*
S-2	SLO-1	*Emergence of computational dynamics*	*Velocity analysis*	*Constraint equation for planar joints*	*Constrained kinematics*	*Computer algorithm*
	SLO-2	*Rigid / flexible multibody systems*	*Acceleration analysis*	*Constraint equation for planar joints*	*Constrained kinematics*	*Computer algorithm*
S-3	SLO-1	*Degrees of freedom*	*Two DOF robot manipulator –kinematic analysis*	*Constraint equation for spatial joints*	*Absolute co-ordinates*	*Flowchart for kinematic analysis*
	SLO-2	*Constrained / unconstrained motion*	*Two DOF robot manipulator –kinematic analysis*	*Constraint equation for spatial joints*	*Driving co-ordinates*	*Flowchart for kinematic analysis*
S-4	SLO-1	*Mechanical joints overview*	*Classical Versus computational approach*	*Mobility criteria*	*Formulation of joint constraints*	*Kinematic modeling and analysis*
	SLO-2	*Prismatic joint*	*General purpose computer program*	*Numerical –slider crank mechanism*	*Ground constraints*	*Kinematic modeling and analysis*
S-5	SLO-1	*Revolute joint*	*Force analysis overview*	*Co-ordinate transformation*	*Revolute and prismatic joint*	*Application to slider crank mechanism*
	SLO-2	*Cylindrical joint*	*Inertia forces*	*Co-ordinate transformation*	*Application to two DOF system*	*Application to slider crank mechanism*
S-6	SLO-1	*Spherical joint*	*Joint forces*	*Rigid body displacement*	*Constraint equations for cams and followers*	*Prescribed rotation of crank shaft*
	SLO-2	*Higher pairs*	*External forces*	*Position equations*	*Constraint equations for gears*	*Prescribed rotation of slider bock*
S-7	SLO-1	*Cam and gear systems*	*Principle of virtual work*	*Velocity equations*	*Computational methods in kinematics*	*Constrained dynamics*
	SLO-2	*Four bar mechanism*	*Use of redundant system*	*Acceleration equations*	*Kinematically driven systems*	*Augmented formulation*
S-8	SLO-1	*Slider crank mechanism*	*Forward dynamics*	*Slider crank mechanism*	*Velocity analysis*	*Embedding technique*
	SLO-2	*Closed chain systems*	*Inverse dynamics*	*Offset slider crank mechanism*	*Computer implementation to simple four bar mechanism*	*Amalgamated formulation*
S-9	SLO-1	*Open chain systems*	*Planar dynamics*	*Singular configuration*	*Computer implementation to simple four bar mechanism*	*Open and closed chains*
	SLO-2	*Robotic manipulators*	*Spatial dynamics*	*Four bar mechanism*	*Numerical based on four bar mechanism*	*Open and closed chains*

Learning Resources	1. *Ahmed A Shabana., "Computational Dynamics ", third edition, Wiley & Sons* 2. *Fundamentals of multibody dynamics : theory and applications, first edition, FaridAmirouche*	3. *Kinematic and dynamic simulation of multibody systems, first edition Garcia De Jalon* 4. *Dynamics of multibody systems by Ahmed A Shabana, third edition*

Learning Assessment											
	Bloom's Level of Thinking	Continuous Learning Assessment (50% weightage)								Final Examination (50% weightage)	
		CLA – 1 (10%)		CLA – 2 (15%)		CLA – 3 (15%)		CLA – 4 (10%)#			
		Theory	Practice	Theory	Practice	Theory	Practice	Theory	Practice	Theory	Practice
Level 1	Remember Understand	*40 %*	-	*30 %*	-	*30 %*	-	*30 %*	-	*30%*	-
Level 2	Apply Analyze	*40 %*	-	*40 %*	-	*40 %*	-	*40 %*	-	*40%*	-
Level 3	Evaluate Create	*20 %*	-	*30 %*	-	*30 %*	-	*30 %*	-	*30%*	-
	Total	100 %		100 %		100 %		100 %		100 %	

CLA – 4 can be from any combination of these: Assignments, Seminars, Tech Talks, Mini-Projects, Case-Studies, Self-Study, MOOCs, Certifications, Conf. Paper etc.,

Course Designers		
Experts from Industry	Experts from Higher Technical Institutions	Internal Experts
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2. Mr.V.Raja Raman Altair *rajarav@asiapac.altair.com*	*2. Dr. R Kannan, PSNA* *Kannanjothy@gmail.com*	*2. Mr.S.SenthilKumar, SRMIST* *senthils6@srmist.edu.in*

Course Code	18AUE443T	Course Name	FINITE ELEMENT ANALYSIS	Course Category	E	Professional Elective	L	T	P	C
							3	0	0	3

Pre-requisite Courses	18MEC106T	Co-requisite Courses	Nil	Progressive Courses	Nil
Course Offering Department	Automobile Engineering	Data Book / Codes/Standards	Nil		

Course Learning Rationale (CLR):	The purpose of learning this course is to:
CLR-1 :	*Predict how a product reacts to real-world forces, vibration, heat, fluid flow, and other physical effects*
CLR-2 :	*Model any physical system in to a finite element model and solve for its field variables*
CLR-3 :	*Solve real world complex problems which cannot be solved by analytical methods*
CLR-4 :	*Practice few commercial standard packages in solving complex problems*
CLR-5 :	*Understand the basics of multibody systems*

		Learning			Program Learning Outcomes (PLO)														
		1	2	3	1	2	3	4	5	6	7	8	9	10	11	12	13	14	15
Course Learning Outcomes (CLO):	At the end of this course, learners will be able to:	Level of Thinking (Bloom)	Expected Proficiency (%)	Expected Attainment (%)	Engineering Knowledge	Problem Analysis	Design & Development	Analysis, Design, Research	Modern Tool Usage	Society & Culture	Environment & Sustainability	Ethics	Individual & Team Work	Communication	Project Mgt. & Finance	Life Long Learning	PSO - 1	PSO - 2	PSO – 3
CLO-1 :	*Apply finite element technique to Engineering problems*	2	80	70	H	H	M	H	H	M	M	H	M	M	L	M	H	M	M
CLO-2 :	*Improve their ability in solving differential equations for real world problems*	2	70	60	H	H	H	M	H	M	M	H	M	M	L	M	H	M	M
CLO-3 :	*Equip themselves familiar with multi-domain phenomenon like thermo-structural problems*	1	80	70	M	H	H	H	H	M	M	H	M	M	L	M	H	M	M
CLO-4 :	*Familiarize themselves with the applications of finite element method & FEA packages*	3	90	90	M	H	H	M	H	M	M	H	M	M	L	M	H	M	M
CLO-5 :	*Solve kinematic and dynamic problems of multibody systems*	2	70	60	H	M	M	M	H	M	M	H	M	M	L	M	H	M	M

Duration (hour)		History and basics of FEA	One dimensional Problems	Two dimensional Problems	Multidomain Problems	Applications of FEA
		9	9	9	9	9
S-1	SLO-1	*Comparison Of FEA With Exact*	*Elements and node numbering*	*Two dimensional elements*	*Vibration analysis introduction*	*Introduction and basics*
	SLO-2	*Solutions*				
S-2	SLO-1	*Methods of engineering analysis*	*Global and local co-ordinates*	*Plane stress formulation*	*Vibration analysis introduction*	*Roll cage analysis*
	SLO-2	*Numerical methods*	*Natural co-ordinates*	*Plane strain formulation*	*Modal analysis of a structure*	*Roll cage analysis*
S-3	SLO-1	*Types of finite elements*	*Polynomial functions*	*CST element*	*Modal analysis of a structure*	*Rotor thermal analysis*
	SLO-2	*Displacement or shape function*	*Displacement function for 1D bar element*	*Shape function derivation for CST element*	*fluid flow problems*	*Rotor thermal analysis*
S-4	SLO-1	*Material behavior*	*General stiffness matrix derivation*	*Strain displacement matrix for CST element*	*fluid flow problems*	*Hub analysis*
	SLO-2	*Stiffness matrix*	*Stiffness matrix for 1D bar element*	*Stress strain matrix for CST element*	*fluid flow problems*	*Knuckle analysis*
S-5	SLO-1	*Steps involved in FEA –preprocessing and solution*	*Assembly of stiffness matrix*	*Stiffness matrix derivation for CST element*	*Heat transfer problems*	*Brake pedal analysis*
	SLO-2	*Post processing*	*Force vector*	*Temperature effects*	*Heat transfer problems*	*Brake pedal analysis*
S-6	SLO-1	*2D and 3D stress element*	*Spring element*	*LST element*	*Heat transfer problems*	*Bump analysis*
	SLO-2	*Strain-displacement relationships*	*Stiffness matrix for spring element*	*QST element*	*Heat transfer problems*	*Bump analysis*
S-7	SLO-1	*Discretization methods*	*Boundary conditions*	*Axi –symmetric formulation*	*Thermo structural analysis*	*Multbodydynamics applications*
	SLO-2	*Discretization process*	*Imposing boundary conditions to bar element*	*Isoparametric formulation*	*Thermo structural analysis*	*Forward and Inverse dynamics*
S-8	SLO-1	*Rayleigh ritz method*	*Beam element*	*Iso, sub. Super parametric element formulation*	*Thermo structural analysis*	*Planar dynamics*
	SLO-2	*Galerkin method*	*Stiffness matrix derivation of beam element*	*Four noded quadrilateral element*	*Thermo structural analysis*	*Spatial dynamics*
S-9	SLO-1	*Advantages and disadvantages of FEA*	*Truss element*	*1D heat conduction problems*	*Introduction to biomedical and MEMS applications*	*Application Of MBD Technique To Four-Bar Mechanisms*
	SLO-2	*Applications of FEA*	*Stiffness matrix for truss element*	*Derivation of stiffness matrix*	*Introduction to biomedical and MEMS applications*	*Application Of MBD Technique Slider Crank Mechanisms*

Learning Resources	
	1. *David V. Hutton, "Fundamentals of Finite Element Analysis", Tata McGraw Hill Publishing Company Ltd., New Delhi, 2005* 2. *Ahmed A Shabana., "Computational Dynamics ", Wiley &Sons.third edition* 3. *Bhavikatti S.S., "Finite Element Analysis", New Age International Publishers, New Delhi, 2008.* 4. *ErdoganMadenci, Ibrahim Guven, "the finite element method and applications in engineering using ansys", Springer (India) Private Limited, New Delhi, 2011.*

Learning Assessment											
	Bloom's Level of Thinking	Continuous Learning Assessment (50% weightage)								Final Examination (50% weightage)	
		CLA – 1 (10%)		CLA – 2 (15%)		CLA – 3 (15%)		CLA – 4 (10%)#			
		Theory	Practice	Theory	Practice	Theory	Practice	Theory	Practice	Theory	Practice
Level 1	Remember Understand	*40 %*	-	*30 %*	-	*30 %*	-	*30 %*	-	*30%*	-
Level 2	Apply Analyze	*40 %*	-	*40 %*	-	*40 %*	-	*40 %*	-	*40%*	-
Level 3	Evaluate Create	*20 %*	-	*30 %*	-	*30 %*	-	*30 %*	-	*30%*	-
	Total	100 %		100 %		100 %		100 %		100 %	

CLA – 4 can be from any combination of these: Assignments, Seminars, Tech Talks, Mini-Projects, Case-Studies, Self-Study, MOOCs, Certifications, Conf. Paper etc.,

Course Designers		
Experts from Industry	Experts from Higher Technical Institutions	Internal Experts
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2. Mr.V.Raja Raman Altair rajarav@asiapac.altair.com	*2. Dr.M.Rajesh, Arbaminch institute of technology Rajesh.m@amu.edu.et*	*2. Mr.S.SenthilKumar, SRMIST senthils6@srmist.edu.in*

Course Code	18AUE202T	Course Name	SENSORS, ACTUATORS AND SIGNAL CONDITIONERS	Course Category	E	Professional Elective	L	T	P	C
							3	0	0	3

Pre-requisite Courses	Nil	Co-requisite Courses	Nil	Progressive Courses	Nil
Course Offering Department	Automobile Engineering	Data Book / Codes/Standards	Nil		

Course Learning Rationale (CLR):	*The purpose of learning this course is to:*
CLR-1 :	*Define the sensors, their operations and select appropriate sensors for automotive applications*
CLR-2 :	*Define and classify the actuators and select to integrate them into an overall system.*
CLR-3 :	*Identify signal conditioning operations and devices*
CLR-4 :	*Evaluate and analyze the sensors signals*
CLR-5 :	*Compare the input signals and select appropriate data conversion methods.*

Course Learning Outcomes (CLO):	*At the end of this course, learners will be able to:*	Learning 1: Level of Thinking (Bloom)	Learning 2: Expected Proficiency (%)	Learning 3: Expected Attainment (%)	PLO 1: Engineering Knowledge	PLO 2: Problem Analysis	PLO 3: Design & Development	PLO 4: Analysis, Design, Research	PLO 5: Modern Tool Usage	PLO 6: Society & Culture	PLO 7: Environment & Sustainability	PLO 8: Ethics	PLO 9: Individual & Team Work	PLO 10: Communication	PLO 11: Project Mgt. & Finance	PLO 12: Life Long Learning	PLO 13: PSO - 1	PLO 14: PSO - 2	PLO 15: PSO – 3
CLO-1 :	*Acquire the knowledge of construction and operation of sensors and its applications in automobiles*	*1,2*	*90*	*85*	*H*	*M*	*L*	*L*	*L*	*L*	*M*	*L*	*M*	*M*	*L*	*H*	*H*	*M*	*L*
CLO-2 :	*Understand the basics of actuators and its operations*	*1,2*	*90*	*85*	*H*	*H*	*M*	*H*	*M*	*M*	*M*	*L*	*M*	*L*	*L*	*H*	*H*	*M*	*L*
CLO-3 :	*Know the fundamentals of signals conditioning and devices and its operation*	*2*	*90*	*85*	*H*	*H*	*M*	*H*	*M*	*M*	*M*	*L*	*M*	*L*	*L*	*M*	*H*	*M*	*L*
CLO-4 :	*Applications of operational amplifier and its applications*	*3*	*85*	*80*	*H*	*H*	*M*	*H*	*M*	*M*	*M*	*L*	*M*	*L*	*L*	*M*	*H*	*M*	*L*
CLO-5 :	*Learn and implement the basics of data conversion devices*	*2*	*85*	*80*	*H*	*H*	*M*	*H*	*M*	*M*	*M*	*L*	*M*	*L*	*L*	*H*	*H*	*M*	*L*

		Automotive Sensors	Automotive Actuators	Introduction To Op-Amp	Operational Amplifier Applications	Waveform Generators, A/D And D/A Convertors
Duration (hour)		9	9	9	9	9
S-1	SLO-1	*Introduction to sensors*	*Basics of actuators and its principles of operations.*	*Introduction – Signal conditioning operations.*	*Applications of operational amplifiers*	*Comparator introduction*
	SLO-2	*Variables to be measured for automotive Engine control applications*	*Variables to be controlled for automotive Engine control applications.*	*Basics of operational amplifier*	*Basics of Instrumentation amplifiers*	*Comparator Applications*
S-2	SLO-1	*Airflow Rate Sensor – Construction and operations*	*Pulse width Modulated signal*	*Ideal operational amplifier Introduction*	*Operational amplifier using diodes- Half wave*	*Regenerative Comparator Introduction*
	SLO-2	*Pressure Measurement – Strain Gauge and MAP sensor*	*H-bridge device for speed and direction control.*	*Ideal operational amplifier characteristics*	*Full wave rectifiers*	*Square Wave Generator*
S-3	SLO-1	*Engine Crank Position sensor - -Magnetic reluctance,*	*Electric motor actuator - DC motor, Brushless DC Motor*	*Operational amplifier- open and closed loop*	*Precision diodes*	*Astable Multivibrator*
	SLO-2	*Hall effect sensor Construction and Operation*	*Stepper Motor mechanism*	*Operational amplifier- Inverting, Non-Inverting amplifier.*	*Sample and Hold circuits*	*Monostable Multivibrator*
S-4	SLO-1	*Optical crank position Construction and Operation*	*Servomechanism*	*Voltage follower*	*Voltage to Current converters*	*Bistable Multivibrator*
	SLO-2	*Throttle angle sensor construction and operations.*	*Engine control actuators -Fuel injector*	*Differential amplifier*	*Current to Voltage converters*	*Introduction to Analog to Digital Converters*
S-5	SLO-1	*Temperature Sensor construction and operations and types.*	*Ignition coil operation*	*Difference mode gain*	*Applications of operational amplifiers as Adder*	*Types of Analog to Digital Converters*
	SLO-2	*Sensors for Engine feedback control - EGO sensor, EGO characteristics*	*EGR Actuator operation*	*Common mode gain*	*Applications of operational amplifiers as Subtractor*	*Direct Type ADC – Flash Type*
S-6	SLO-1	*White Band Lambda sensor*	*Electric actuators- Introduction.*	*Common Mode Rejection Ratio*	*Applications of operational amplifiers as Multiplier*	*Direct Type ADC – Successive approximation type*
	SLO-2	*Magnetostrictive principle and Knock sensor*	*Relays – Construction and Operation*	*Operation amplifier internal circuit*	*Applications of operational amplifiers as divider*	*Numerical Examples for ADC*

S-7	SLO-1	*Oil Pressure sensors*	*Reed switches - Construction and Operation*	*DC characteristics of operational amplifier*	*Applications of operational amplifiers as Differentiator*	*Basics of Digital to Analog Conversion Techniques*
	SLO-2	*Accelerometer construction and operations*	*Actuators applications*	*IC 741 internal circuit Introduction*	*Applications of operational amplifiers as Integrator*	*R-2R Ladder DAC*
S-8	SLO-1	*Gyro sensors construction and operations*	*Electric Power Assisted Steering*	*IC 741 Operations*	*Instrumentation amplifier application*	*Inverted R-2R Ladder DAC*
	SLO-2	*Inertial measurement unit*	*Rain sensing wipers*	*Filters – Introduction*	*Instrumentation amplifier application. Cont*	*Weighted Resistor type DAC*
S-9	SLO-1	*Sensors for climate control*	*Motorized seat position control*	*High pass and low pass Filter*	*Voltage comparator*	*Numerical Examples for weighted resistor*
	SLO-2	*Switches and Knobs*	*Power Window application*	*Band pass Filter*	*Peak detector*	*Numerical Examples for R-2R and Inverted R-2R*

Learning Resources	*1. William. B. Ribbens, "Understanding Automotive Electronics" 8th Edition Butterworth-Heinemann publications, 2017.* *2. Ronald. K. Jurgan "Automotive Electronics Handbook", 2nd Edition , McGraw-Hill, Inc 1999* *3. Robert F. Coughlin, Frederick F. Driscoll, "Operational Amplifiers and Linear Integrated Circuits", 6th Edition, PHI, 2000.*	*4. D.Roy Choudhry, Shail Jain, "Linear Integrated Circuits", New Age International Pvt. Ltd., 2000* *5. Sergio Franco, "Design with Operational Amplifiers and Analog Integrated Circuits", 3rd Edition, Tata Mc Graw-Hill, 2007.*

Learning Assessment

	Bloom's Level of Thinking	Continuous Learning Assessment (50% weightage)								Final Examination (50% weightage)	
		CLA – 1 (10%)		CLA – 2 (15%)		CLA – 3 (15%)		CLA – 4 (10%)#			
		Theory	Practice	Theory	Practice	Theory	Practice	Theory	Practice	Theory	Practice
Level 1	Remember Understand	*40 %*	-	*30 %*	-	*30 %*	-	*30 %*	-	*30%*	-
Level 2	Apply Analyze	*40 %*	-	*40 %*	-	*40 %*	-	*40 %*	-	*40%*	-
Level 3	Evaluate Create	*20 %*	-	*30 %*	-	*30 %*	-	*30 %*	-	*30%*	-
	Total	100 %		100 %		100 %		100 %		100 %	

CLA – 4 can be from any combination of these: Assignments, Seminars, Tech Talks, Mini-Projects, Case-Studies, Self-Study, MOOCs, Certifications, Conf. Paper etc.,

Course Designers

Experts from Industry	Experts from Higher Technical Institutions	Internal Experts
1. Mr.Jegan Amirthalingam, Senior Educator, KPIT a.jegan@kpit.com	*1. Mr. Sam Jebakumar, SRM IST, jebakumj@srmist.edu.in*	*1. Mr. N Ganesh Kumar, SRMIST*
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Course Code	18AUE351T	Course Name	AUXILIARY VEHICLE SYSTEMS	Course Category	E	Professional Elective	L	T	P	C
							3	0	0	3

Pre-requisite Courses	18AUC302J	Co-requisite Courses	Nil	Progressive Courses	Nil
Course Offering Department	Automobile Engineering	Data Book / Codes/Standards	Nil		

Course Learning Rationale (CLR):	*The purpose of learning this course is to:*
CLR-1 :	*Recognize the vehicle motion control and stabilization system*
CLR-2 :	*Identify the importance of Driver assistance, security and warning system*
CLR-3 :	*Buildthe knowledge of Safety and comfort system*
CLR-4 :	*Understand the auxiliary systems of chassis.*
CLR-5 :	*Assess the automotive Safety System*

Course Learning Outcomes (CLO):	*At the end of this course, learners will be able to:*	Learning			Program Learning Outcomes (PLO)														
		1	2	3	1	2	3	4	5	6	7	8	9	10	11	12	13	14	15
		Level of Thinking (Bloom)	Expected Proficiency (%)	Expected Attainment (%)	Engineering Knowledge	Problem Analysis	Design & Development	Analysis, Design, Research	Modern Tool Usage	Society & Culture	Environment & Sustainability	Ethics	Individual & Team Work	Communication	Project Mgt. & Finance	Life Long Learning	PSO - 1	PSO - 2	PSO – 3
CLO-1 :	*Understand the vehicle motion control and stabilization system*	*2*	*85*	*80*	*H*	*H*	*H*	*H*	*L*	*L*	*L*	*L*	*H*	*L*	*L*	*L*	*H*	*M*	*H*
CLO-2 :	*Know the importance of Driver assistance, security and warning system*	*2*	*85*	*80*	*H*	*H*	*H*	*M*	*L*	*L*	*L*	*H*	*H*	*L*	*L*	*L*	*H*	*M*	*H*
CLO-3 :	*Know the working of the compartment while moving of the vehicle, about the collapsible steering and tillable steering column, about the collision avoidance system, front and rearObject detection.*	*2*	*85*	*80*	*H*	*H*	*H*	*M*	*L*	*L*	*L*	*H*	*H*	*L*	*L*	*L*	*H*	*M*	*H*
CLO-4 :	*Understand the auxiliary systems of chassis.*	*2*	*85*	*80*	*H*	*M*	*H*	*H*	*L*	*L*	*L*	*L*	*H*	*L*	*L*	*L*	*H*	*M*	*H*
CLO-5 :	*Know the various types of safety aspects such as active and passive safety, the active safety components and the working passive safety components such as air bags, seat belts*	*2*	*85*	*80*	*H*	*H*	*H*	*H*	*L*	*L*	*L*	*H*	*H*	*L*	*L*	*L*	*H*	*M*	*H*

		Vehicle Motion Control and Stabilization System	Information, Security and Warning System	Comfort Systems	Chassis Auxiliary System	Safety System
Duration (hour)		9	9	9	9	9
S-1	SLO-1	*Introduction*	*Vehicle integration*	*Heating, Ventilation*	*Needs for Auxiliary systems*	*Seat belt, Seat belt tightener system and importance.*
	SLO-2	*Introduction*	*Vehicle integration*	*Heating, Ventilation*	*Needs for Auxiliary systems*	*Seat belt, Seat belt tightener system and importance.*
S-2	SLO-1	*Antilock braking system,*	*And navigation system*	*And Air Conditioning Systems*	*Power Assisted Steering System*	*Collapsible Steering Column,*
	SLO-2	*Stability Control*	*Looking out sensors*	*Principles and working*	*Working principle*	*Air Bags Deployment System*
S-3	SLO-1	*Adaptive cruise control*	*And Looking in sensors,*	*Electronic Outside Rear View Mirror (OVRM)*	*Regenerative Braking System*	*Designing aspects of automotive bumpers*
	SLO-2	*Lane Keep Assist System*	*Intelligent vision system,*	*Rain Sensing Wiper System*	*Principle and operation*	*Designing aspects of automotive bumpers*
S-4	SLO-1	*CollisionWarning*	*Vehicle Integration system.*	*Environment Information System*	*Servo Brake*	*Materials for bumpers.*
	SLO-2	*avoidance system,*	*Global Positioning System.*	*Tilt Able Steering Wheel,*	*Servo Brake*	*Materials for bumpers.*
S-5	SLO-1	*Blind Spot Detection system,*	*Vehicle Navigation System.*	*Garage Door Opening System*	*Vehicle Retarders*	*Steering and mirroradjustment,*
	SLO-2	*Blind Spot Detection system,*	*Road Network*	*Automatic Climate Control*	*Electrical retarders*	*Frontal Object Detection*
S-6	SLO-1	*Driver alertness detection system*	*Onboard Diagnosis System*	*Adaptive Head Light*	*Hydrodynamic retarders*	*Rear Vehicle Object Detection System*
	SLO-2	*Driver alertness detection system*	*Immobilizer*	*Night Vision Assist,*	*Advantages of retarders*	*Anti-roll bar*
S-7	SLO-1	*Electronic Transmission Control System*	*Anti-Theft Alarm System*	*Traffic Jam Assist*	*Hydro Elastic Suspension System*	*Emergency Brake Assist,*
	SLO-2	*Working principle*	*Voice Warning System*	*Hill Start Assist*	*Hydro Elastic Suspension System*	*Emergency Response*
S-8	SLO-1	*Electronic Brake Force Distribution System*	*Keyless Entry System*	*Need for Active suspension*	*Rubber Suspension*	*Child Lock System*
	SLO-2	*Electronic Brake Force Distribution System*	*Central Locking System*	*Need for Active suspension*	*Pneumatic Suspension*	*Child Lock System*
S-9	SLO-1	*Tutorial*	*Tire Pressure Monitoring System*	*Construction of active suspension*	*Drive By Wire System*	*Central locking system*
	SLO-2	*Tutorial*	*Tire Pressure Monitoring System*	*Working of active suspension*	*Brake by wire*	*Central locking system*

Learning Resources	1. William B. Ribbens, “Understanding Automotive Electronics”, 6th Edition, Newnes, 2003. 2. Robert N Brady "Automotive computers and Digital Instrumentation". A Reston Book, Prentice Hill, Eagle Wood Cliffs, New Jersey, 1988. 3. Ronald.K.Jurgen-“Automotive Electronics Handbook”-Second edition- McGraw -Hill Inc., -1999.	4. Dr. Kirpal Singh, “Automobile Engineering” Volume – 1, 12th Edition, Standard Publishers 5. BOSCH, Automotive Handbook, 6th Edition, Bentley publishers 6. Robert Bosch GmbH -“Safety, Comfort and Convenience Systems”-Wiley; 3rd edition, 2007

Learning Assessment

	Bloom's Level of Thinking	Continuous Learning Assessment (50% weightage)								Final Examination (50% weightage)	
		CLA – 1 (10%)		CLA – 2 (15%)		CLA – 3 (15%)		CLA – 4 (10%)#			
		Theory	Practice	Theory	Practice	Theory	Practice	Theory	Practice	Theory	Practice
Level 1	Remember Understand	*40 %*	-	*30 %*	-	*30 %*	-	*30 %*	-	*30%*	-
Level 2	Apply Analyze	*40 %*	-	*40 %*	-	*40 %*	-	*40 %*	-	*40%*	-
Level 3	Evaluate Create	*20 %*	-	*30 %*	-	*30 %*	-	*30 %*	-	*30%*	-
	Total	100 %		100 %		100 %		100 %		100 %	

CLA – 4 can be from any combination of these: Assignments, Seminars, Tech Talks, Mini-Projects, Case-Studies, Self-Study, MOOCs, Certifications, Conf. Paper etc.,

Course Designers

Experts from Industry	Experts from Higher Technical Institutions	Internal Experts
1. Mr.MyilavanPalanivel, WABCO India limited ,myilavan@gmail.com	*1. Dr.R.Ben Ruben, Sri Krishna College of Engineering and Technology, benrubenr@skcet.ac.in.*	*1. Mr,S.Devanand, SRMIST*
2. Mr.SureshMekalathuru, WABCO India limited, sureshme305@gmail.com	*2. Dr.S.Ramkumar, Vel Tech, drsramkumar@veltech.edu.*	*2. Dr. Edwin Geo V, SRMIST*

Course Code	18AUE352T	Course Name	TWO AND THREE WHEELER TECHNOLOGY	Course Category	E	Professional Elective	L	T	P	C
							3	0	0	3

Pre-requisite Courses	Nil	Co-requisite Courses	Nil	Progressive Courses	Nil
Course Offering Department	Automobile Engineering	Data Book / Codes/Standards	Nil		

Course Learning Rationale (CLR):	*The purpose of learning this course is to:*
CLR-1 :	*Impart knowledge on power plant and different systems in two wheelers*
CLR-2 :	*Know the arrangement of chassis in two wheelers and subsystems like transmission and suspension*
CLR-3 :	*Identify different brakes used in two wheelers and construction of wheels and tires*
CLR-4 :	*Understand Servicing, maintenance and troubleshooting techniques particularly for two wheelers*
CLR-5 :	*Gain knowledge on different types of three wheelers, pickup and delivery vans arrangements*

Course Learning Outcomes (CLO):	*At the end of this course, learners will be able to:*	Learning 1: Level of Thinking (Bloom)	2: Expected Proficiency (%)	3: Expected Attainment (%)	PLO 1: Engineering Knowledge	2: Problem Analysis	3: Design & Development	4: Analysis, Design, Research	5: Modern Tool Usage	6: Society & Culture	7: Environment & Sustainability	8: Ethics	9: Individual & Team Work	10: Communication	11: Project Mgt. & Finance	12: Life Long Learning	13: PSO - 1	14: PSO - 2	15: PSO – 3
CLO-1 :	*Classify the different power plants and systems arrangement of petrol and electric vehicles*	*1,2*	*90*	*85*	*H*	*M*	*H*	*H*	*H*	*M*	*M*	*L*	*M*	*M*	*L*	*M*	*H*	*H*	*H*
CLO-2 :	*Distinguish chassis and transmission systems arrangements in two wheelers*	*1,2*	*90*	*85*	*H*	*M*	*H*	*H*	*H*	*L*	*L*	*L*	*M*	*M*	*L*	*M*	*H*	*H*	*H*
CLO-3 :	*Classify different brakes and tires used in two wheelers and their applications*	*1,2*	*90*	*80*	*H*	*M*	*H*	*H*	*H*	*L*	*L*	*L*	*M*	*M*	*L*	*L*	*H*	*H*	*H*
CLO-4 :	*Gain knowledge on different servicing and troubleshooting techniques and case studies of two wheelers*	*1,2*	*80*	*75*	*H*	*H*	*H*	*H*	*H*	*L*	*L*	*L*	*M*	*M*	*L*	*L*	*H*	*H*	*H*
CLO-5 :	*Infer different types of three wheeler arrangements for different applications and case studies on recent models*	*1,2*	*90*	*85*	*H*	*H*	*H*	*H*	*M*	*L*	*L*	*L*	*M*	*M*	*L*	*M*	*H*	*H*	*H*

		Power plant	Chassis and sub systems	Brakes and wheels	Servicing, Maintenance, Trouble Shooting and Case Study of Major Indian Models	Three wheelers
Duration (hour)		9	9	9	9	9
S-1	SLO-1	*Power plant components*	*Chassis and sub systems-components*	*Brakes-introduction*	*Servicing-Introduction*	*Three wheelers-types*
	SLO-2	*Two stroke and four stroke SI engines - merits and demerits*	*Types of main frames.*	*Braking systems*	*Service procedure for two wheelers*	*Case study of Indian models*
S-2	SLO-1	*Symmetrical and unsymmetrical port timing diagram*	*Drive from engine to rear wheel*	*Drum brakes-principle, construction and working*	*Service procedure for two wheelers*	*Case study of Indian models*
	SLO-2	*Valve timing diagram.*	*chain drive – shaft drive*	*Disc brakes-principle, construction and working*	*Petrol engine tune up*	*Front engine auto rickshaws*
S-3	SLO-1	*Types of scavenging processes – merits and demerits.*	*Clutch requirements*	*Brake links layout – for front wheels – for rear wheels*	*Petrol engine tune up*	*Front engine auto rickshaws*
	SLO-2	*Scavenging efficiency, scavenging pumps*	*Single plate – multiple plates – centrifugal clutch.*	*Brake adjustment*	*Petrol engine tune up*	*Rear engine auto rickshaws*
S-4	SLO-1	*Fuel systems*	*Transmission (gear box)*	*Need of ABS for two wheelers*	*Preventive and scheduled maintenance in two wheelers*	*Rear engine auto rickshaws*
	SLO-2	*Carburetion, gasoline fuel injection systems. Lubrication systems.*	*gear controls and gear change mechanism*	*Single channel and dual channel ABS*	*Preventive and scheduled maintenance in two wheelers*	*Pickup vans*
S-5	SLO-1	*Ignition system – magneto coil spark ignition system*	*CVT for two wheelers*	*Wheels*	*Troubleshooting and maintenance of two-wheeler transmission*	*Delivery vans*
	SLO-2	*battery coil spark ignition system, electronic ignition system*	*Suspension*	*spokes wheel – cast wheel – disc wheel*	*Troubleshooting and maintenance of two-wheeler transmission*	*Trailers*
S-6	SLO-1	*Starting systems*	*Suspension – for front wheels*	*Tires*	*Troubleshooting of brakes and wheels*	*frames and transmission*
	SLO-2	*Kick starter and electrical systems.*	*Suspension – for rear wheels*	*Tire construction*	*Troubleshooting of brakes and wheels*	*frames and transmission*
S-7	SLO-1	*Electric scooter power plant*	*Telescopic and gas charged suspension*	*Tube and tubeless tires*	*Servicing and case study of major Indian models*	*wheel types*
	SLO-2	*Different types of batteries for electric scooters*	*Shock absorbers*	*Radial ply and cross ply tires*	*Servicing and case study of major Indian models*	*wheel mountings attachment*

S-8	SLO-1	*Different traction motors*	*Panel meters and controls on handle bar*	*Tubes – vulcanizing.*	*Case study of Electric scooters*	*Tyre types.*
	SLO-2	*Different traction motors*	*Panel meters and controls on handle bar*	*Tire requirements of electric vehicles*	*Case study of Electric scooters*	*Brake systems.*
S-9	SLO-1	*Tutorial*	*Tutorial*	*Tutorial*	*Tutorial*	*Tutorial*
	SLO-2	*Tutorial*	*Tutorial*	*Tutorial*	*Tutorial*	*Tutorial*

Learning Resources	*1. K.K. Ramalingam., "Two wheelers", Scitech Publications (India) Pvt. Ltd., Chennai 2012.* *2. William H crouse, "Automotive Mechanics", McGraw Hill Education; 10 edition 2017*	*3. Irving, P.E., "Motor cycle Engineering"., Veloce Enterprises, Inc.2017* *4. Tim Gilles., "Automotive service".,Delmar Cengage Learning; 4th edition edition, 2011* *5. Manufacturers manual of various vehicles*

Learning Assessment

	Bloom's Level of Thinking	Continuous Learning Assessment (50% weightage)								Final Examination (50% weightage)	
		CLA – 1 (10%)		CLA – 2 (15%)		CLA – 3 (15%)		CLA – 4 (10%)#			
		Theory	Practice	Theory	Practice	Theory	Practice	Theory	Practice	Theory	Practice
Level 1	Remember Understand	*70 %*	-	*60 %*	-	*60 %*	-	*50 %*	-	*50 %*	-
Level 2	Apply Analyze	*30 %*	-	*40 %*	-	*40 %*	-	*40 %*	-	*40 %*	-
Level 3	Evaluate Create	-	-	-	-	-	-	-	-	-	-
	Total	100 %		100 %		100 %		100 %		100 %	

CLA – 4 can be from any combination of these: Assignments, Seminars, Tech Talks, Mini-Projects, Case-Studies, Self-Study, MOOCs, Certifications, Conf. Paper etc.,

Course Designers

Experts from Industry	Experts from Higher Technical Institutions	Internal Experts
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2. Mr.R.Srikanth, Altair, srikanth.r@altair.com	*2. Mr. N.Ravikumar, Crescent Institute of Science and Technology, ravikumar@crescent.education*	*2. Mr.K.Devanathan, SRMIST*

Course Code	18AUE353T	Course Name	VEHICLE PERFORMANCE AND TESTING	Course Category	E	Professional Elective	L	T	P	C
							3	0	0	3

Pre-requisite Courses	18AUC302J	Co-requisite Courses	Nil	Progressive Courses	Nil
Course Offering Department	Automobile Engineering	Data Book / Codes/Standards	Nil		

Course Learning Rationale (CLR):	*The purpose of learning this course is to:*
CLR-1 :	*Learn about the various parameters that influence the performance of vehicles*
CLR-2 :	*Understand the engine performance characteristics and match with transmission related requirements*
CLR-3 :	*Learn about various vehicle tests conducted.*

Course Learning Outcomes (CLO):	*At the end of this course, learners will be able to:*	Learning 1: Level of Thinking (Bloom)	Learning 2: Expected Proficiency (%)	Learning 3: Expected Attainment (%)	PLO 1: Engineering Knowledge	PLO 2: Problem Analysis	PLO 3: Design & Development	PLO 4: Analysis, Design, Research	PLO 5: Modern Tool Usage	PLO 6: Society & Culture	PLO 7: Environment & Sustainability	PLO 8: Ethics	PLO 9: Individual & Team Work	PLO 10: Communication	PLO 11: Project Mgt. & Finance	PLO 12: Life Long Learning	PLO 13: PSO - 1	PLO 14: PSO - 2	PLO 15: PSO – 3
CLO-1 :	*Determine the parameters influencing vehicle performance and predict the performance*	*2*	*90*	*75*	*M*	*M*	*H*	*M*	*M*	*M*	*M*	*M*	*L*	*L*	*L*	*M*	*H*	*L*	*H*
CLO-2 :	*Diagnose the various engine sub systems for improving engine performance*	*2*	*80*	*80*	*M*	*M*	*H*	*M*	*M*	*H*	*H*	*H*	*L*	*L*	*L*	*M*	*H*	*L*	*H*
CLO-3 :	*Analyze the performance characteristics of transmission, braking and suspension systems*	*3*	*85*	*80*	*M*	*H*	*H*	*H*	*M*	*M*	*M*	*M*	*L*	*L*	*L*	*M*	*H*	*L*	*H*
CLO-4 :	*Study the operational performance of vehicles*	*1*	*90*	*85*	*M*	*M*	*H*	*M*	*M*	*M*	*M*	*M*	*L*	*L*	*L*	*M*	*H*	*L*	*H*
CLO-5 :	*Acquire knowledge about the various vehicle testing methods*	*2*	*85*	*80*	*M*	*M*	*H*	*M*	*M*	*M*	*M*	*M*	*L*	*L*	*L*	*M*	*H*	*L*	*H*

		Vehicle performance estimation and prediction	Engine performance diagnosis	Vehicle Transmission and control system performance	Operational performance	Vehicle Testing
Duration (hour)		9	9	9	9	9
S-1	SLO-1	*Estimate the aerodynamic drag of road vehicles*	*List the reasons for engine leakage*	*Identify the causes of clutch slippage and drag*	*Restate the engine performance parameters*	*Review the fundamentals of acoustics*
	SLO-2	*List the methods of estimation of resistance to vehicle motion*	*Discuss the cylinder leakage test*	*Identify the causes of clutch vibration*	*Discuss the operating characteristics of engines*	*Discuss the human response to sound*
S-2	SLO-1	*List the parameters involved in calculating power required for propulsion*	*Determine and locate the sources of engine noise*	*Recall the working of automatic transmission systems*	*Study the operation of engine at full load conditions*	*Explain the testing procedure for vehicle power*
	SLO-2	*Calculate the power required for propulsion*	*Suggest the methods of reducing noise from the various sources*	*Analyze the performance of automatic transmission systems*	*Study the operation of engine at part load conditions*	*Explain the testing procedure for evaluating fuel consumption*
S-3	SLO-1	*Analyze the power plant characteristics of vehicles*	*Interpret engine oil issues that affect engine performance*	*Analyze the performance of bands*	*Recall the various parameters influencing fuel economy*	*Explain the head light alignment testing*
	SLO-2	*Compare the power plant characteristics with the requirements of transmission system of vehicles*	*Analyze the effect of temperature and its measurement on engine performance*	*Analyze the performance of transmission fluids*	*Predict the influence of various parameters influencing fuel economy*	*Explain the light intensity testing*
S-4	SLO-1	*Study about the various vehicle controls*	*Identify the symptoms of cooling system failure*	*Describe the solenoid valve testing method*	*Recite the various conditions of vehicle running*	*Explain the road testing of vehicles*
	SLO-2	*Sketch the different arrangements in power train configuration*	*Diagnose the cooling system*	*Describe the diagnostic procedure for testing of driveline components*	*Discuss the effects of vehicle conditions on fuel economy*	*Classify and study the different test tracks for vehicle testing*
S-5	SLO-1	*Calculate the vehicle acceleration and maximum speed of vehicles*	*Identify the weak cylinder through power balance test*	*Categorize the various braking arrangements*	*Recall the various tyre and road conditions a vehicle is subjected to*	*Describe the initial inspection procedure in vehicle testing*
	SLO-2	*Estimate the grade ability performance of vehicles*	*Conduct compression test and identify the reasons for power loss*	*Analyze the performance and characteristics of braking systems*	*Predict the effect of various tyre and road conditions on fuel economy*	*Describe the PDI procedure in vehicle testing*
S-6	SLO-1	*List the various drive system of vehicles*	*Understand valve timing test*	*Predict the effect of weight transfer in vehicles*	*List the various traffic conditions*	*Explain the maximum speed estimation procedure*

	SLO-2	*Compare the various drive systems for vehicle requirements*	*Understand clearance test*	*Diagram the various steering system arrangements*	*Study the effect of various traffic conditions and driving habits on fuel economy*	*Explain the maximum acceleration estimation procedure*
S-7	SLO-1	*Study the hill climbing requirements*	*Estimate the intake system performance*	*Evaluate the performance of rigid suspension system*	*Recall the definition of turning circle radius of a vehicle*	*Quote the principles of brake testing of road vehicles*
	SLO-2	*Characterize the vehicle power requirements for hill climbing*	*Estimate the exhaust system performance*	*Analyze the characteristics of rigid suspension system*	*Formulate the turning circle radius test of a vehicle*	*Explain the procedure of brake testing of road vehicles*
S-8	SLO-1	*Define ride characteristics of vehicles*	*Estimate the boost pressure available from a turbocharger*	*Evaluate the performance of independent suspension system*	*Describe the testing of vehicles in a two-wheeler chassis dynamometer*	*Review the basic concepts of vehicle handling*
	SLO-2	*Study the ride characteristics of vehicles on different road surfaces*	*Analyze the effect of waste gate on boost pressure*	*Analyze the characteristics of independent suspension system*	*Evaluate the performance of vehicles in a two-wheeler chassis dynamometer*	*Evaluate the handling characteristics of vehicles on different road surfaces*
S-9	SLO-1	*Analyze the effect of pressure and temperature on power output*	*List the steps in no start diagnosis*	*Evaluate the performance of torsion bar, stabilize and radius bars*	*Describe the testing of vehicles in a four-wheeler chassis dynamometer*	*Review the basic concepts of side slip*
	SLO-2	*Analyze the effect of humidity on power output*	*Explain the scope testing of ignition systems*	*Analyze the characteristics of torsion bar, stabilize and radius bars*	*Evaluate the performance of vehicles in a four-wheeler chassis dynamometer*	*Explain the side slip determination method*

Learning Resources	1. *Martyr A.J, Plint M.A, Engine Testing Theory and Practice", 3rd edition, Butter worth-Heinemann, 2007. Butterworth - Heinemann, 2007.* 2. *Ken Pickerill, "Automotive Engineering Engine Performance Shop Manual", Cengage Learning, 2010*	3. *Gousha H. M, "Engine Performance Diagnosis & Tune Up Shop Manual".* 4. *Crouse. W. H, Anglin. D. L, "Motor Vehicle Inspection", McGraw Hill, 1978.* 5. *Giles J. G, "Vehicle Operation & Performance".*

Learning Assessment

	Bloom's Level of Thinking	Continuous Learning Assessment (50% weightage)								Final Examination (50% weightage)	
		CLA – 1 (10%)		CLA – 2 (15%)		CLA – 3 (15%)		CLA – 4 (10%)#			
		Theory	Practice	Theory	Practice	Theory	Practice	Theory	Practice	Theory	Practice
Level 1	Remember Understand	*40 %*	-	*30 %*	-	*30 %*	-	*30 %*	-	*30%*	-
Level 2	Apply Analyze	*40 %*	-	*40 %*	-	*40 %*	-	*40 %*	-	*40%*	-
Level 3	Evaluate Create	*20 %*	-	*30 %*	-	*30 %*	-	*30 %*	-	*30%*	-
	Total	100 %		100 %		100 %		100 %		100 %	

CLA – 4 can be from any combination of these: Assignments, Seminars, Tech Talks, Mini-Projects, Case-Studies, Self-Study, MOOCs, Certifications, Conf. Paper etc.,

Course Designers

Experts from Industry	Experts from Higher Technical Institutions	Internal Experts
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Course Code	18AUE354T	Course Name	TYRE TECHNOLOGY	Course Category	E	Professional Elective	L	T	P	C
							3	0	0	3

Pre-requisite Courses	Nil	Co-requisite Courses	Nil	Progressive Courses	Nil
Course Offering Department	Automobile Engineering	Data Book / Codes/Standards	Nil		

Course Learning Rationale (CLR):	*The purpose of learning this course is to:*
CLR-1 :	*Provide a broad overview of the basic aspects of the design, materials and operation of pneumatic vehicle tyres*
CLR-2 :	*Understand the engine performance characteristics and match with transmission related requirements*

Course Learning Outcomes (CLO):	*At the end of this course, learners will be able to:*	Learning 1: Level of Thinking (Bloom)	Learning 2: Expected Proficiency (%)	Learning 3: Expected Attainment (%)	PLO 1: Engineering Knowledge	PLO 2: Problem Analysis	PLO 3: Design & Development	PLO 4: Analysis, Design, Research	PLO 5: Modern Tool Usage	PLO 6: Society & Culture	PLO 7: Environment & Sustainability	PLO 8: Ethics	PLO 9: Individual & Team Work	PLO 10: Communication	PLO 11: Project Mgt. & Finance	PLO 12: Life Long Learning	PLO 13: PSO - 1	PLO 14: PSO - 2	PLO 15: PSO – 3
CLO-1 :	*Understand tyre design processes and its testing*	2	90	85	H	H	H	M	M	L	M	L	M	L	L	H	H	H	H
CLO-2 :	*Know about pneumatic tyre applications in various vehicles*	2	90	85	H	H	H	H	M	L	M	L	L	L	L	L	H	H	H
CLO-3 :	*Understand the forces and moments acting on the vehicle.*	3	90	85	H	H	H	M	H	L	H	H	L	L	L	L	M	M	M
CLO-4 :	*Evaluate various tyre analysis procedure*	1	90	85	H	H	H	H	H	L	M	L	L	L	L	L	M	M	M
CLO-5 :	*Know the tyre measurement techniques*	2	90	85	H	M	M	M	H	H	H	H	L	H	L	L	M	M	M

		Overview of tyre technology	Applications of Pneumatic Tyres	Mechanics of Pneumatic Tyres	Tyre Analysis	Tyre Measurement Techniques
Duration (hours)		9	9	9	9	9
S-1	SLO1 / SLO2	*Types-Diagonal- belted bias- radial bias*	*Bicycle Tyres*	*Tyre Axis system*	*Tyre Load Capacity*	*Tyre component Profilometer-Thickness control*
S-2	SLO1	*Industry Standards*	*Two Wheeler – Castoring Trail for Motor cycle*	*Rolling Resistance – Variation of Rolling resistance coeffiecient of bias ply and radial ply tyres with speed*	*TRA Formula , Basic Formula*	*On roll profile thickness measurement*
	SLO2	*Tyre components – Radial Tyre*	*Two Wheeler – Internal heat generation*	*Rolling Resistance – variation with surface textures*	*Constant, Pressure exponent, Section Diameter.*	*On roll profile thickness measurement*
S-3	SLO1	*Tyre Design Process*	*Passenger Car Tyres – Tyre ground Contact area*	*Rolling Resistance – Effect of Tyre diameter*	*Deflection Analysis:*	*Dimension control – length measurement*
	SLO2	*Tyre Design Process*	*Passenger Car Tyres – contact area shape*	*Rolling Resistance – Effect of Tractive and Braking effort*	*Deflection Analysis:*	*Dimension Control – Width measurement*
S-4	SLO1	*Tyre performance criteria outdoor test – Wear rate, Irregular wear*	*Passenger Car Tyres – distribution of ground contact Pressure*	*Tractive Effort and Longitudinal Slip - Behaviour of Tyre under driving torque*	*Deflection Analysis:*	*Tyre piece weight measurement*
	SLO2	*Tyre performance criteria outdoor test - Handling Dry,Wet and Snow*	*Passenger Car Tyres - deflation – effects of run – flat*	*Tractive Effort and Longitudinal Slip - Variation of Tractive effort with longitudinal Slip*	*Deflection Analysis:*	*Tyre colour inspection*
S-5	SLO1	*Tyre performance criteria outdoor test - Ride comfort*	*Truck Tyres Design*	*Tractive Effort and Longitudinal Slip - Behaviour of Tyre under braking torque*	*Sliding Abraration, Tyre Stiffness and Tyre wear*	*Tyre Geometry inspection*
	SLO2	*Tyre performance criteria outdoor test – Noise, Drift/Pull*	*Truck Tyres Design*	*Tractive Effort and Longitudinal Slip - Variation of braking effort with longitudinal Slip*	*Sliding Abraration, Tyre Stiffness and Tyre wear*	*Tyre Geometry Inspection*
S-6	SLO1	*Tyre performance criteria indoor test – High speed*	*Truck Tyres – Tread patterns*	*Cornering Properties - slip angle and cornering force*	*Sliding Abraration, Tyre Stiffness and Tyre wear*	*Tyre Mark Inspection*
	SLO2	*Tyre performance criteria indoor test – Endurance*	*Truck Tyres – Tread patterns*	*Cornering Properties - cornering characteristics of bias and radial ply tyres for cars and trucks*	*Sliding Abraration, Tyre Stiffness and Tyre wear*	*Retrofit- Tyre Geometry line*
S-7	SLO1	*Tyre performance criteria indoor test –Rolling resistance Vs Inflation*	*Truck Tyres – Tread compounds*	*Cornering Properties - Self aligning torque*	*Failure Analysis: Structural Failures*	*Retrofit- Tyre Uniformity line*
	SLO2	*Tyre performance criteria indoor test –Rolling resistance Vs Inflation*	*Truck Tyres – Tread Compounds*	*Cornering Properties – Variation of Self aligning torque with slip angle for bias and radial ply tyres*	*Failure Analysis: Structural Failures*	*Retrofit – Tyre balancing line*

S-8	SLO1	*Technical Test- Force and Moment Properties, Resistitvity, Uniformity*	*Tyres for Agricultural and Earth Movers*	*Cornering Properties – Camber and Camber Thrust*	*Failure Analysis: In service failure modes*	*Non Destructive Testing Methods*
	SLO2	*Technical Test-Flat spotting, Traction*	*Tyres for Agricultural and Earth Movers*	*Cornering Properties – Variation of Camber thrust with normal load and camber angle for car tyres*	*Failure Analysis: In service failure modes*	*X-ray Examination*
S-9	SLO1	*Tyre Manufacturing Process – Compound Preparation, Extrusion process*	*Tyres for Military Vehicle*	*Models for Cornering Behavior of tires - Stretched String model*	*Tyre durability, Servicing, maintenance and safety*	*Shearography*
	SLO2	*Tyre Assembly and Curing*	*Tyres for Military Vehicle*	*Models for Cornering Behavior of tires - Beam on Elastic foundation model*	*Tyre durability, Servicing, maintenance and safety*	*Eddy Current*

Learning Resources	1. *US Department of Transportation., "The Pneumatic Tire",February 2006* 2. *Tom French, "Tyre Technology" Taylor and Francis 2007*	3. *J. Y. Wong, "Theory of Ground Vehicles", 4th Edition"2008* 4. *H. B. Pacejka "Tyre and vehicle dynamics", Second Edition 2006*

Learning Assessment

	Bloom's Level of Thinking	Continuous Learning Assessment (50% weightage)								Final Examination (50% weightage)	
		CLA – 1 (10%)		CLA – 2 (15%)		CLA – 3 (15%)		CLA – 4 (10%)#			
		Theory		Theory		Theory		Theory		Theory	
Level 1	Remember Understand	*40%*		*40%*		*40%*		*40%*		*40%*	
Level 2	Apply Analyze	*40%*		*40%*		*40%*		*40%*		*40%*	
Level 3	Evaluate Create	*20%*		*20%*		*20%*		*20%*		*20%*	
	Total	100 %		100 %		100 %		100 %		100%	

CLA – 4 can be from any combination of these: Assignments, Seminars, Tech Talks, Mini-Projects, Case-Studies, Self-Study, MOOCs, Certifications, Conf. Paper etc.,

Course Designers		
Experts from Industry	Experts from Higher Technical Institutions	Internal Experts
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Course Code	18AUE355T	Course Name	MOTORSPORT TECHNOLOGY	Course Category	E	Professional Elective	L	T	P	C
							3	0	0	3

Pre-requisite Courses	18AUC302J	Co-requisite Courses	18AUC401J	Progressive Courses	Nil
Course Offering Department	Automobile Engineering	Data Book / Codes/Standards	Nil		

Course Learning Rationale (CLR):	*The purpose of learning this course is to:*
CLR-1 :	*Provide an insight on the problems imposed by racing, race car design and development strategies..*
CLR-2 :	*Understand the aerodynamic requirements in racing vehicles and the purpose of various aerodynamic devices.*
CLR-3 :	*Understand the behavior of a racing vehicle chassis at different conditions.*
CLR-4 :	*Gain knowledge about the concepts of various suspension characteristics of racing vehicles.*
CLR-5 :	*Understand the problems faced in drives and braking systems in motorsports.*

Course Learning Outcomes (CLO):	*At the end of this course, learners will be able to:*	Learning 1: Level of Thinking (Bloom)	Learning 2: Expected Proficiency (%)	Learning 3: Expected Attainment (%)	PLO 1: Engineering Knowledge	2: Problem Analysis	3: Design & Development	4: Analysis, Design, Research	5: Modern Tool Usage	6: Society & Culture	7: Environment & Sustainability	8: Ethics	9: Individual & Team Work	10: Communication	11: Project Mgt. & Finance	12: Life Long Learning	13: PSO - 1	14: PSO - 2	15: PSO – 3
CLO-1 :	*Demonstrate their knowledge on the fundamentals of race car design and development.*	2	75	75	H	H	H	M	L	M	L	H	H	H	L	H	H	M	H
CLO-2 :	*Identify the aerodynamic requirements of a race car and characteristics of various aerodynamic devices.*	2	80	80	H	M	H	M	M	M	L	H	M	L	L	H	H	M	H
CLO-3 :	*Interpret the effects of various dynamic conditions on a race car chassis.*	2	80	80	H	H	H	M	L	M	L	H	M	L	L	H	H	M	H
CLO-4 :	*Compare and classify the different types of suspension systems used in racing.*	2	75	75	M	M	M	M	L	M	L	H	M	L	L	H	H	M	H
CLO-5 :	*Identify the appropriate drives and braking systems for the required racing applications.*	2	75	75	M	M	M	M	L	M	L	H	M	L	L	M	H	M	H

		Race Car Design and Development	Race Car Aerodynamics	Race Car Chassis	Race Car Suspension System	Race Car Drives And Braking Systems
Duration (hour)		9	9	9	9	9
S-1	SLO-1	*Problems Imposed By Racing*	*Aerodynamic Force And Moment, Race Car Drag Components*	*Conditions For Traversing A 90° Corner*	*Front Suspension- General Design Issues, Camber Effects.*	*Merits Of Front and Rear wheel drive in racing.*
	SLO-2	*Racing Objective*	*Drag Estimation and Drag Improvement*	*Principle Chassis Tuning Items*	*McPherson Struts, SLA Suspension.*	*Four-Wheel Drive In Racing.*
S-2	SLO-1	*"g-g" Diagram*	*Ground Effects in a race car*	*Effects Of High Speed Braking*	*SLA suspension geometry, Instant Axis Concept.*	*Differentials Used In Racing- Open Differentials, Locked (Spool) differentials.*
	SLO-2	*Road car vs race car "g-g" Diagram.*	*Ground Plane Simulation In Race Car Applications.*	*Effects Of High Speed Cornering*	*SLA Rear Suspension, Beam Axle Rear Suspensions, Decoupled Rear Axle Suspension*	*Limited Slip Differential*
S-3	SLO-1	*Constraints And Specifications – Performance and Handling*	*Spoilers, Dams, Wings*	*Effects of Combined Braking Cornering*	*F1 car suspension: Double wishbone and outboard spring*	*Traction Control And Other Electronic Improvements In Racing.*
	SLO-2	*Constraints And Specifications –Structure, weight distribution.*	*Effectiveness Of Wings In Steady State Cornering.*	*Steady State Cornering*	*Top rocker and inboard spring, pull-rod and inboard spring*	*Traction Control And Other Electronic Improvements In Racing.*
S-4	SLO-1	*Driver Accommodation And Safety.*	*High Lift Devices- Flaps And Slats.*	*Acceleration Out Of A Corner*	*Push rod and vertical coil spring, push rod and horizontal coil spring and damper*	*Mechanical Components In Braking System.*
	SLO-2	*Tire and adjustable features.*	*Flow Control Devices- Dams, Fences, Vanes, Skirts, Spoilers.*	*Straight Line Acceleration*	*Push rod and Vertical torsion bar with horizontal damper*	*Mechanical Components In Braking System.*
S-5	SLO-1	*Preliminary Design And Analysis.*	*Vortex Creating Devices- Ledges, Edge, Cusps, Lips.*	*Throttle Behaviour*	*Suspension Springs- Torsion Springs, Coil Springs*	*Limitations And Considerations Of Braking In Racing.*
	SLO-2	*Driver-Vehicle Relationship*	*Pressure Change Creation Devices- Perforations, Vents, Bleeds, Scoops, Seals.*	*Steering Wheel Force And Kick Back*	*Progressive Rate Coil Springs*	*Limitations And Considerations Of Braking In Racing.*
S-6	SLO-1	*Desirable Vehicle Characteristics.*	*Air-Foil Devices- Slats, Flaps, End Plates, Cuffs, Fillets, Trips.*	*Moving CG Position, Ballasts.*	*Installation Consideration*	*Brake Boost in racing*

	SLO-2	*Fundamentals Of Testing*	*Active Flow Control Devices- Internal Airflow, RAM Air Ducted Radiator, Air Entrance Scoop*	*Effect of engine weight reduction on longitudinal CG position.*	*Damping In Racing, Ride/Handling Compromise*	*Effects Of "g" Force On Brake Fluids*
S-7	SLO-1	*Track Test Program Planning*	*Full size wind tunnel testing*	*Roll Center Position Changing Anti-Pitch Geometry*	*Steering Activity, Transient Maneuvering*	*Brake Hydraulics*
	SLO-2	*Test Methodology*	*Full size wind tunnel testing*	*Chassis Steering Axis Geometry, Changing Camber*	*Bump Damping And Rebound Damping*	*Brake Ventilation*
S-8	SLO-1	*General Notes On Development*	*Case study: Chaparral wings*	*Chassis Ride Roll Characteristics*	*Racing damper schematic*	*Brake Distribution*
	SLO-2	*Circular Skid Pad Testing.*	*Case study: Performance benefits from the Chaparral wings.*	*Chassis Track Width , Chassis Ride Spring Rate, Tires And Rims*	*Case study: Penske four-way adjustable damper.*	*ABS In Racing*
S-9	SLO-1	*Case study- 1955 Mercedes W196 Grand Prix car.*	*Case study: Formula Benetton's pressurized, half-scale wind tunnel.*	*Adjusting Roll Stiffness*	*Lateral restraints- Pan hard bar, Watts's linkage.*	*Carbon-Carbon discs.*
	SLO-2	*Case study- 1998 Ferrari F300 Grand Prix car.*	*Case study: Moving ground plane Benetton's wind tunnel.*	*Roll Stiffness Distribution*	*Cam and follower in track, A-arms.*	*Case study: Ferrari F300 two-pedal arrangement for braking.*

Learning Resources	*1. William F.Milliken and Douglas L.Milliken, "Race car vehicle dynamics", 11th edition, SAE, 1995.* *2. Peter Wright, "Formula 1Technology", 2001.*	*3. Thomas D. Gillespie, "Fundamental of Vehicle Dynamics, Society of Automotive Engineers", USA 11th edition , 2006* *4. Wolf-Heinrich Hucho, "Aerodynamics of road vehicles", 4th edition, 2000.*

Learning Assessment

	Bloom's Level of Thinking	Continuous Learning Assessment (50% weightage)								Final Examination (50% weightage)	
		CLA – 1 (10%)		CLA – 2 (15%)		CLA – 3 (15%)		CLA – 4 (10%)#			
		Theory	Practice	Theory	Practice	Theory	Practice	Theory	Practice	Theory	Practice
Level 1	Remember Understand	*40 %*	-	*30 %*	-	*30 %*	-	*30 %*	-	*30%*	-
Level 2	Apply Analyze	*40 %*	-	*40 %*	-	*40 %*	-	*40 %*	-	*40%*	-
Level 3	Evaluate Create	*20 %*	-	*30 %*	-	*30 %*	-	*30 %*	-	*30%*	-
	Total	100 %		100 %		100 %		100 %		100 %	

CLA – 4 can be from any combination of these: Assignments, Seminars, Tech Talks, Mini-Projects, Case-Studies, Self-Study, MOOCs, Certifications, Conf. Paper etc.,

Course Designers

Experts from Industry	Experts from Higher Technical Institutions	Internal Experts
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Course Code	18AUE356T	Course Name	AUTOMOTIVE NVH	Course Category	E	Professional Elective	L	T	P	C
							3	0	0	3

Pre-requisite Courses	Nil	Co-requisite Courses	Nil	Progressive Courses	Nil
Course Offering Department	Automobile Engineering	Data Book / Codes/Standards	Nil		

Course Learning Rationale (CLR):	*The purpose of learning this course is to:*
CLR-1 :	*Understand fundamentals of noise and vibration theory*
CLR-2 :	*Explain fundamental principles of sound quality and vibration modal analysis*
CLR-3 :	*Equip themselves familiar with basics of vibration and their mathematic models*
CLR-4 :	*Understand measuring instrumentations, techniques and metrics used for automotive NVH*
CLR-5 :	*Understands the various automotive noise sources and their control techniques*

Course Learning Outcomes (CLO):	*At the end of this course, learners will be able to:*	Learning 1: Level of Thinking (Bloom)	2: Expected Proficiency (%)	3: Expected Attainment (%)	PLO 1: Engineering Knowledge	2: Problem Analysis	3: Design & Development	4: Analysis, Design, Research	5: Modern Tool Usage	6: Society & Culture	7: Environment & Sustainability	8: Ethics	9: Individual & Team Work	10: Communication	11: Project Mgt. & Finance	12: Life Long Learning	13: PSO - 1	14: PSO - 2	15: PSO – 3
CLO-1 :	*Identify the basics of vibration and formulate the equations for various types of vibrations*	*3*	*95*	*80*	*H*	*H*	*H*	*H*	*M*	*L*	*L*	*L*	*M*	*L*	*L*	*M*	*H*	*L*	*L*
CLO-2 :	*Design various vibration control techniques*	*3*	*95*	*80*	*H*	*H*	*H*	*H*	*H*	*L*	*L*	*L*	*M*	*L*	*L*	*M*	*H*	*H*	*L*
CLO-3 :	*Interpret fundamental of noise and its transmission*	*2*	*85*	*80*	*H*	*M*	*H*	*M*	*M*	*L*	*H*	*M*	*M*	*H*	*M*	*M*	*H*	*H*	*M*
CLO-4 :	*Compare and classify different vibration measurement test*	*3*	*90*	*85*	*H*	*M*	*H*	*H*	*M*	*L*	*M*	*M*	*L*	*L*	*L*	*M*	*M*	*H*	*M*
CLO-5 :	*Explain the causes of automotive noise and its control methods*	*3*	*95*	*90*	*H*	*M*	*H*	*H*	*M*	*M*	*H*	*H*	*L*	*L*	*L*	*M*	*H*	*M*	*M*

		Basics of Vibration Analysis	Vibration Control Techniques	Noise Fundamentals	NVH Measurements	Automotive Noise Sources and Control Techniques
Duration (hour)		9	9	9	9	9
S-1	SLO-1	*Basic concepts*	*Transmissibility Ratio*	*Fundamental of acoustics*	*Vibration and Noise Standards*	*Engine noise- causes*
	SLO-2	*Formulating the equations of motion*	*Transmissibility ratio and its different cases*	*General sound propagation*	*Pass/Drive by noise-test site*	*Methods for control of engine noise-control measures-*
S-2	SLO-1	*Free undamped vibration*	*Vibration isolation*	*Structure borne sound& air borne sound*	*Pass/Drive by noise meteorological condition*	*Mufflers*
	SLO-2	*Free undamped vibration*	*Vibration isolation*	*Structure borne sound& air borne sound*	*Pass/Drive by noise meteorological condition*	*Mufflers*
S-3	SLO-1	*Free damped vibration*	*Tuned viscous dampers*	*Plane wave propagation - wave equation*	*Pass/Drive by noise-constant speed test-wide open throttle test*	*Transmission Noise- control methods*
	SLO-2	*Free damped vibration*	*Tuned viscous dampers*	*Specific acoustic impedance, acoustic intensity*	*Pass/Drive by noise-constant speed test-wide open throttle test*	*Transmission Noise- control methods*
S-4	SLO-1	*Logarithmic decrement*	*Tuned viscous dampers*	*Spherical wave propagation*	*Interior Noise test- standards – test track condition*	*Intake and exhaust noise – attenuation of intake and exhaust noise*
	SLO-2	*Graphical analysis of Logarithmic decrement*	*Tuned viscous dampers*	*Acoustic near and far fields*	*Interior Noise test- standards– vehicle operating condition*	*Intake and exhaust noise – attenuation of intake and exhaust noise*
S-5	SLO-1	*Forced Vibration*	*Untuned viscous dampers*	*The decibel scale, Summation of pure tones*	*Interior Noise test- standards steady speed – Full throttle test –stationery test*	*Control methods dissipative silencers – reactive silencers - resonators*
	SLO-2	*Magnification Factor*	*Untuned viscous dampers*	*Relationship among sound power, sound intensity and sound pressure level*	*Interior Noise test- standards-microphone positions*	*Aerodynamic Noise, its sources and control methods*
S-6	SLO-1	*Magnification Factor Different Cases*	*Untuned viscous dampers*	*Relationship among sound power, sound intensity and sound pressure level*	*Stationery vehicle test- standards*	*Tyre Noise, Brake noise and their control methods*
	SLO-2	*Magnification Factor Different Cases*	*Untuned viscous dampers*	*Relationship among sound power, sound intensity and sound pressure level*	*Stationery vehicle test- test site*	*Tyre Noise, Brake noise and their control methods*

S-7	SLO-1	*Torsional system characteristics and single disc*	*Damping treatments and its significance*	*Decibel addition, subtraction and averaging matrix from element stiffness*	*Stationery vehicle test- preparation of the vehicle*	*Noise control strategy, noise control at source*
	SLO-2	*Torsional system characteristics of two disc*	*Damping treatments and its significance*	*Decibel addition, subtraction and averaging matrix from element stiffness*	*Stationery vehicle test-vehicle operating condition*	*Noise control along the transmission path*
S-8	SLO-1	*Two degree of freedom systems under harmonic force, modal analysis.*	*Free layer damping*	*Anatomy of Human Ear,*	*NVH measurement tools and techniques*	*Barriers, enclosures*
	SLO-2	*Modal analysis.*	*Free layer damping*	*Anatomy of Human Ear,*	*NVH measurement tools and techniques-vibration and noise measurement transducers*	*Resonators*
S-9	SLO-1	*Coordinate coupling*	*Constrained Layer damping*	*Mechanism of hearing*	*Advanced acquisition techniques*	*Industrial noise control measures-*
	SLO-2	*Coordinate coupling*	*Constrained Layer damping*	*Mechanism of hearing*	*Advanced acquisition techniques*	*Green belt development*

Learning Resources	1. *Singiresu S. Rao , "Mechanical Vibrations" 5th Edition, Pearson, September , 2010* 2. *Ambekar, A. G., "Mechanical Vibrations and Noise Engineering", Prentice Hall of India, New Delhi, 2006* 3. *Munjal , "Acoustics of Ducts and Mufflers" Wiley publications, 2010* 4. *Beranek, L. L. and Ver, I, L., "Noise and Vibration Control Engineering –Principles and Application", John Wiley & Sons, Inc, 1992*	5. *Beranek, Leo Leroy ,"Acoustic measurements" 10th Edition 2007* 6. *Manasi P. Joshi, "Noise &Vibration Measurement Techniques in Automotive NVH " 2012* 7. *Malcolm J. Crocker , "Handbook Of Noise And Vibration Control" John Wiley & Sons, Inc 2007*

Learning Assessment											
	Bloom's Level of Thinking	Continuous Learning Assessment (50% weightage)								Final Examination (50% weightage)	
		CLA – 1 (10%)		CLA – 2 (15%)		CLA – 3 (15%)		CLA – 4 (10%)#			
		Theory	Practice	Theory	Practice	Theory	Practice	Theory	Practice	Theory	Practice
Level 1	Remember Understand	*40 %*	-	*30 %*	-	*30 %*	-	*30 %*	-	*30%*	-
Level 2	Apply Analyze	*40 %*	-	*40 %*	-	*40 %*	-	*40 %*	-	*40%*	-
Level 3	Evaluate Create	*20 %*	-	*30 %*	-	*30 %*	-	*30 %*	-	*30%*	-
	Total	100 %		100 %		100 %		100 %		100 %	

Course Designers		
Experts from Industry	Experts from Higher Technical Institutions	Internal Experts
1. Mr. M. Shivakumar, Mahendra and Mahendra, sivakumar.k2309@gmail.com	*1. Dr.V.Gnanamoorthy, UCEV,Anna University, cvgnana@gmail.com*	*1. Dr. K. Kamalakannan, SRMIST,kamalakk1@srmist.edu.in*
2. , Mr. S. Prabhakar, Hyundai Motors, prabhakarjeevamit@gmail.com	*2. Mr. R. Selvakumar, Hindustan Institute of technology, rselvak@hindustanuniv.ac.in*	*2. Mr. T. Kaviyarasu, SRMIST, kaviyart@srmist.edu.in*

Course Code	18AUE451T	Course Name	ADVANCED VEHICLE TECHNOLOGY	Course Category	E	Professional Elective	L	T	P	C
							3	0	0	3

Pre-requisite Courses	Nil	Co-requisite Courses	Nil	Progressive Courses	Nil
Course Offering Department	Automobile Engineering	Data Book / Codes/Standards	Nil		

Course Learning Rationale (CLR):	The purpose of learning this course is to:
CLR-1 :	*Understand electric and hybrid vehicle operation and architectures*
CLR-2 :	*Analyse the suspension system used in automobiles*
CLR-3 :	*Identify suitable methods to reduce the noise emission and categorize the emission norms*
CLR-4 :	*Apply the function, construction and operation of various sensors and actuators*
CLR-5 :	*Understand the basics of control system used in automobiles*

Course Learning Outcomes (CLO):	At the end of this course, learners will be able to:	Learning 1: Level of Thinking (Bloom)	2: Expected Proficiency (%)	3: Expected Attainment (%)	PLO 1: Engineering Knowledge	2: Problem Analysis	3: Design & Development	4: Analysis, Design, Research	5: Modern Tool Usage	6: Society & Culture	7: Environment & Sustainability	8: Ethics	9: Individual & Team Work	10: Communication	11: Project Mgt. & Finance	12: Life Long Learning	13: PSO - 1	14: PSO - 2	15: PSO – 3
CLO-1 :	*Understand various trends in automotive power plants*	2	95	92	H	H	M	M	H	L	L	L	H	L	L	L	H	M	H
CLO-2 :	*Gain knowledge about various modern suspension and braking systems*	2	96	90	H	H	M	M	H	L	L	L	H	L	L	L	H	M	H
CLO-3 :	*Understand various emissions and noise pollution control techniques*	2	95	90	H	H	M	M	H	L	L	L	H	L	L	L	H	M	H
CLO-4 :	*Understand the fundamentals of modern sensors, actuators, ignition and injection systems*	2	93	89	H	H	M	M	H	L	L	L	H	L	L	L	H	M	H
CLO-5 :	*Gain knowledge about automated tracks for safe and fast travel*	2	95	90	H	H	M	M	H	L	L	L	H	L	L	L	H	M	H

		Trends in Automotive Power Plants	Suspension and Brakes	Emission And Noise Pollution Control	Vehicle Operation and Control	Vehicle Automated Tracks
Duration (hour)		9	9	9	9	9
S-1	SLO-1 SLO-2	*Introduction to power plant*	*Introduction to suspension systems*	*Sources of Pollution. Various emissions fro m Automobiles*	*Fundamentals of Automotive Electronics*	*Introduction automated tracks*
S-2	SLO-1	*Lean Burn Engines*	*Interconnected Air And Liquid Suspensions*	*Formation — Effects of pollutants on environment human beings.*	*Introduction to sensors, actuators, Processors*	*Road network*
	SLO-2	*Working principle of lean Burn engines*	*Hydro Elastic Suspension System*	*Emission control techniques*	*Introduction to sensors, actuators, Processors*	*Road network Preparation*
S-3	SLO-1	*Stratified Charged*	*Hydro Gas Suspension*	*Emission standards*	*Sensors : Position, speed,*	*Maintenance Of Proper Road Network*
	SLO-2	*Stratified Charged*	*Closed Loop Suspension*	*Engine Emissions, Types Of Catalytic Conversion-*	*Acceleration/Vibrational , Force/Torque, Flow me ters,*	*Traffic survey*
S-4	SLO-1	*Needs, advantages and dis advantages of Hydrogen Engines*	*Introduction to brakes*	*Charcoal Canister*	*Automotive Actuators*	*proposed road priority index*
	SLO-2	*Hydrogen Engines*	*Modern Rear Wheel Brake*	*CI engine emission and its control*	*Electromechanical actuators*	*Working principle*
S-5	SLO-1	*Need for Hybrid Vehicles*	*Self-Energizing Disc Brake*	*Formation — Smokes, NOx, soot, sulphur particulate*	*Fluid-mechanical actuators*	*Automated highway system*
	SLO-2	*Hybrid Vehicles working principle*	*Indirect Floating Caliper Disc Brake Brake Limiting Device,*	*Control Techniques-Fumigation, EGR, HCCI, Particulate Traps, SCR*	*Computer Control for pollution, noise and for fuel economy*	*Advantages and disadvantages*
S-6	SLO-1	*Concept of electric vehicles*	*Power–Assisted Braking System*	*Sources of Noise*	*Basics of networks*	*National Highway Network With Automated Roads And Vehicles*
	SLO-2	*Electric Propulsion With Cables*	*Power–Assisted Braking System*	*Engine Noise, Transmission Noise, vehicle*	*Examples of networked Vehicles - Bus system*	*National Highway Network With Automated Roads And Vehicles*
S-7	SLO-1	*Fuel cell introduction*	*Constructional Details Anti-Skid System*	*Structural Noise, aerodynamics noise*	*Introduction to Control area network in vehicle*	*Satellite Control Of Vehicle Operation For Safe And Fast Travel*
	SLO-2	*Fuel cell Vehicles*	*Anti-Skid System*	*Exhaust Noise. Noise reduction in Automo biles*	*Control area network in vehicle*	

S-8	SLO-1	Introduction about the Magnetic Track Vehicles	Regenerative Braking	Noise Control Techniques.	Electronic Fuel Injection	Intelligent transportation systems
	SLO-2		Working principle of Regenerative Braking	Silencer Design.		
S-9	SLO-1	Magnetic Track Vehicles.	Constructional Details. Active suspension	Noise Control Techniques.	Electronic Ignition system	Transducers and Operation Of The Vehicle Like Optimum Speed And Direction
	SLO-2					

Learning Resources	1. *T. K. Garrett "The Motor Vechicle"., 13th edition 2009.* 2. *Dr. N.K. Giri, "Automobile Mechanic", Khanna Publishers, 2006* 3. *Beranek. L.L. "Noise Reduction"., McGraw-Hill Book Co., Inc, Newyork, 1993*	4. *Heinz Heisler, "Advanced vehicle technology"., elsevier Store.2002* 5. *Crouse/Anglin "Automotive Mechanics" Career Education; 10th edition January 13, 1993* 6. *"Bosch Hand Book"., 3rd Edition, SAE,1993*

Learning Assessment

	Bloom's Level of Thinking	Continuous Learning Assessment (50% weightage)								Final Examination (50% weightage)	
		CLA – 1 (10%)		CLA – 2 (15%)		CLA – 3 (15%)		CLA – 4 (10%)#			
		Theory	Practice	Theory	Practice	Theory	Practice	Theory	Practice	Theory	Practice
Level 1	Remember Understand	*40 %*	-	*30 %*	-	*30 %*	-	*30 %*	-	*30%*	-
Level 2	Apply Analyze	*40 %*	-	*40 %*	-	*40 %*	-	*40 %*	-	*40%*	-
Level 3	Evaluate Create	*20 %*	-	*30 %*	-	*30 %*	-	*30 %*	-	*30%*	-
	Total	100 %		100 %		100 %		100 %		100 %	

CLA – 4 can be from any combination of these: Assignments, Seminars, Tech Talks, Mini-Projects, Case-Studies, Self-Study, MOOCs, Certifications, Conf. Paper etc.,

Course Designers

Experts from Industry	Experts from Higher Technical Institutions	Internal Experts
1. Mr. MyilavanPalanivel, WABCO indialimited ,myliavan@gmail.com	*1. Dr.P D Jeyakumar, Cresent University, pdjeyakumar@cresent.education.*	*1.. Dr K. Kamalakkannan SRMIST Kamalakk1@srmist.edu.in*
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Course Code	18AUE452T	Course Name	AUTOMOTIVE SAFETY AND ERGONOMICS	Course Category	E	Professional Elective	L	T	P	C
							3	0	0	3

Pre-requisite Courses	Nil	Co-requisite Courses	Nil	Progressive Courses	Nil
Course Offering Department	Automobile Engineering	Data Book / Codes/Standards	Nil		

Course Learning Rationale (CLR):	*The purpose of learning this course is to:*
CLR-1 :	*Impart knowledge on basics of vehicle construction details and its effects.*
CLR-2 :	*Know the various safety concepts used in passenger cars.*
CLR-3 :	*Gain knowledge about various safety systems and its equipment.*
CLR-4 :	*Understand the concepts of vehicle ergonomics.*
CLR-5 :	*Interpret the various automotive comfort features.*

Course Learning Outcomes (CLO):	*At the end of this course, learners will be able to:*	Learning 1 Level of Thinking (Bloom)	2 Expected Proficiency (%)	3 Expected Attainment (%)	Program Learning Outcomes (PLO) 1 Engineering Knowledge	2 Problem Analysis	3 Design & Development	4 Analysis, Design, Research	5 Modern Tool Usage	6 Society & Culture	7 Environment & Sustainability	8 Ethics	9 Individual & Team Work	10 Communication	11 Project Mgt. & Finance	12 Life Long Learning	13 PSO - 1	14 PSO - 2	15 PSO – 3
CLO-1 :	*Understand the fundamentals of design and construction of vehicle body.*	*1*	*80*	*75*	*H*	*L*	*L*	*M*	*L*	*L*	*L*	*L*	*L*	*L*	*L*	*H*	*H*	*L*	*L*
CLO-2 :	*Classify the various safety parameters such as interior and exterior safety concepts.*	*2*	*75*	*70*	*H*	*L*	*M*	*M*	*L*	*L*	*L*	*L*	*L*	*L*	*L*	*L*	*H*	*M*	*L*
CLO-3 :	*Understand the concepts of active and passive safety systems for real time application.*	*2*	*80*	*77*	*H*	*L*	*L*	*L*	*L*	*L*	*L*	*L*	*L*	*L*	*L*	*M*	*H*	*L*	*L*
CLO-4 :	*Implementing the vehicle ergonomics for enhancing the comfort level.*	*3*	*75*	*70*	*H*	*M*	*M*	*M*	*L*	*L*	*M*	*L*	*M*	*L*	*L*	*M*	*H*	*M*	*M*
CLO-5 :	*Describe the different types of comfort and convenience systems.*	*2*	*85*	*80*	*H*	*L*	*L*	*M*	*L*	*L*	*L*	*L*	*L*	*L*	*L*	*M*	*H*	*M*	*L*

		Design and Construction of Vehicle Body	Interior and Exterior Safety Concepts	Active and Passive Safety systems	Vehicle Ergonomics	Comfort and Convenience Systems
Duration (hour)		09	09	09	09	09
S-1	SLO-1	*Introduction to design and construction of vehicle body*	*Safety concepts- Introduction*	*Introduction to safety systems*	*Introduction to human body*	*Comfort and Convenience Systems- Introduction*
	SLO-2	*Design of the body for Safety. Energy equations, Engine location*	*Active safety, Driving safety, Conditional safety*	*Seat belt, Automatic seat belt fastening system*	*Anthropometrics and its application to vehicle ergonomics*	*Cabin comfort - In-Car air conditioning – overall energy efficiency*
S-2	SLO-1	*Effects of deceleration inside passenger compartment*	*Perceptibility safety*	*Collapsible steering column*	*Cockpit design*	*Air Management, Central and unitary systems, Air flow circuits*
	SLO-2		*Operating safety*	*Tiltable steering wheel*		*Air Cleaning, Ventilation, Air space diffusion*
S-3	SLO-1	*Deceleration on impact with stationary and movable obstacle*	*Passive safety*	*Air bags*	*Driver comfort – seating, visibility*	*Compact heat exchanger design, Controls and Instrumentation*
	SLO-2		*Exterior Safety*	*Electronic systems for activating air bags*		*Compact heat exchanger design, controls and Instrumentation*
S-4	SLO-1	*Concept of crumble zone and safety sandwich construction*	*Interior Safety Systems*	*Frontal design for safety*	*Driver comfort – Seat pan, Back rest, Steering wheel, Head rest and mirrors*	*Steering and mirror adjustment*
	SLO-2			*Collision warning system*		*Central locking system*
S-5	SLO-1	*Active and passive safety*	*Deformation behaviour of vehicle body*	*Causes of rear end collision, frontal object detection*	*Man-Machine system*	*Garage Door Opening System, Tire Pressure Control System, Rain sensor System*
	SLO-2			*Rear vehicle object detection system*	*Psychological factors – stress, attention*	*Environment information System, Automotive lamps, Types, Design, Construction, performance*
S-6	SLO-1	*Characteristics of vehicle structures*	*Speed and acceleration characteristics of passenger compartment on impact*	*Object detection system with braking system interactions*	*Passenger comfort - Ingress and Egress*	*Light signalling devices- stop lamp*
	SLO-2				*Spaciousness*	*Rear position lamp, Direction indicator*
S-7	SLO-1	*Optimization of vehicle structures for crash worthiness*	*Pedestrian safety*	*Anti-lock braking system*	*Ventilation, Temperature control*	*Reverse lamp, Reflex reflector*
	SLO-2		*Human impact tolerance- Determination Of injury thresholds*		*Dust and fume prevention*	*Position lamp, Gas discharge lamp, LED*
S-8	SLO-1	*Types of crash / Roll over tests*	*Severity index, Study of comparative*	*ESP And EBD Systems*	*Interior features and conveniences*	*Adoptive Front Lighting System (AFLS)*

	SLO-2	*Regulatory requirements for crash testing*	*tolerance*	*Adaptive Cruise Control (ACC)*		*Daylight Running Lamps (DRL)*
S-9	SLO-1	*Instrumentation, High speed photography*	*Study of crash dummies*	*Navigation systems, traffic telematics*	*Placement of vehicle controls*	*Role of MCU in security and safety features*
	SLO-2	Image analysis.		*Infrared night vision system*	*Use of Modern technology for the same*	

Learning Resources	1. *Prasad, Priya and Belwafa Jamel, "Vehicles Crashworthiness and Occupant Protection", American Iron and Steel Institute, USA.* 2. *JullianHappian-Smith "An Introduction to Modern Vehicle Design" SAE, 2002*	3. *Bosch - "Automotive Handbook" - 10th edition - SAE publication - 2018.* 4. *"Recent development in Automotive Safety Technology", SAE International Publication. Editor: Daniel J Helt, 2013.* 5. *Keitz H.A.E. "Light Calculations and Measurements", Macmillan 1971.*

Learning Assessment

	Bloom's Level of Thinking	Continuous Learning Assessment (50% weightage)								Final Examination (50% weightage)	
		CLA – 1 (10%)		CLA – 2 (15%)		CLA – 3 (15%)		CLA – 4 (10%)#			
		Theory	Practice	Theory	Practice	Theory	Practice	Theory	Practice	Theory	Practice
Level 1	Remember Understand	*40 %*	-	*30 %*	-	*30 %*	-	*30 %*	-	*30%*	-
Level 2	Apply Analyze	*40 %*	-	*40 %*	-	*40 %*	-	*40 %*	-	*40%*	-
Level 3	Evaluate Create	*20 %*	-	*30 %*	-	*30 %*	-	*30 %*	-	*30%*	-
	Total	100 %		100 %		100 %		100 %		100 %	

CLA – 4 can be from any combination of these: Assignments, Seminars, Tech Talks, Mini-Projects, Case-Studies, Self-Study, MOOCs, Certifications, Conf. Paper etc.,

Course Designers

Experts from Industry	Experts from Higher Technical Institutions	Internal Experts
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Course Code	18AUE453T	Course Name	VEHICLE MAINTENANCE	Course Category	E	Professional Elective	L	T	P	C
							3	0	0	3

Pre-requisite Courses	Nil	Co-requisite Courses	Nil	Progressive Courses	Nil
Course Offering Department	Automobile Engineering	Data Book / Codes/Standards	Nil		

Course Learning Rationale (CLR):	The purpose of learning this course is to:
CLR-1 :	*Learn how to maintain the various systems and components in an automobile*
CLR-2 :	*Effectively troubleshoot common problems in an automobile*
CLR-3 :	*Prevent premature failure of components and systems by audio-visual inspection*
CLR-4 :	*Ensure the safety of occupants by preventive maintenance*

Course Learning Outcomes (CLO):	At the end of this course, learners will be able to:	Learning 1: Level of Thinking (Bloom)	Learning 2: Expected Proficiency (%)	Learning 3: Expected Attainment (%)	PLO 1: Engineering Knowledge	PLO 2: Problem Analysis	PLO 3: Design & Development	PLO 4: Analysis, Design, Research	PLO 5: Modern Tool Usage	PLO 6: Society & Culture	PLO 7: Environment & Sustainability	PLO 8: Ethics	PLO 9: Individual & Team Work	PLO 10: Communication	PLO 11: Project Mgt. & Finance	PLO 12: Life Long Learning	PLO 13: PSO - 1	PLO 14: PSO - 2	PLO 15: PSO – 3
CLO-1 :	*Understand vehicle operation and maintenance principles*	3	90	90	H	H	M	H	H	M	M	L	H	L	L	H	H	H	H
CLO-2 :	*Understand and perform scheduled services*	3	90	90	H	H	M	H	H	M	M	H	H	H	H	H	H	H	H
CLO-3 :	*Handle situations where the vehicle is likely to fail*	3	90	90	H	H	M	M	H	M	M	H	H	H	M	H	H	L	M
CLO-4 :	*Understand maintenance procedures like repairing, overhauling etc.,*	3	90	90	H	H	M	H	H	M	M	L	H	L	H	H	H	H	H

		Maintenance of Workshop Records and Schedules	Powertrain Maintenance	Vehicle Chassis and Body Maintenance	Electrical System Maintenance	Maintenance of Auxiliary Systems
Duration (hour)		09	09	09	09	09
S-1	SLO-1 SLO-2	*Importance Of Maintenance, Scheduled And Unscheduled Maintenance*	*Dismantling Of Engine Components And Cleaning*	*Maintenance And Servicing Of Front Axle*	*Testing Methods For Checking Electrical Components*	*Servicing Of Fuel System Of Different Types Of Vehicles*
S-2	SLO-1	*Requirements Of Maintenance*	*Cleaning Methods*	*Maintenance And Servicing of Rear Axle*	*Checking of Battery*	*Maintenance Of Fuel System Of Different Types Of Vehicles*
	SLO-2	*Preparation Of Check Lists*	*Visual And Dimensional Inspections*	*Maintenance And Servicing of Suspension Systems*	*Checking of Starter Motor*	*Calibration And Tuning Of Engine For Optimum Fuel Supply*
S-3	SLO-1	*Vehicle Down Time*	*Minor And Major Reconditioning Of Various Components*	*Maintenance And Servicing of Braking Systems*	*Checking of Charging System*	*Maintenance of Cooling System*
	SLO-2	*Vehicle Inspection, Inspection Schedule*	*Reconditioning Methods*	*Overhauling of Steering Systems*	*Checking of, DC Generator*	*Water Pump, Radiator*
S-4	SLO-1	*Maintenance Of Records, Reports*	*Engine Assembly*	*Maintenance of Steering Systems*	*Checking of Alternator*	*Thermostat*
	SLO-2	*Log Books, Trip Sheets And Other Forms*	*Special Tools Used For Maintenance And Overhauling*	*Wheel Alignment*	*Checking of Ignition Systems*	*Anticorrosion And Antifreeze Additives*
S-5	SLO-1	*Safety Precautions In Maintenance*	*Engine Tune Up*	*Computerized Alignment*	*Checking of Lighting Systems*	*Maintenance of Lubrication System*
	SLO-2	*Fleet Maintenance Requirement*	*Layout of transmission system*	*Wheel Balancing*	*Fault Diagnosis Of Modern Electronic Controls*	*Different grades of oil*
S-6	SLO-1	*Work Shop Layout*	*Servicing And Maintenance Of Automobile Clutch*	*Troubleshooting Checklist For Front Axle*	*Maintenance Of Modern Electronic Controls*	*lubricant oil additives*
	SLO-2	*Tools And Equipment*	*Servicing And Maintenance Of Gear Box*	*Troubleshooting Checklist For Rear Axle*	*Checking Of Dash Board Instruments*	*Lubricating Oil Changing*
S-7	SLO-1	*Spare Parts And Lubricants Stocking*	*Servicing And Maintenance Of Propeller Shaft*	*Troubleshooting Checklist For Suspension Systems*	*Servicing Of Dash Board Instruments*	*Greasing Of Parts*
	SLO-2	*Manpower, Training*	*Servicing And Maintenance Of Differential System*	*Troubleshooting Checklist For Steering Systems*	*Trouble Shooting On Engine Management System*	*Minor And Major Repairs Of Body Parts*
S-8	SLO-1	*Workshop Management*	*Trouble Shooting Checklist For Engine*	*Body Panel Tools For Repairing*	*Multi-Scanner*	*Maintenance Of Door Locking Mechanism*
	SLO-2	*Warranty*	*Trouble Shooting Checklist For Clutch*	*Body Panel Tools for Tinkering And Painting*	*On Board Diagnosis Using Multi-Scanner*	*Maintenance Of Window Glass Actuating System*

S-9	SLO-1	*Replacement Policy*	*Trouble Shooting Checklist Gear Box*	*Case studies*	*Case-Studies*	*Case-Studies*
	SLO-2		*Case-Studies*			

Learning Resources	1. *John Doke, "Fleet Management", McGraw Hill Co. 1984* 2. *James D Halderman, "Advanced Engine Performance Diagnosis", PHI, 1998*	3. *Tim Gilles, "Automotive service", 5th edition, Delmar CENGAGE Learning, 2009.* 4. *Service manuals.*

Learning Assessment

	Bloom's Level of Thinking	Continuous Learning Assessment (50% weightage)								Final Examination (50% weightage)	
		CLA – 1 (10%)		CLA – 2 (15%)		CLA – 3 (15%)		CLA – 4 (10%)#			
		Theory	Practice	Theory	Practice	Theory	Practice	Theory	Practice	Theory	Practice
Level 1	Remember Understand	40 %	-	30 %	-	30 %	-	30 %	-	30%	-
Level 2	Apply Analyze	40 %	-	40 %	-	40 %	-	40 %	-	40%	-
Level 3	Evaluate Create	20 %	-	30 %	-	30 %	-	30 %	-	30%	-
	Total	100 %		100 %		100 %		100 %		100 %	

CLA – 4 can be from any combination of these: Assignments, Seminars, Tech Talks, Mini-Projects, Case-Studies, Self-Study, MOOCs, Certifications, Conf. Paper etc.,

Course Designers

Experts from Industry	Experts from Higher Technical Institutions	Internal Experts
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Course Code	18AUE454T	Course Name	VEHICLE BODY ENGINEERING AND AERODYNAMICS	Course Category	E	Professional Elective	L	T	P	C
							3	0	0	3

Pre-requisite Courses	18AUC302J	Co-requisite Courses	Nil	Progressive Courses	Nil
Course Offering Department	Automobile Engineering	Data Book / Codes/Standards	Nil		

Course Learning Rationale (CLR):	*The purpose of learning this course is to:*	Learning			Program Learning Outcomes (PLO)														
		1	2	3	1	2	3	4	5	6	7	8	9	10	11	12	13	14	15
CLR-1 :	*Identify different types of vehicle body structures and their details*																		
CLR-2 :	*Know the details of bus bodies, classification and its regulations*																		
CLR-3 :	*Impart knowledge on the concept of car aerodynamics and testing of scale models*																		
CLR-4 :	*Classify different types of commercial vehicles and its types*																		
CLR-5 :	*Understand the various concepts of commercial vehicle aerodynamics*																		
Course Learning Outcomes (CLO):	*At the end of this course, learners will be able to:*	Level of Thinking (Bloom)	Expected Proficiency (%)	Expected Attainment (%)	Engineering Knowledge	Problem Analysis	Design & Development	Analysis, Design, Research	Modern Tool Usage	Society & Culture	Environment & Sustainability	Ethics	Individual & Team Work	Communication	Project Mgt. & Finance	Life Long Learning	PSO - 1	PSO - 2	PSO – 3
CLO-1 :	*Understand the fundamentals of various automotive body construction details*	*1*	*80*	*75*	*H*	*L*	*L*	*M*	*L*	*L*	*L*	*L*	*M*	*L*	*L*	*M*	*H*	*L*	*M*
CLO-2 :	*Classify the various types of bus body construction and able to identify the body layout.*	*2*	*75*	*73*	*H*	*L*	*M*	*M*	*L*	*L*	*L*	*L*	*L*	*L*	*L*	*L*	*H*	*M*	*L*
CLO-3 :	*Understand the concepts of car aerodynamics in body engineering for better style and low drag.*	*1*	*80*	*78*	*H*	*H*	*L*	*L*	*L*	*L*	*M*	*L*	*M*	*L*	*L*	*M*	*H*	*L*	*L*
CLO-4 :	*Select a suitable body optimization technique to minimize drag and able to describe the wind tunnel testing procedure*	*2*	*75*	*73*	*H*	*L*	*M*	*M*	*L*	*L*	*L*	*L*	*L*	*L*	*L*	*L*	*H*	*M*	*L*
CLO-5 :	*Describe the different types of commercial vehicles and its design*	*2*	*85*	*80*	*H*	*L*	*H*	*H*	*L*	*L*	*M*	*L*	*L*	*L*	*L*	*M*	*H*	*L*	*L*
CLO-6 :	*Apply the concept of commercial vehicle aerodynamics for reducing the drag.*	*2*	*75*	*72*	*H*	*L*	*M*	*M*	*L*	*L*	*L*	*L*	*M*	*L*	*L*	*L*	*H*	*M*	*L*

Duration (hour)		Car Body Details	Bus Body Details	Car Aerodynamics	Commercial Vehicle Details	Commercial Vehicle Aerodynamics
		9	9	9	9	9
S-1	SLO-1	*History - Evolution of vehicle body, Importance of vehicle body*	*Introduction to bus bodies*	*Car Aerodynamics - Introduction*	*Commercial vehicles - Introduction*	*Commercial vehicle aerodynamics - Introduction*
	SLO-2	*Car Body Terminologies & types of car bodies*	*Bus body panels & terminologies*	*Importance of Aerodynamics*	*Classification of Commercial vehicle bodies*	*Importance of Commercial vehicle Aerodynamics*
S-2	SLO-1	*Visibility - Forward visibility*	*Classification of bus body*	*Types of Aerodynamic drag*	*LCV – Light commercial vehicles and its types – Pickups and delivery vans*	*Effects of rounding sharp front body edges*
	SLO-2	*Forward vision measurement and Regulations*	*Based on distance travelled by the vehicle*			
S-3	SLO-1	*Driver's Visibility, All round visibility of the vehicle – sensors and its functions*	*Based on capacity of the vehicle*	*Various Aerodynamic forces and moments*	*HCV - Heavy commercial vehicles and its types*	*Effects of various cabs on trailer body*
	SLO-2	*Methods of improving visibility*	*Based on shape and style of the vehicle*			
S-4	SLO-1	*Safety - factors influencing safety in traffic*	*Based on types of metal section used*	*Effect of Aerodynamic forces and moments*	*Dimensions of commercial vehicle driver's seat in relation to various controls*	*Fore body pressure distribution*
	SLO-2	*Classification - Active & Passive safety*	*Bus body regulations*			
S-5	SLO-1	*Active safety - Driving, Conditional, Perceptibility & Operational safety*	*Sequence of bus building operation*	*Various body optimization techniques for minimum drag*	*Constructional details of Tanker body*	*Effect of Cab to trailer body roof height*
	SLO-2	*Passive safety - Interior & Exterior safety*				
S-6	SLO-1	*Safety aspects in design - Bumper end, front end*	*Construction of conventional type of bus body*	*Wind tunnel technology - Principle & Construction details*	*Construction of Tipper body*	*Effects of a cab to trailer body gab seals*
	SLO-2	*Safety aspects in design - Rear end and importance of larger distance*			*Various tipping methods*	
S-7	SLO-1	*Passive Safety devices - Air bag*	*Construction of Integral type of bus body*	*Types of wind tunnels*	*Various Tipping mechanisms*	*Commercial vehicle drag reducing devices*
	SLO-2	*Telescopic/Collapsible Steering column*			*Flat platform and drop side body construction*	*Cab roof deflectors & Corner Vanes*
S-8	SLO-1	*Active Safety devices*	*Comparison of test results of integral and conventional bus.*	*Flow visualization techniques – Smoke method, Tuft method, Oil coating method*	*Segmental design of driver's cab*	*Vortex generators and Diffusers*
	SLO-2	*Modern Painting process of a passenger car body*				*Tractor and Trailer Skirting*

S-9	SLO-1	*Selection of paint and painting process*	*Frame Construction*	*Testing with wind tunnel balance (scale models)*	*Compactness of Driver's cab*	*Effect of Trailer load position on vehicle's drag resistance*
	SLO-2	*Corrosion and Anti corrosion methods*	Double Skin construction			

Learning Resources	1. *Pawloski J, " Vehicle Body Engineering" - Business Books Ltd.,* 2. *Wolf-Heinrich Hucho, "Aerodynamics of road vehicles", 4th edition, 2000.*	3. *John Fenton, "Vehicle Body layout and analysis", Mechanical Engineering Publication Ltd., 1984* 4. *Heinz Heisler, "Advanced Vehicle Technology", 2nd edition, Butterworth – Heinemann, 2002.*

Learning Assessment

	Bloom's Level of Thinking	Continuous Learning Assessment (50% weightage)								Final Examination (50% weightage)	
		CLA – 1 (10%)		CLA – 2 (15%)		CLA – 3 (15%)		CLA – 4 (10%)#			
		Theory	Practice	Theory	Practice	Theory	Practice	Theory	Practice	Theory	Practice
Level 1	Remember Understand	40 %	-	30 %	-	30 %	-	30 %	-	30%	-
Level 2	Apply Analyze	40 %	-	40 %	-	40 %	-	40 %	-	40%	-
Level 3	Evaluate Create	20 %	-	30 %	-	30 %	-	30 %	-	30%	-
	Total	100 %		100 %		100 %		100 %		100 %	

CLA – 4 can be from any combination of these: Assignments, Seminars, Tech Talks, Mini-Projects, Case-Studies, Self-Study, MOOCs, Certifications, Conf. Paper etc.,

Course Designers

Experts from Industry	Experts from Higher Technical Institutions	Internal Experts
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Course Code	18AEE211J	Course Name	ANALOG AND DIGITAL CIRCUITS FOR AUTOMOTIVE APPLICATIONS	Course Category	E	Professional Elective	L	T	P	C
							2	0	2	3

Pre-requisite Courses	Nil	Co-requisite Courses	Nil	Progressive Courses	Nil
Course Offering Department	Automobile Engineering	Data Book / Codes/Standards	Nil		

Course Learning Rationale (CLR):	*The purpose of learning this course is to:*
CLR-1 :	*Acquire knowledge of about the BJT,MOS based amplifiers*
CLR-2 :	*Know the working of oscillator and Wave Shaper and Multi vibrator circuits*
CLR-3 :	*Impart the techniques of minimizing digital logic circuits*
CLR-4 :	*Familiarize the combinational circuits for different digital applications*
CLR-5 :	*Familiarize the digital sequential circuits and memory devices*

Course Learning Outcomes (CLO):	*At the end of this course, learners will be able to:*	Learning 1: Level of Thinking (Bloom)	Learning 2: Expected Proficiency (%)	Learning 3: Expected Attainment (%)	PLO 1: Engineering Knowledge	PLO 2: Problem Analysis	PLO 3: Design & Development	PLO 4: Analysis, Design, Research	PLO 5: Modern Tool Usage	PLO 6: Society & Culture	PLO 7: Environment & Sustainability	PLO 8: Ethics	PLO 9: Individual & Team Work	PLO 10: Communication	PLO 11: Project Mgt. & Finance	PLO 12: Life Long Learning	PLO 13: PSO - 1	PLO 14: PSO - 2	PLO 15: PSO – 3
CLO-1 :	*Understanding the use of analog circuits that are essential for Automotive Application*	*2*	*85*	*75*	*H*	*M*	*H*	*L*	*H*	*M*	*M*	*H*	*H*	*M*	*L*	*H*	*H*	*H*	*H*
CLO-2 :	*Understand the Oscillators, Wave Shaping and Multi Vibrator Circuits*	*2*	*80*	*75*	*H*	*M*	*H*	*H*	*H*	*M*	*M*	*H*	*H*	*M*	*L*	*M*	*H*	*H*	*H*
CLO-3 :	*Apply the Minimization Techniques and understand Digital Logic Gates*	*2*	*90*	*85*	*H*	*H*	*H*	*H*	*L*	*M*	*M*	*H*	*M*	*M*	*M*	*H*	*H*	*H*	*M*
CLO-4 :	*Design and implement the Combinational Circuits*	*2*	*85*	*80*	*H*	*M*	*H*	*H*	*H*	*H*	*H*	*H*	*H*	*H*	*M*	*H*	*H*	*H*	*H*
CLO-5 :	*Design and implement Sequential Circuits and understand the Memory Devices*	*2*	*80*	*75*	*H*	*M*	*M*	*M*	*H*	*H*	*H*	*H*	*H*	*H*	*M*	*H*	*H*	*H*	*H*

		Introduction to Analog Circuits	Oscillators, Wave Shaping and Multi Vibrator Circuits	Digital Logic Gates and Minimization Techniques	Combinational Circuits	Sequential Circuits and Memory Devices
Duration (hour)		12	12	12	12	12
S-1	SLO-1	*Introduction to Analog circuits*	*Oscillator Introduction*	*AND,OR Logic circuit implementation*	*Introduction to Combinational Circuit*	*Latches, Flip-flops –SR,JK,D,T characteristic table and Equation*
	SLO-2	*BJT Small signal Model*	*Analysis of LC oscillator*	*NOT Logic circuit implementation*	*Half Adder and Full Adder*	*Asynchronous Counters*
S-2	SLO-1	*CMOS Circuit Model*	*Active RC,RL Filters*	*NAND,NOR Logic circuit implementation*	*Half Subtractor and Full Subtractor*	*Synchronous Counters*
	SLO-2	*CMOS Circuit Model*	*RC,RL integrator*	*EXOR, EX-NOR Logic circuit implementation*	*Adder and Subtractor circuit example*	*Programmable Counters*
S 3-4	SLO-1 SLO-2	*Lab 1: basic Digital IC's AND,OR,EXOR,NOT,NOR,NAND*	*Lab 3: Combination Logic Adder, Subtractor*	*Lab 5: Realization of Encoder, Decoder*	*Lab 7: Op-Amp Linear Application :Adder, Subtractor*	*Lab 9: Op-Amp Nonlinear Application : Clipper, Clamper, Peak Detector*
S-5	SLO-1	*Biasing Circuits*	*Differentiator Circuits*	*TTL Logic*	*Carry look ahead adder*	*Registers overview*
	SLO-2	*Biasing Circuits*	*Diode-Clippers*	*CMOS Logic*	*Serial adder/Subtractor*	*Shift Registers*
S-6	SLO-1	*MOS amplifiers*	*Diode Clamper*	*Boolean Postulates*	*BCD addition*	*Universal Shift Register*
	SLO-2	*MOS amplifiers - types*	*Diode Comparator*	*Demorgan's Theorem*	*Multiplexer*	*Sequence Generator*
S 7-8	SLO-1 SLO-2	*Lab 2: Circuit realization of Flip-flops JK , RS , D*	*Lab 4: Circuit realization of Code Converter*	*Lab 6: Circuit realization of MUX,DEMUX*	*Lab 8: Op-Amp Linear Application : Comparator, Differentiator, Integrator*	*Lab 10: Filters Realization*
S-9	SLO-1	*Frequency response of amplifiers*	*UJT-Sawtooth Waveform Generator*	*Min term, Max term*	*Demultiplixer*	*Classification of Memories – RAM,ROM,PROM,EPROM,EEPROM*
	SLO-2	*Frequency response of amplifiers*	*Astable, MonostableMultivibrators*	*POS,SOP form*	*Decoder, Encoder*	*RAM,ROM Organization*
S-10	SLO-1	*Differential amplifiers*	*BistableMultivibrator*	*K-MAP*	*Parity Checker, Parity Generator*	*PLA VS PLD – Combinational Circuit implementation*
	SLO-2	*Differential amplifiers. Cont*	*Schmitt trigger circuits*	*Don't care conditions*	*Code Convertor*	*Introduction to FPGA*
S 11-12	SLO-1 SLO-2	*Lab: Assessment 1*	*Lab: Assessment 2*	*Lab: Assessment 3*	*Lab: Repeat class*	*Lab: Mini Project*

Learning Resources	1. *David A.Bell "Electronic Devices and Circuits", Oxford Higher Education Press, 5th Edition, 2010* 2. *M. Morris Mano, "Digital Design", 4th Edition, Prentice Hall of India Pvt. Ltd., 2008 / Pearson Education (Singapore) Pvt. Ltd., New Delhi.*	3. *Donald P.Leach and Albert Paul Malvino, "Digital Principles and Applications", 6th Edition, TMH, 2006.* 4. *Sedra and Smith, "Micro Electronic Circuits"; Sixth Edition, Oxford University Press, 2011. Millman and Halkias. C., Integrated Electronics, TMH, 2007.*

Learning Assessment

	Bloom's Level of Thinking	Continuous Learning Assessment (50% weightage)								Final Examination (50% weightage)	
		CLA – 1 (10%)		CLA – 2 (15%)		CLA – 3 (15%)		CLA – 4 (10%)			
		Theory	Practice	Theory	Practice	Theory	Practice	Theory	Practice	Theory	Practice
Level 1	Remember Understand	*40 %*	-	*30 %*	-	*30 %*	-	*30 %*	-	*30%*	-
Level 2	Apply Analyze	*40 %*	-	*40 %*	-	*40 %*	-	*40 %*	-	*40%*	-
Level 3	Evaluate Create	*20 %*	-	*30 %*	-	*30 %*	-	*30 %*	-	*30%*	-
	Total	100 %		100 %		100 %		100 %		100 %	

CLA – 4 can be from any combination of these: Assignments, Seminars, Tech Talks, Mini-Projects, Case-Studies, Self-Study, MOOCs, Certifications, Conf. Paper etc.,

Course Designers

Experts from Industry	Experts from Higher Technical Institutions	Internal Experts
1. Mr.Jegan Amirthalingam, Senior Educator, KPIT a.jegan@kpit.com	*1. Mr. Sam Jebakumar, SRM IST, jebakumj@srmist.edu.in*	*1. Mr. Joshua Paul E, SRMIST* *2. Mr.Jesu Godwin D, SRMIST*

Course Code	18AEE311T	Course Name	PRINCIPLES OF LINEAR SYSTEMS AND SIGNALS	Course Category	E	Professional Elective	L	T	P	C
							3	0	0	3

Pre-requisite Courses	Nil	Co-requisite Courses	18AEE211J	Progressive Courses	Nil
Course Offering Department	Automobile Engineering	Data Book / Codes/Standards	Nil		

Course Learning Rationale (CLR):	*The purpose of learning this course is to:*
CLR-1 :	*Understand and classify the signals, their operations and the systems*
CLR-2 :	*Test and execute the continuous time system's response, stability in time domain.*
CLR-3 :	*Formulate and solve the continuous time system equations using Laplace transform.*
CLR-4 :	*Solve and examine the discrete time system using Z transform*
CLR-5 :	*Execute the Fourier series based representation of continuous time signal systems*

Course Learning Outcomes (CLO):	*At the end of this course, learners will be able to:*	Learning 1: Level of Thinking (Bloom)	2: Expected Proficiency (%)	3: Expected Attainment (%)	PLO 1: Engineering Knowledge	2: Problem Analysis	3: Design & Development	4: Analysis, Design, Research	5: Modern Tool Usage	6: Society & Culture	7: Environment & Sustainability	8: Ethics	9: Individual & Team Work	10: Communication	11: Project Mgt. & Finance	12: Life Long Learning	13: PSO - 1	14: PSO - 2	15: PSO – 3
CLO-1 :	*Acquire the fundamentals of signal operation andbasics of system*	*1*	*90*	*85*	*H*	*L*	*L*	*L*	*L*	*L*	*L*	*L*	*L*	*L*	*L*	*M*	*H*	*M*	*L*
CLO-2 :	*Perform time domain analysis of a continuous time system with various inputs.*	*2*	*85*	*80*	*H*	*H*	*M*	*H*	*M*	*M*	*M*	*L*	*L*	*L*	*L*	*M*	*H*	*M*	*L*
CLO-3 :	*Analyse and examine the Continuous Time System in frequency domain using Laplace transform.*	*2,3*	*85*	*80*	*H*	*H*	*M*	*H*	*M*	*M*	*M*	*L*	*L*	*L*	*L*	*M*	*H*	*M*	*L*
CLO-4 :	*Test the stability and the response of discrete time system using Z transform*	*2,3*	*85*	*80*	*H*	*H*	*M*	*H*	*M*	*M*	*M*	*L*	*L*	*L*	*L*	*M*	*H*	*M*	*L*
CLO-5 :	*Know the fundamentals involved in continuous time signal analysis*	*2*	*85*	*80*	*H*	*H*	*M*	*H*	*M*	*M*	*M*	*L*	*L*	*L*	*L*	*M*	*H*	*M*	*L*

		Signals and Systems	Time Domain Analysis of Continuous Time Systems	Continuous Time System Analysis Using Laplace Transform	Discrete Time Analysis Using Z-Transform	Continuous Time Signal Analysis
Duration (hour)		09	09	09	09	09
S-1	SLO-1	*Size of a signal – Signal Energy*	*System response to internal condition– Zero input response*	*Laplace transform – Inverse Laplacetransform*	*Z-Transform introduction*	*Periodic signal representation by trigonometric Fourier series*
	SLO-2	*Size of a signal –Signal Power*	*System response to internal condition – Zero input response.*	*Properties of the Laplace transform – Time shifting*	*Finding inversetransform*	*Periodic signal representation by trigonometric Fourier series - The Fourier spectrum*
S-2	SLO-1	*Signal Operations –Time shifting, Time scaling*	*Unit Impulse response*	*Properties of the Laplace transform – frequency shifting*	*Properties of Z-transform*	*Periodic signal representation by trigonometric Fourier series - The Fourier spectrum.*
	SLO-2	*Signal Operations – Time reversal, combined operation*	*Impulse response.*	*Properties of the Laplace transform – time differentiation property*	*Z-transform solution of linear difference equations – Zero-state response of LTID system*	*Periodic signal representation by trigonometric Fourier series - Effect of symmetry*
S-3	SLO-1	*Classification of signals –Continuous-Time.*	*System response to external input – Zero state response*	*Properties of the Laplace transform – time integration property.*	*Z-transform solution of linear difference equations – Stability and Inversesystem*	*Periodic signal representation by trigonometric Fourier series - Determining the Fundamental Frequency and Period*
	SLO-2	*Classification of signals –Discrete-time signals*	*System response to external input – Zero state response.*	*Properties of the Laplace transform – Time convolution*	*Z-transform solution of linear difference equations – Stability and Inversesystem*	*Existences and Convergence of Fourier series*
S-4	SLO-1	*Classification of signals –Analog and Digital signals*	*System response to external input – Convolution integral*	*Properties of the Laplace transform – frequency convolution*	*System Realization*	*Existences and Convergence of Fourier series.*
	SLO-2	*Classification of signals –Periodic and Aperiodic signals,*	*System response to external input – Convolution integral*	*Solution of differential and integro - differential equation –Zero state response*	*System Realization.*	*Exponential Fourier series - Exponential Fourier spectra*
S-5	SLO-1	*Classification of signals - Energy and Power signals,*	*System response to external input – Interconnected systems*	*Solution of differential and integro - differential equation –Zero state response.*	*Frequency response of discrete time systems – Periodic nature of frequency response*	*Exponential Fourier series- Exponential Fourier spectra.*

	SLO-2	*Classification of signals –Deterministic and Randomsignals*	*System response to external input – Interconnected system.*	*Solution of differential and integro-differential equation – stability*	*Frequency response of discrete time systems – Periodic nature of frequency response.*	*Exponential Fourier series - Parseval's theorem*
S-6	SLO-1	*Excitation signals- Unit Step function*	*System stability –Internal Asymptoticstability*	*Solution of differential and integro - differential equation – Inverse system*	*Frequency response of discrete time systems – Aliasing andsampling rate*	*LTI System response to periodic inputs*
	SLO-2	*Excitation signals-Unit impulse function and Exponential function*	*System stability –Internal Asymptoticstability.*	*System Realization -Introduction*	*Frequency response of discrete time systems –Aliasing andsampling rate.*	*LTI System response to periodic inputs.*
S-7	SLO-1	*Even functions and Odd functions- Properties*	*Relationship between BIBO and asymptotic stability.*	*System realization - Direct Form I Realization*	*Frequency response from pole-zero location*	*Aperiodic signal representation by Fourier integral*
	SLO-2	*Classification of system – Linear and nonlinear systems,*	*Relationship between BIBO and asymptotic stability.*	*System realization - Direct Form II Realization*	*Frequency response from pole-zero Location.*	*Aperiodic signal representation by Fourier integral.*
S-8	SLO-1	*Classification of system –Time invariant, time varying*	*Dependence of system behavior on characteristics modes*	*Analysis of a simple feedback control system*	*Relationship between Laplace transform and z-transform*	*Relationship between the Fourier and Laplace transform*
	SLO-2	*Classification of system – Instantaneous and dynamic*	*Dependence of system behavior on characteristics modes.*	*Analysis of a simple feedback control system.*	*Relationship between Laplace transform and z-transform.*	*Relationship between the Fourier and Laplace transform.*
S-9	SLO-1	*Classification of system – causal and non-causal system*	*Response time of system –time constant, rise time*	*Frequency response of an LTIC System*	*Bilateral Z-transform -Introduction*	*Properties of Fourier transform*
	SLO-2	*Classification of system –Analog and Digital system*	*Response time of system –resonance Phenomenon.*	*Frequency response of an LTIC system.*	*Bilateral Z-transform -Properties*	*Properties of Fourier transform.*

Learning Resources	1. *B.P. Lathi "Principles Of Linear Systems And Signals "Oxford University Press, 2009.* 2. *Allan V.Oppenheim, S.Wilsky and S.H.Nawab, "Signals and Systems", Pearson, 2007.*	3. *R.E.Zeimer, W.H.Tranter and R.D.Fannin, "Signals & Systems - Continuous and Discrete", Pearson, 2007.*

Learning Assessment											
	Bloom's Level of Thinking	Continuous Learning Assessment (50% weightage)								Final Examination (50% weightage)	
		CLA – 1 (10%)		CLA – 2 (15%)		CLA – 3 (15%)		CLA – 4 (10%)			
		Theory	Practice	Theory	Practice	Theory	Practice	Theory	Practice	Theory	Practice
Level 1	Remember Understand	40 %	-	30 %	-	30 %	-	30 %	-	30%	-
Level 2	Apply Analyze	40 %	-	40 %	-	40 %	-	40 %	-	40%	-
Level 3	Evaluate Create	20 %	-	30 %	-	30 %	-	30 %	-	30%	-
	Total	100 %		100 %		100 %		100 %		100 %	

CLA – 4 can be from any combination of these: Assignments, Seminars, Tech Talks, Mini-Projects, Case-Studies, Self-Study, MOOCs, Certifications, and Conf. Paper etc.

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Experts from Industry	Experts from Higher Technical Institutions	Internal Experts
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	2. Dr. P. Sathish Kumar,Jiangsu University, China sathishkumar8989@gmail.com	*2. Mr.Jesu Godwin D, SRMIST*

Course Code	18AEE312T	Course Name	AUTOMOTIVE INFOTRONICS	Course Category	E	Professional Elective	L	T	P	C
							3	0	0	3

Pre-requisite Courses	Nil	Co-requisite Courses	Nil	Progressive Courses	Nil
Course Offering Department	Automobile Engineering	Data Book / Codes/Standards	Nil		

Course Learning Rationale (CLR):	*The purpose of learning this course is to:*
CLR-1 :	*State and classify the various driver and vehicle support systems.*
CLR-2 :	*Interpret and construct the vehicle communication systems according to the requirement*
CLR-3 :	*Differentiate and construct the various automotive safety systems*
CLR-4 :	*Develop and examine the comfort suitable for the driver's convenience*
CLR-5 :	*Investigate and test the required security for the vehicles*

Course Learning Outcomes (CLO):	*At the end of this course, learners will be able to:*	Learning 1: Level of Thinking (Bloom)	Learning 2: Expected Proficiency (%)	Learning 3: Expected Attainment (%)	PLO 1: Engineering Knowledge	PLO 2: Problem Analysis	PLO 3: Design & Development	PLO 4: Analysis, Design, Research	PLO 5: Modern Tool Usage	PLO 6: Society & Culture	PLO 7: Environment & Sustainability	PLO 8: Ethics	PLO 9: Individual & Team Work	PLO 10: Communication	PLO 11: Project Mgt. & Finance	PLO 12: Life Long Learning	PLO 13: PSO - 1	PLO 14: PSO - 2	PLO 15: PSO – 3
CLO-1 :	*Define and identify the driver convenience, perception and general vehicle control*	*1*	*90*	*85*	*H*	*M*	*L*	*L*	*L*	*M*	*L*	*L*	*L*	*L*	*L*	*H*	*H*	*M*	*M*
CLO-2 :	*Solve and implement the sensors, their modelling for the vehicle communication systems*	*2,3*	*90*	*85*	*H*	*H*	*H*	*H*	*M*	*M*	*M*	*L*	*M*	*H*	*L*	*H*	*H*	*H*	*H*
CLO-3 :	*Relate and formulate the required safety systems for the required vehicle model.*	*2,3*	*90*	*85*	*H*	*H*	*H*	*H*	*M*	*M*	*M*	*L*	*M*	*M*	*L*	*H*	*H*	*H*	*M*
CLO-4 :	*Examine and value the relationship between driver and vehicle in comfort perspective.*	*2,3*	*90*	*85*	*H*	*H*	*H*	*H*	*M*	*M*	*M*	*L*	*M*	*M*	*L*	*H*	*H*	*H*	*M*
CLO-5 :	*Design and experiment the automotive security systems for its performance*	*2,3*	*90*	*85*	*H*	*H*	*H*	*H*	*M*	*M*	*M*	*L*	*M*	*M*	*L*	*H*	*H*	*H*	*H*

		Driver and vehicle support systems - Introduction	Automotive Telematics	Automotive safety systems	Automotive comfort systems	Automotive security systems
Duration (hour)		09	09	09	09	09
S-1	SLO-1	*Driver information - navigation routing, integrated navigation*	*Global positioning system – Basics and working*	*Active and passive safety systems - Introduction*	*Adaptive cruise control system*	*Anti-theft technologies – mechanical, electromechanical*
	SLO-2	*Real-time traffic, traveller information*	*Geographical information systems - Data representations*	*Active and passive safety systems - Features*	*Active suspension system*	*Anti-theft technologies – Electronic immobilizers*
S-2	SLO-1	*Driver perception - vision enhancement, electronic mirror*	*Geographical information systems - Analysis and modeling*	*Airbag System - components*	*Aadjustable ORVMs*	*Alarm and warning system*
	SLO-2	*Parking and reversing aid, state of the road surface systems*	*geographical information systems – Applications*	*Airbag System - Working*	*Electrical Power assisted steering*	*Stolen vehicle tracking system*
S-3	SLO-1	*Driver convenience-driver identification, hands – free and remote control*	*Signpost navigation system*	*Seat belt tightening system- Block diagram*	*Collapsible and tiltable steering column*	*Remote keyless entry*
	SLO-2	*Driver convenience - automated transactions*	*Dead reckoning navigation system*	*seat belt tightening system- Working*	*Power windows*	*Smart card system*
S-4	SLO-1	*Driver monitoring - driver vigilance monitoring*	*Automotive vision system*	*Forward collision warning system- Block diagram*	*Adaptive lighting system*	*Number plate recoginition*
	SLO-2	*Driver health monitoring*	*Intelligent Speed Adaptation system*	*Forward collision warning system- Working*	*Electrically adjustable seats*	*Security antenna and transponders*
S-5	SLO-1	*General vehicle control - automatic stop and go*	*Fleet Tracking system*	*Child lock and anti-lock braking system- Block diagram*	*Rain sensing Wiper systems*	*Electronic ignition lock*
	SLO-2	*Vehicle Platooning*	*Voice based Turn-by-Turn system*	*Child lock and anti-lock braking system- Working*	*Reverse parking camera*	*Radio security system*
S-6	SLO-1	*Longitudinal control - road and lane departure collision avoidance*	*Smart-phone App Integration*	*Electronic Brake force Distribution system- Block diagram*	*Hands free Bluetooth*	*Fingerprint vehicle unlock*
	SLO-2	*Longitudinal control - road and lane departure collision avoidance Cont.*	*Automotive Collision Notification system*	*Electronic Brake force Distribution system- Working*	*Automatic Temperature control*	*GPS security systems*

S-7	SLO-1	*Lateral control - lane change and merge collision avoidance*	*Integrated theft recovery system*	*Electronic Stability Programme- Block diagram*	*Connected Mobility assistance and telematics*	*Speed governing systems*
	SLO-2	*Lane change and merge collision avoidance .Cont*	*Intelligent Speed Adaptation system*	*Electronic Stability Programme- Working*	*USB charging and navigation systems*	*Vehicle tracking systems*
S-8	SLO-1	*rear-end collision avoidance, \obstacle and pedestrian detection*	*Intelligent Speed Adaptation system .Cont*	*Traction control system - Block diagram*	*Intelligent windshield wipers*	*Anti-hijack system*
	SLO-2	*Intersection collision warning*	*Voice recognition cell phone dialing system*	*Traction control system - Working*	*Intelligent windshield wipers*	*Vehicle Immobilizer*
S-9	SLO-1	*Vehicle monitoring - tachograph*	*Voice recognition cell phone dialing system*	*Lane departure warning system- Block diagram*	*Adaptive climate control*	*Steering-wheel lock*
	SLO-2	*Vehicle monitoring - alerting systems, vehicle diagnostics*	*Emergency calling system*	*Lane departure warning system- Working*	*Adaptive climate control.*	*Vehicle GPS tracking*

Learning Resources	1. *LjuboVlacic, Michel Parent and Fumio Harashima, "Intelligent Vehicle Technologies", Butterworth-Heinemann publications, Oxford, 2001.* 2. *Robert Bosch, "Automotive Hand Book", SAE, 2000.* 3. *Allan W M B, "Automotive Computer Controlled Systems", Elsevier Butterworth-Heinemann, 2011.*	4. *Ronald K Jurgen, "Navigation and Intelligent Transportation Systems – Progress in Technology", Automotive Electronics Series, SAE, USA, 1998.* 5. *William B R, "Understanding Automotive Electronics", Butter worth Heinemann Woburn, 1998.* 6. *Bechhold, "Understanding Automotive Electronics", SAE, 1998.*

Learning Assessment

	Bloom's Level of Thinking	Continuous Learning Assessment (50% weightage)								Final Examination (50% weightage)	
		CLA – 1 (10%)		CLA – 2 (15%)		CLA – 3 (15%)		CLA – 4 (10%)			
		Theory	Practice	Theory	Practice	Theory	Practice	Theory	Practice	Theory	Practice
Level 1	Remember Understand	*40 %*	-	*30 %*	-	*30 %*	-	*30 %*	-	*30%*	-
Level 2	Apply Analyze	*40 %*	-	*40 %*	-	*40 %*	-	*40 %*	-	*40%*	-
Level 3	Evaluate Create	*20 %*	-	*30 %*	-	*30 %*	-	*30 %*	-	*30%*	-
	Total	100 %		100 %		100 %		100 %		100 %	

CLA – 4 can be from any combination of these: Assignments, Seminars, Tech Talks, Mini-Projects, Case-Studies, Self-Study, MOOCs, Certifications, and Conf. Paper etc.

Course Designers

Experts from Industry	Experts from Higher Technical Institutions	Internal Experts
1. Mr.Jegan Amirthalingam, Senior Educator, KPIT a.jegan@kpit.com	*1. Mr. Arockiya Vijay, SRMIST, arockiaj1@srmist.edu.in*	*1. Mr. Srividya K, SRMIST*
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Course Code	18AEE313T	Course Name	ARTIFICIAL NEURAL NETWORKS AND FUZZY LOGIC	Course Category	E	Professional Elective	L	T	P	C
							3	0	0	3

Pre-requisite Courses	Nil	Co-requisite Courses	Nil	Progressive Courses	Nil
Course Offering Department	Automobile Engineering	Data Book / Codes/Standards	Nil		

Course Learning Rationale (CLR):	*The purpose of learning this course is to:*
CLR-1 :	*Define and understand the concept of Neural Network Models and Learning algorithm.*
CLR-2 :	*Understand the concepts and implementation of fuzzy logic and fuzzy logic controllers.*
CLR-3 :	*Interpret and relate the Fuzzy Sets And Fuzzy Relations.*
CLR-4 :	*Compare and contrast the Hybrid fuzzy systems such as Neuro fuzzy systems with classical systems.*
CLR-5 :	*Understand the implementation of Fuzzy and neuro systems in hardware.*

Course Learning Outcomes (CLO):	*At the end of this course, learners will be able to:*	Learning			Program Learning Outcomes (PLO)														
		1	2	3	1	2	3	4	5	6	7	8	9	10	11	12	13	14	15
		Level of Thinking (Bloom)	Expected Proficiency (%)	Expected Attainment (%)	Engineering Knowledge	Problem Analysis	Design & Development	Analysis, Design, Research	Modern Tool Usage	Society & Culture	Environment & Sustainability	Ethics	Individual & Team Work	Communication	Project Mgt. & Finance	Life Long Learning	PSO - 1	PSO - 2	PSO – 3
CLO-1 :	*List and recognize the various Fuzzy systems in automobile applications.*	*1*	*90*	*85*	*H*	*M*	*M*	*M*	*L*	*L*	*L*	*L*	*M*	*M*	*L*	*M*	*H*	*M*	*M*
CLO-2 :	*Identify and Estimate Parameters of a system through Fuzzy Logic and Neural Networks*	*2*	*90*	*85*	*H*	*H*	*M*	*H*	*M*	*M*	*M*	*L*	*M*	*L*	*M*	*H*	*H*	*H*	*M*
CLO-3 :	*Identify and use various Fuzzy sets and Fuzzy Relations*	*2*	*85*	*80*	*H*	*H*	*M*	*H*	*M*	*M*	*M*	*L*	*M*	*L*	*M*	*H*	*H*	*H*	*M*
CLO-4 :	*Relate and use the various fuzzy logic and fuzzy logic controllers.*	*2*	*85*	*80*	*H*	*H*	*M*	*H*	*M*	*M*	*M*	*L*	*M*	*L*	*M*	*H*	*H*	*H*	*M*
CLO-5 :	*Select and Investigate on the various Neural Network Models.*	*3*	*85*	*80*	*H*	*H*	*H*	*H*	*M*	*H*	*H*	*M*	*M*	*M*	*M*	*H*	*H*	*H*	*H*

		Introduction To Neural Networks	Neural Network Models and Application	Fuzzy Sets And Fuzzy Relations	Embedded Fuzzy Application	Hybrid Fuzzy-Neuro Systems And Hardware Implementation
Duration (hour)		09	09	09	09	09
S-1	SLO-1	*Introduction to ANN*	*Neural Network-Feed Forward Application*	*Basic Concepts of Classical Sets*	*Introduction to conventional Control System*	*Introduction to Hybrid Systems*
	SLO-2	*Components of ANN-Connection, weights, biases*	*Neural Network-Back Propagation Network Application*	*Set Operation, Boolean Logic*	*Description, Design and Analysis*	*Fuzzy Neuron Overview*
S-2	SLO-1	*Structure of Neural Network*	*Layers In Neural Network-Single Layer*	*Basics of Fuzzy Sets*	*PID controller*	*Multilayer FNN architectures XOR Problem*
	SLO-2	*Structure of Neural Network.*	*Layers In Neural Network- Multilayer*	*Representation of Fuzzy Sets*	*Introduction to Fuzzy logic Controller (FLC)*	*Types of decision Region*
S-3	SLO-1	*Output of a Neuron*	*XOR Function and Linear Separability*	*Fuzzy Membership Function*	*Fuzzy logic Controller (FLC)-Description, Design*	*FNN Neuron Model*
	SLO-2	*Propagation functions, Learning Rules*	*XOR Function and Linear Separability.*	*Trapezoidal, Gaussian and Its Determination*	*Membership values, Rule table*	*Fuzzy ART, Fuzzy ARTMAP*
S-4	SLO-1	*Supervised and unsupervised learning*	*Threshold Functions-Sigmoid Function, Step Function*	*Fuzzy Set Properties, Operations*	*Membership values invented pendulum case study*	*Fuzzy ARTMAP- Incremental supervised Learning*
	SLO-2	*Reinforced Learning*	*Ramp Function And Linear Function*	*Logic Operation And Algebraic Operations.*	*Fuzzy logic Controller (FLC) – Knowledge base and Defuzzyification*	*Learning Normalized analog input patterns*
S-5	SLO-1	*Perception and Multilayer Perception*	*Function Approximation With Neural Networks*	*Classical Relations And Fuzzy Reasoning overview*	*Implementation of Antilock controller example*	*Neuro-Fuzzy systems*
	SLO-2	*Perception and Multilayer Perception.*	*Function Approximation With Neural Networks.*	*Fundamentals Of Fuzzy Relations*	*Fuzzy logic Controller (FLC) – Analysis with computer aided Tools*	*Neuro-Fuzzy applications*
S-6	SLO-1	*Feed forward Network and Hopfield Network.*	*System Identification With Neural Networks*	*Binary Fuzzy Relation operation*	*Fuzzy based antilock braking system overview*	*Neuro-Fuzzy systems Linguistic Fuzzy Model*
	SLO-2	*Introduction to Neural Network Models*	*Block Box Model Structure*	*Fuzzy Relations introduction*	*Fuzzy based antilock braking system.*	*Fuzzy Membership Fuzzy Rules, Fine-tune Fuzzy Rules*

S-7	SLO-1	*Neural Network Models –Adaline*	*Static Neural Network in system Identification*	*Types Of Fuzzy Relations*	*Performance and robustness of Fuzzy controller*	*Hardware Implementation –Analog Techniques*
	SLO-2	*Neural Network Models –Madaline*	*Dynamic Neural Network in system Identification*	*Membership Matrix*	*Self-Organizing Fuzzy controller*	*Hardware Implementation - Digital Techniques*
S-8	SLO-1	*Neural Network Models –Back propagation Network*	*Model Parameters estimation with Neural Network*	*Union and intersection of Fuzzy Relations*	*Fuzzy logic Controller for Automotive Embedded System applications.*	*Fuzzy Memory and OP-Amp based implementation of basic Neuron Model*
	SLO-2	*Radial basis function Neural Network*	*Control system and Neural Networks*	*Composition of Fuzzy Relations*	*Case study on Fuzzy logic Controller : Automatic Gearboxes*	*Fuzzy Memory and OP-Amp based implementation of basic Neuron Model.*
S-9	SLO-1	*Self-organizing, Recurrent Neural Network*	*Neural Networks in Predictive control*	*Fuzzy Reasoning- Fuzzy If-Then Rules*	*Case study on Fuzzy logic Controller : Four- wheel steering*	*Microcontroller Based Implementation of Fuzzy controller algorithm for automotive air conditioning Case study*
	SLO-2	*Convolution, Modular Neural Network*	*Model Reference Neural Controller*	*Fuzzy If-Then Rules.*	*Case study on Fuzzy logic Controller : Vehicle environment control*	*Microcontroller Based Implementation of Fuzzy controller algorithm for automotive air conditioning. Cont*

Learning Resources	1. *Ahmad.M.Ibrahim "Fuzzy logic for Embedded System application" -Newness 2004,ISBN: 0-7506-7699* 2. *Valluru B.Rao " C++,Neural Network and Fuzzy logic"., -M&T Books ,IDG books Worldwide,ISBN1558515526* 3. *M.Gopal "Digital Control and State Variable Methods"-2nd edition, Tata McGraw Hill Publishing,2006*	4. *Simon Haykin", Neural Networks and Learning Machines –3rd Edition- Pearson Prentice Hall-ISBN-13: 978-0131471399.* 5. *Guanrong Chen "Introduction to Fuzzy Sets,Fuzzy logic and Fuzzy control System" Trung Tat Pham-CRC Press -ISBN 0-8493-1658-8*

Learning Assessment

	Bloom's Level of Thinking	Continuous Learning Assessment (50% weightage)								Final Examination (50% weightage)	
		CLA – 1 (10%)		CLA – 2 (15%)		CLA – 3 (15%)		CLA – 4 (10%)			
		Theory	Practice	Theory	Practice	Theory	Practice	Theory	Practice	Theory	Practice
Level 1	Remember Understand	*40 %*	-	*30 %*	-	*30 %*	-	*30 %*	-	*30%*	-
Level 2	Apply Analyze	*40 %*	-	*40 %*	-	*40 %*	-	*40 %*	-	*40%*	-
Level 3	Evaluate Create	*20 %*	-	*30 %*	-	*30 %*	-	*30 %*	-	*30%*	-
	Total	100 %		100 %		100 %		100 %		100 %	

CLA – 4 can be from any combination of these: Assignments, Seminars, Tech Talks, Mini-Projects, Case-Studies, Self-Study, MOOCs, Certifications, and Conf. Paper etc.

Course Designers		
Experts from Industry	Experts from Higher Technical Institutions	Internal Experts
1. Mr.Jegan Amirthalingam, Senior Educator, KPIT <a.jegan@kpit.com>	*1. Dr. P. Sathish Kumar,Jiangsu University, China sathishkumar8989@gmail.com*	*1. Mr. Srividya K, SRMIST*
		2. Mr.Jesu Godwin D, SRMIST

Course Code	18AEE314T	Course Name	CAD FOR ELECTRONICS	Course Category	E	Professional Elective	L	T	P	C
							3	0	0	3

Pre-requisite Courses	Nil	Co-requisite Courses	Nil	Progressive Courses	Nil
Course Offering Department	Automobile Engineering	Data Book / Codes/Standards	Nil		

Course Learning Rationale (CLR):	*The purpose of learning this course is to:*
CLR-1 :	*Understand concepts of modeling in 2D and 3D.*
CLR-2 :	*Gain knowledge on computer graphics and Simulation.*
CLR-3 :	*Understand CAD Packages for electronics and recent technologies.*
CLR-4 :	*Use concepts of Computer Graphics in Printed Circuit Boards and Packaging*
CLR-5 :	*Use relevant CAD Standards for Circuit Simulation*

Course Learning Outcomes (CLO):	*At the end of this course, learners will be able to:*	Learning 1 Level of Thinking (Bloom)	2 Expected Proficiency (%)	3 Expected Attainment (%)	PLO 1 Engineering Knowledge	2 Problem Analysis	3 Design & Development	4 Analysis, Design, Research	5 Modern Tool Usage	6 Society & Culture	7 Environment & Sustainability	8 Ethics	9 Individual & Team Work	10 Communication	11 Project Mgt. & Finance	12 Life Long Learning	13 PSO - 1	14 PSO - 2	15 PSO – 3
CLO-1 :	*Use and Relate the role of CAD in Electronics and board design.*	1	90	85	H	H	H	H	M	L	L	L	M	M	H	H	L	L	M
CLO-2 :	*Understand the basic Math fundamentals behind CAD software Graphics.*	2	90	85	H	H	H	H	H	M	M	L	H	M	L	M	M	H	M
CLO-3 :	*Design and Execute Circuits Boards Simulations*	2	85	80	H	H	H	H	H	L	M	M	H	M	H	H	H	H	H
CLO-4 :	*Design Models for Electronic Packaging using CAD*	2	85	80	H	H	H	H	H	M	M	H	H	H	M	H	M	H	M

		Introduction	Graphics Concepts and Algorithms	Analog Circuit simulation	CAD for Circuit and Component Analysis	CAD for Printed Circuits Boards and Packaging
Duration (hour)		9	9	9	9	9
S-1	SLO-1	*Introduction to Design process – CAD*	*Introduction to computer Graphics*	*Introduction to simulation*	*Introduction to Circuits*	*Components of a CAD package and its highlights.*
	SLO-2	*Steps and design Process*	*Interactive graphics display*	*Purpose Of Simulation*	*DC Steady State analysis*	*Circuit design with CAD package.*
S-2	SLO-1	*Geometric Modeling Introduction*	*Display devices, Pixels*	*Simulation Examples*	*Simulation Example :Voltage regulator*	*Work layout and component layout*
	SLO-2	*Parametric Representation of Lines and curves*	*Algorithms in computer Graphics*	*Circuit Equation Modulation*	*AC Analysis*	*Process flow-chart.*
S-3	SLO-1	*Parametric Representation of synthetic curves*	*DDA Line Drawing Algorithms*	*Simulation of Modified Nodal analysis method*	*Simulation Example : Cascode amplifiers with Macro Models*	*Printing technologies for Printed Wiring Boards*
	SLO-2	*Geometric Modeling: Entities - Line - Circle - Ellipse - Parabola*	*Bresenham's Line Drawing algorithm*	*Modified Nodal analysis.*	*Cascode amplifiers with Macro Models*	*Semiconductor Packaging Overview*
S-4	SLO-1	*Geometric Modeling: Types – Wireframe modeling.*	*Bresenham's Circle Drawing algorithm*	*Active device Models overview*	*Simulation example : Transient analysis Phase Locked Loop circuit*	*Semiconductor Packages*
	SLO-2	*Geometric Modeling: Types - surface and solid modeling.*	*Point clipping algorithms*	*DC Circuit Simulation Overview*	*Process and device simulation Overview*	*Semiconductor Packages design case study*
S-5	SLO-1	*Solid modeling techniques Overview*	*Cohen Sutherland Line clipping algorithms*	*Newton's Method on DC analysis*	*Process simulation, diffusion, Oxidation, Ion implantation*	*Board-level packaging aspects*
	SLO-2	*Constructive Solid Geometry – Boolean set Operations, Sweep Representation*	*Hidden line removal algorithms*	*AC Circuit Simulation Overview*	*Simulation Example: NMOS Transistor*	*Board-level packaging aspects.*
S-6	SLO-1	*Constructive Solid Geometry – Quad tree Structure.*	*2D and 3D transformations*	*AC Circuit Simulation Example Program*	*Device simulation*	*Packaging Examples Case study*
	SLO-2	*Constructive Solid Geometry- Octree structure*	*Translation, rotation*	*Noise Simulation*	*NMOS IV Curves*	*CAD output files for PCB fabrication*
S-7	SLO-1	*Boundary Representation*	*Scaling – Concatenation.*	*Noise Simulation Example Program*	*Parameters Extraction for analog circuit simulation Overview*	*CAD output files Slandered file format*
	SLO-2	*Feature Based Modelling and Constraint Based Modelling*	*Homogeneous Transformation*	*Transient system Simulation*	*Device Characterization*	*Photo plotting and mask generation.*

S-8	SLO-1	*Parametric Modelling, Extrude, Sweep, Revolve*	*Translation and scaling*	*Verilog-A Overview*	*Least squares curve fitting*	*Photo Mask File Generation.*
	SLO-2	*Parametric Modelling Tools Cont*	*Refection and rotation*	*Verilog-A Example Program*	*Extraction and Optimization*	*Introduction to DFM, DFR , DFT*
S-9	SLO-1	*Feature Manipulation*	*Shear Transformation*	*Fast Simulation Methods*	*MOS DC models*	*DFM, DFR , DFT.*
	SLO-2	*CAD in Assembly and Drafting*	*Concatenated transformation - Inverse transformation*	*General Simulators Overview*	*MOS DC models.*	*Computer-Aided Analysis Application*

Learning Resources	1. *Ibrahim Zeid, "CAD / CAM - Theory and Practice"., Tata Mcgraw-Hill, New Delhi, 2001* 2. *Newman and Sproull R. F., "Principles of interactive computer graphics", Tata Mcgraw-Hill, New Delhi,1997*	3. *Mikell P. Groover, "CAD / CAM"., Prentice Hall of India Private Limited, New Delhi, 1997* 4. *The Circuits and Filters Handbook Third Edition "Computer Aided Design Automation" Edited By Wai-Kai Chen*

Learning Assessment

	Bloom's Level of Thinking	Continuous Learning Assessment (50% weightage)								Final Examination (50% weightage)	
		CLA – 1 (10%)		CLA – 2 (15%)		CLA – 3 (15%)		CLA – 4 (10%)#			
		Theory	Practice	Theory	Practice	Theory	Practice	Theory	Practice	Theory	Practice
Level 1	Remember Understand	40 %	-	30 %	-	30 %	-	30 %	-	30%	-
Level 2	Apply Analyze	40 %	-	40 %	-	40 %	-	40 %	-	40%	-
Level 3	Evaluate Create	20 %	-	30 %	-	30 %	-	30 %	-	30%	-
	Total	100 %		100 %		100 %		100 %		100 %	

CLA – 4 can be from any combination of these: Assignments, Seminars, Tech Talks, Mini-Projects, Case-Studies, Self-Study, MOOCs, Certifications, and Conf. Paper etc.

Course Designers		
Experts from Industry	Experts from Higher Technical Institutions	Internal Experts
1.Mr.Jegan Amirthalingam, Senior Educator, KPIT a.jegan@kpit.com	*1. Dr. P. Sathish Kumar,Jiangsu University, China sathishkumar8989@gmail.com*	*1. Mr. Joshua Paul E, SRMIST*
2. Jonny N, BGR Energy systems, jonnynallathampi@gmail.com		*2. Mr.Jesu Godwin D, SRMIST*

Course Code	18AEE316J	Course Name	AUTOMOTIVE MICROCONTROLLERS	Course Category	E	Professional Elective	L	T	P	C
							2	0	2	3

Pre-requisite Courses	18AEE211J	Co-requisite Courses	Nil	Progressive Courses	Nil
Course Offering Department	Automobile Engineering	Data Book / Codes/Standards	Nil		

Course Learning Rationale (CLR):	*The purpose of learning this course is to:*
CLR-1 :	*Acquire the knowledge of 8051 Microcontroller architecture*
CLR-2 :	*Program 8051 using Assembly level programming*
CLR-3 :	*Use the high level programming language for embedded application development*
CLR-4 :	*Get familiarized with the internals of AVR and program it using C language.*
CLR-5 :	*Learn about the special on-chip peripherals available on automotive grade Microcontrollers.*

Course Learning Outcomes (CLO):	*At the end of this course, learners will be able to:*	Learning 1	2	3	Program Learning Outcomes (PLO) 1	2	3	4	5	6	7	8	9	10	11	12	13	14	15
		Level of Thinking (Bloom)	Expected Proficiency (%)	Expected Attainment (%)	Engineering Knowledge	Problem Analysis	Design & Development	Analysis, Design, Research	Modern Tool Usage	Society & Culture	Environment & Sustainability	Ethics	Individual & Team Work	Communication	Project Mgt. & Finance	Life Long Learning	PSO - 1	PSO - 2	PSO – 3
CLO-1 :	*Perform the basic Operations of 8051 Microcontroller*	2	85	75	H	M	H	L	H	M	M	H	H	M	L	H	H	H	H
CLO-2 :	*Carry out basic Operations of 8051 Microcontroller.*	2	80	75	H	M	H	H	H	M	M	H	H	M	L	M	H	H	H
CLO-3 :	*Apply Embedded C Programming in Microcontroller.*	2	90	85	H	H	H	H	L	M	M	H	M	M	M	H	H	H	M
CLO-4 :	*Program ATMEGA328 Microcontroller using Embedded C*	2	85	80	H	M	H	H	H	H	H	H	H	H	M	H	H	H	H
CLO-5 :	*Identify and relate the various Microcontroller in automotive subsistence*	2	80	75	H	M	M	M	H	H	H	H	H	H	M	H	H	H	H

		8051 Architecture	Programming 8051	Introduction to Embedded C	Advanced Virtual Risc (AVR) Microcontrollers	Automotive Grade Processors
Duration (hour)		12	12	12	12	12
S-1	SLO-1	*Introduction to Microprocessors and Microcontrollers and differences*	*Logical Operations-Bit level, Byte Level*	*Program Languages for Embedded system application*	*Introduction to ATMEGA328*	*Introduction to Automotive grade processors*
	SLO-2	*8051 Pin diagram and description*	*Internal RAM Bit address and SFR Bit address*	*Introduction to Higher level programming language*	*ATMEGA328 –Basic Features*	*Automotive grade processors ex: Renesas, Quorivva*
S-2	SLO-1	*8051 internal Architecture*	*Logical Operations-Rotate and swap Operation*	*Advantages of Higher level programming language*	*ATMEGA328 – Core SFR'S and Ports*	*Automotive grade processors : NXP, Infineon*
	SLO-2	*Clock, PC, DP, CPU registers,*	*Arithmetic Operations Incrementing, Decrementing*	*Basics of C program language – Data Types, variables*	*ATMEGA 328-Timer TMR0,TMR1,TMR2*	*Architectural attributes of Automotive grade processors Based on subsystems*
S 3-4	SLO-1	*Lab 1: 8051- Assembly level programming – Basic Arithmetic and logical operations*	*Lab 3: Introduction to Embedded C Programming and IDE-Tool chains - AVR-ATMEGA328 Operation on bits Blinking with Digital Outputs –Delay functions*	*Lab 5: ATMEGA328- Configuring on-chip ADC –Interfacing sensors*	*Lab 7: ATMEGA328- Programming Serial Communication with Interrupts Type1,Type 2*	*Lab 9: Implementing a moving average filter for sensor noise correction*
	SLO-2					
S-5	SLO-1	*Data memory Organization*	*Arithmetic Operations : Addition, Subtraction*	*Keywords, Pointers ,Declarations, Constants and Operators*	*ATMEGA 328-Capture Compare Module-*	*On-chip Peripherals overview*
	SLO-2	*PSW, RAM, ROM, SP, SFR*	*Jumps, Calls and Subroutines*	*Introduction to Datatype conversions*	*ATMEGA 328-CCM in PWM Mode*	*Special On-chip Peripherals for Body and chassis control applications*
S-6	SLO-1	*IO ports, Connecting External Memory, Counters, Timers*	*Interrupts and Return*	*Switch case and If Loop,For Loop and While Loop*	*ATMEGA 328-Interrupts Type1,Type 2*	*On-chip Peripherals for Engine and Power train control*
	SLO-2	*Serial Data Input / output, Interrupts*	*Expanding I/O overview*	*Arrays and pointers*	*ATMEGA 328- Interrupt Model, Interrupts vectors*	*Overview of Automotive communication protocols : CAN, LIN*
S	SLO-1	*Lab 2: 8051-Finding 2's complement of a number*	*Lab 4:ATMEGA328 –EEPROM*	*Lab 6: ATMEGA328-*	*Lab 8: ATMEGA328-Working with RTC and*	*Lab 10:Building an Automotive Embedded*

7-8	SLO-2		Programming	Programming Interrupts and Timers	I2C	application with ATMEGA328
S-11	SLO-1	Addressing Modes of 8051 Microcontroller Overview	Memory Mapped I/O	Functions and Structure	ATMEGA 328-Serial Communication Modules-I2C,SPI	Automotive communication protocols : Flex Ray, MOST
	SLO-2	Immediate and Register Addressing ModesDirect and Register indirect Addressing modes of 8051 Microcontroller	Timing Subroutine-Software and Hardware Delay	Embedded Programming Tool ,IDE with Simulator	ATMEGA 328-Serial Communication Basic Programs	Automotive communication protocols : Ethernet,D2B and DSI
S-10	SLO-1	External memory access of 8051 Microcontroller	Lookup table for 8051 PC,DPTR as Base address	Embedded C Compilers	Analog Modules –A/D converter,Comparator	Introduction to Real-time operating system – for task scheduling activities
	SLO-2	Timer and counter of 8051 Microcontroller	Serial Data Transmission-Polling and interrupt driven for transmission and reception	Data types and libraries in Embedded C	Clock Oscillator ,EEPROM	RTOS Classification - Hard Real-time and Soft Real time
S 11-12	SLO-1 SLO-2	Lab: Assessment 1	Lab: Assessment 2	Lab: Assessment 3	Lab: Review class	Lab: Mini Project

Learning Resources	1. Kenneth.J.Ayala "The 8051 Microcontroller,Architecture,Programming and Application" West Publishing Company,1991 2. Muhammad Ali Mazidi, SarmadNaimi, SepehrNaimi "AVR Microcontroller and Embedded Systems Using Assembly and C "Pearson Custom Electronics Technology, 2011.	3. Muhammad Ali Mazidi, Janice Mazidi, Janice Gillispie Mazidi-8051 Microcontroller and Embedded Systems, The (1999) 4. Gilbert Held "Inter and Intra Vehicle Communications: Auerbach Publications,2008 5. DataSheets of Kinetis 32-bit MCU based on ARM,InfineonXCxx series and Multicore Aurix Architecture

Learning Assessment

	Bloom's Level of Thinking	Continuous Learning Assessment (50% weightage)								Final Examination (50% weightage)	
		CLA – 1 (10%)		CLA – 2 (15%)		CLA – 3 (15%)		CLA – 4 (10%)			
		Theory	Practice	Theory	Practice	Theory	Practice	Theory	Practice	Theory	Practice
Level 1	Remember Understand	40 %	-	30 %	-	30 %	-	30 %	-	30%	-
Level 2	Apply Analyze	40 %	-	40 %	-	40 %	-	40 %	-	40%	-
Level 3	Evaluate Create	20 %	-	30 %	-	30 %	-	30 %	-	30%	-
	Total	100 %		100 %		100 %		100 %		100 %	

CLA – 4 can be from any combination of these: Assignments, Seminars, Tech Talks, Mini-Projects, Case-Studies, Self-Study, MOOCs, Certifications, Conf. Paper etc.,

Course Designers

Experts from Industry	Experts from Higher Technical Institutions	Internal Experts
1. Mr.Jegan Amirthalingam, Senior Educator, KPIT <a.jegan@kpit.com>	1. Mr. Sam Jebakumar, SRM IST, jebakumj@srmist.edu.in	1. Mr. D. Jesu Godwin, SRMIST
		2. Mr. E. Joshua Paul, SRMIST

Course Code	18AEE317J	Course Name	AUTOMOTIVE CONTROL ENGINEERING	Course Category	E	Professional Elective	L	T	P	C
							2	0	2	3

Pre-requisite Courses	Nil	Co-requisite Courses	Nil	Progressive Courses	Nil
Course Offering Department	Automobile Engineering	Data Book / Codes/Standards	Nil		

Course Learning Rationale (CLR):	*The purpose of learning this course is to:*
CLR-1 :	*Familiarize about the importance of feedback control in automotive applications*
CLR-2 :	*Understand the status of the system in terms of stability*
CLR-3 :	*Develop the knowledge of controller and compensator design*
CLR-4 :	*Familiarize and execute stability analysis on linear system*
CLR-5 :	*Understand the concept of frequency response and analyze feedback systems*

Course Learning Outcomes (CLO):	*At the end of this course, learners will be able to:*	Learning 1 Level of Thinking (Bloom)	2 Expected Proficiency (%)	3 Expected Attainment (%)	PLO 1 Engineering Knowledge	2 Problem Analysis	3 Design & Development	4 Analysis, Design, Research	5 Modern Tool Usage	6 Society & Culture	7 Environment & Sustainability	8 Ethics	9 Individual & Team Work	10 Communication	11 Project Mgt. & Finance	12 Life Long Learning	13 PSO - 1	14 PSO - 2	15 PSO – 3
CLO-1 :	*Find the transfer function for linear control systems .*	2	85	75	H	M	H	L	H	M	M	H	H	M	L	H	H	H	H
CLO-2 :	*Perform time response analysis for standard prototyping systems.*	2	80	75	H	M	H	H	H	M	M	H	H	M	L	M	H	H	H
CLO-3 :	*Perform stability analysis for the system under study*	2	90	85	H	H	H	H	L	M	M	H	M	M	M	H	H	H	M
CLO-4 :	*Apply frequency analysis for the system under study*	2	85	80	H	M	H	H	H	H	H	H	H	H	M	H	H	H	H
CLO-5 :	*Design and implement controllers and compensators for the system under study*	2	80	75	H	M	M	M	H	H	H	H	H	H	M	H	H	H	H

Duration (hour)		Introduction to Feedback Systems	Performance of Feedback Systems	Stability Analysis of Linear System	Frequency Response Analysis of Feedback Systems	Controller Design for Linear Feedback System
		12	12	12	12	12
S-1	SLO-1	*Introduction to Systems and its types*	*Introduction to time response analysis*	*Introduction to the Concept of Stability*	*Introduction to Frequency response*	*Introduction to controllers P,PI,PD,PID*
	SLO-2	*Examples of automotive feedback systems*	*Transient response and steady state response*	*Bounded-input, Bounded-output stability(BIBO)*	*Sinusoidal excitation and response to a system*	*Effect of Proportional, Integral and differentiator constants*
S-2	SLO-1	*ADAS, Engine Management system*	*Sensitivity of a feedback system*	*Routh –Hurwitz stability criterion*	*Introduction to Frequency response plots and performance specification*	*PID design for an automotive feedback system*
	SLO-2	*Linear Time invariant systems*	*Standard test inputs for feedback system analysis*	*Routh –Hurwitz stability - Basic Numerical Problems*	*Bode plot - constant gain*	*Frequency domain interpretation of PID controller*
S 3-4	SLO-1 SLO-2	*Lab 1:Introduction To Matlab Control System Tool Box, Simulink Tool Box*	*Lab 3: Simulation of cruise control example using Matlab Simulink*	*Lab 5: Stability analysis of Second Order UnityFeedback System using Matlab control system toolbox.*	*Lab 7: Determination Of Bode Plot Using Matlab Control System Toolbox for 2nd Order System & Obtain Controller Specification Parameters.*	*Lab 9: Implementantion of Proportional-Integral-Derivative (PID) controller using Matlab Control System Toolbox.*
S-5	SLO-1	*Parameter varying system and Nonlinear system*	*Transient response and steady state response - Numerical Problems*	*Routh – Hurwitz stability - Basic Numerical Problems Cont.*	*Bode plot - differentiator ,integrator and second order term*	*Frequency domain interpretation of PID controller*
	SLO-2	*Impulse response of a system and transfer function representation*	*Time response analysis of a first order prototyping system*	*Routh – Hurwitz stability in controller parameter selection*	*Phase Margin and Gain Margin fundamentals*	*PID Numerical Problems*
S-6	SLO-1	*Transfer function of a D.C motor*	*Time response analysis of First order prototyping system - Numerical Problems*	*Stability analysis of tracked vehicle turning control*	*Procedure to plot bode diagram – Gain margin,Phase margin and stability conditions*	*Lead compensator,Lag compensator*
	SLO-2	*Transfer function of Throttle position sensor, Velocity Sensor,Accelerometer Model*	*Time response analysis - Cruise control model*	*Stability analysis of tracked vehicle turning control Cont.*	*Bode Diagram - Numerical Problems*	*Lead Lag compensators Numerical Examples*
S	SLO-1	*Lab 1: Transfer Function -*	*Lab 4:Simulation of suspension system*	*Lab 6: Determination Of Root Locus Plot*	*Lab 8: Determination Of Nyquist Plot Using*	*Lab 10: Designing Compensators using*

7-8	SLO-2	*DC Motor Speed control Simulink Modeling,*	*System in Matlab Simulink*	*And Controller Specifications Using Matlab Control SystemToolbox*	*Matlab Control System Toolbox.*	*Matlab Simulink*
S-9	SLO-1	*Introduction to Block diagram algebra*	*Time response analysis of second order prototyping system*	*The Root locus procedure for stability analysis*	*.Polar Plot - Overview*	*Design of phase lead and phase lag compensation*
	SLO-2	*Block diagram algebra Numerical examples*	*Time response analysis of second order prototyping system - Numerical Problems*	*Root locus Analysis - Basic Problems*	*.Polar Plot - Numerical Problems*	*Time domain and frequency domain interpretation of design of phase lead and phase lag compensation*
S-10	SLO-1	*Introduction to Signal Flow Graph*	*Complex Plane root location and transient response*	*Root locus Analysis of speed control system*	*Nyquistcriterin for non-minimum phase system*	*Notch Filter*
	SLO-2	*Signal Flow Graph numerical problems*	*Steady state error of feedback control system - Numerical Problems*	*Controller design using root locus for a closed loop control system-Numerical Example*	*Nyquistcriterin for non-minimum phase system*	*Notch Filter Numerical Problems*
S 11-12	SLO-1 SLO-2	*Lab: Assessment 1*	*Lab: Assessment 2*	*Lab: Assessment 3*	*Lab: Review class*	*Lab: Mini Project*

Learning Resources	1. *Richard.C.Dorf and Robert.H.Bishop, "Modern Control System" 12th edition Pearson Prentice Hall, 2013.* 2. *Benjamin.C.Kuo, "Automatic control systems", Prentice Hall of India, 7th Edition,1995* 3. *P N J.Nagrath and M.Gopal, "Control System Engineering", New Age International Publishers, 5th Edition, 2007.*

Learning Assessment

	Bloom's Level of Thinking	Continuous Learning Assessment (50% weightage)								Final Examination (50% weightage)	
		CLA – 1 (10%)		CLA – 2 (15%)		CLA – 3 (15%)		CLA – 4 (10%)			
		Theory	Practice	Theory	Practice	Theory	Practice	Theory	Practice	Theory	Practice
Level 1	Remember Understand	*40 %*	-	*30 %*	-	*30 %*	-	*30 %*	-	*30%*	-
Level 2	Apply Analyze	*40 %*	-	*40 %*	-	*40 %*	-	*40 %*	-	*40%*	-
Level 3	Evaluate Create	*20 %*	-	*30 %*	-	*30 %*	-	*30 %*	-	*30%*	-
	Total	100 %		100 %		100 %		100 %		100 %	

CLA – 4 can be from any combination of these: Assignments, Seminars, Tech Talks, Mini-Projects, Case-Studies, Self-Study, MOOCs, Certifications, and Conf. Paper etc.

Course Designers

Experts from Industry	Experts from Higher Technical Institutions	Internal Experts
1. Mr.Jegan Amirthalingam, Senior Educator, KPIT a.jegan@kpit.com	*1. Dr. Teoh Yew Heng, University Sains, Malaysia,yewhengteoh@usm.my*	*1. Mr.Jesu Godwin D, SRMIST*
	2. Mr. Arockiya Vijay, SRMIST, arockiaj1@srmist.edu.in	*2. Mr. E. Joshua Paul, SRM IST*

Course Code	18AEE411T	Course Name	POWER ELECTRONICS FOR ELECTRIC VEHICLE APPLICATION	Course Category	E	Professional Elective	L	T	P	C
							3	0	0	3

Pre-requisite Courses	18AEE211J	Co-requisite Courses	Nil	Progressive Courses	Nil
Course Offering Department	Automobile Engineering	Data Book / Codes/Standards	Nil		

Course Learning Rationale (CLR):	*The purpose of learning this course is to:*
CLR-1 :	*Define and understand the power semiconductor components and its characteristics*
CLR-2 :	*Distinguish and demonstrate the different DC-DC and AC-AC converters topology*
CLR-3 :	*Interpret and relate the operation, characteristics and performance parameters of rectifiers*
CLR-4 :	*Compare and contrast the operation, switching techniques for various types of DC-AC inverters*
CLR-5 :	*Design and develop the motor drives for automotive motor control applications*

Course Learning Outcomes (CLO):	*At the end of this course, learners will be able to:*	Learning 1: Level of Thinking (Bloom)	Learning 2: Expected Proficiency (%)	Learning 3: Expected Attainment (%)	PLO 1: Engineering Knowledge	PLO 2: Problem Analysis	PLO 3: Design & Development	PLO 4: Analysis, Design, Research	PLO 5: Modern Tool Usage	PLO 6: Society & Culture	PLO 7: Environment & Sustainability	PLO 8: Ethics	PLO 9: Individual & Team Work	PLO 10: Communication	PLO 11: Project Mgt. & Finance	PLO 12: Life Long Learning	PLO 13: PSO - 1	PLO 14: PSO - 2	PLO 15: PSO – 3
CLO-1 :	*List and recognize the various power semiconductor devices suitable for motor drive applications*	*1*	*90*	*85*	*H*	*M*	*M*	*M*	*L*	*L*	*L*	*L*	*M*	*M*	*L*	*M*	*H*	*M*	*M*
CLO-2 :	*Identify and solve the DC-DC and AC-AC converters suitable for the desired requirements*	*2*	*90*	*85*	*H*	*H*	*M*	*H*	*M*	*M*	*M*	*L*	*M*	*L*	*M*	*H*	*H*	*H*	*M*
CLO-3 :	*Experiment and sketch the various AC-DC Rectifier configurations and their input and output Waveforms*	*2*	*85*	*80*	*H*	*H*	*M*	*H*	*M*	*M*	*M*	*L*	*M*	*L*	*M*	*H*	*H*	*H*	*M*
CLO-4 :	*Relate and use the DC - AC Inverters with various sources and control techniques*	*2*	*85*	*80*	*H*	*H*	*M*	*H*	*M*	*M*	*M*	*L*	*M*	*L*	*M*	*H*	*H*	*H*	*M*
CLO-5 :	*Investigate and select the various motor drives suitable for the desired applications*	*3*	*85*	*80*	*H*	*H*	*H*	*H*	*M*	*H*	*H*	*M*	*M*	*M*	*M*	*H*	*H*	*H*	*H*

		Automotive Semiconductor Devices	AC -DC Converters	AC-DC Rectifiers	DC - AC Inverters	Automotive Motor Drives
Duration (hour)		09	09	09	09	09
S-1	SLO-1	*Introduction to power semiconductor devices*	*DC-DC Converter - Basics*	*Half Bridge Diode AC-DC Rectifier*	*DC-to-AC Conversion- Basics*	*DC motor drives-introduction*
	SLO-2	*Diodes - Rectification*	*DC-DC Converter - Types*	*Characteristics and Circuit Configuration*	*DC-to-AC Conversion- Basics.*	*DC motor drives-Types*
S-2	SLO-1	*Diodes – Freewheeling*	*Buck, Boost, and Buck-Boost Converter overview*	*Full Bridge Diode AC-DC Rectifier*	*Introduction to Inverters*	*Torque Production in Brushed DC-Motor Drives*
	SLO-2	*Diodes - Clamping Devices*	*Buck, Boost, and Buck-Boost Converter Circuit overview*	*Characteristics and Circuit Configuration*	*Types of Inverters overview*	*Torque Production in Brushed DC-Motor Drives.*
S-3	SLO-1	*Power MOSFETs - Characteristics*	*Buck Converter - Components*	*Three-Phase Full-Bridge Diode Rectifier - Circuit Configuration*	*Voltage Source Inverters-Single phase inverters*	*Series connected DC motor drives*
	SLO-2	*Power MOSFETs - Low-Voltage Load Drivers*	*Buck Converter - circuit*	*Three-Phase Full-Bridge Diode Rectifier - Analysis*	*Voltage Source Inverters-Single phase Inverters applications*	*Series connected DC motor drives.*
S-4	SLO-1	*IGBTs - Characteristics*	*Buck Converter - Analysis*	*Three-Phase Full-Bridge Diode Rectifier - Waveforms*	*Voltage Source Inverters -Three phase Inverters`*	*Induction Motor Drives -Introduction*
	SLO-2	*IGBTs - High-Voltage Power Switches*	*Buck Converter*	*Design of Dynamic Breaking Unit*	*Voltage Source Inverters -Three phase Inverters applications*	*Induction Motor Drives.*
S-5	SLO-1	*Power Integrated Circuits*	*Boost Converter - Components*	*Design of Dynamic Breaking Unit.*	*Current Source inverters*	*Induction motor Variable Speed Drive operating modes*
	SLO-2	*Power Integrated Circuits Examples*	*Boost Converter - Circuit*	*Calculation of DC-Link Power*	*Current Source inverters applications*	*Induction motor Variable Speed Drive operating modes.*
S-6	SLO-1	*Smart Power Devices*	*Boost Converter - Analysis*	*Calculation of DC-Link Power*	*Voltage Control Techniques – Sinusoidal PWM (SPWM) Technique*	*Torque and speed control of Induction - Motor Drives*
	SLO-2	*Smart Power Devices.*	*Boost Converter - Analysis.*	*Three-Phase Full-Bridge. Thyristor AC-DC Rectifier-Circuit Configuration*	*Voltage Control Techniques – Sinusoidal PWM (SPWM) Techniques.*	*Torque and speed control of Induction - Motor Drives.*
S-7	SLO-1	*Emerging Device Technologies - Super-Junction*	*Buck-Boost Converter - Components*	*Three-Phase Full-Bridge Thyristor AC-DC Rectifier-Analysis*	*Current control techniques - HysteresisCurrent Control*	*Fundamentals of Scalar and vector control for induction motors*

	SLO-2	*Emerging Device Technologies - Super-Junction.*	*Buck-Boost Converter - Circuit*	*Three-Phase Full-Bridge Thyristor AC-DC Rectifier-Waveforms*	*Current control techniques – Hysteresis Current Control*	*Types of scalar control for induction motors*
S-8	SLO-1	*Emerging Device Technologies - SiC Devices*	*Buck-Boost Converter - Analysis*	*Topology and Operation Modes*	*Multilevel inverters*	*Vector control for induction motors.*
	SLO-2	*Emerging Device Technologies - SiC Devices.*	*Push-Pull Converter - Half Bridge*	*Topology and Operation Modes.*	*Multilevel inverters.*	*Types of vector control for induction motors.*
S-9	SLO-1	*Power Losses in semiconductors*	*Push-Pull Converter - Full Bridge*	*Fire Angle Control Scheme*	*Hard Switching Effects*	*Induction motor drives for Electric Vehicles*
	SLO-2	*Thermal Management in semiconductors*	*AC- AC Converters*	*Fire Angle Control Scheme.*	*Hard Switching Effects. .*	*Induction motor drives for Electric Vehicles.*

Learning Resources	*1. Ali_Emadi" Handbook of automotive power electronics and motor drives",3rd Edition, 2014* *2. Ned Mohan, T.M.Undeland, W.P.Robbins," Power Electronics: Converters, applications and design", John wiley and Sons, 3rd Edition, 2006.* *3. Rashid M.H., "Power Electronics Circuits, Devices and Applications", Prentice Hall India, 3rd Edition, New Delhi, 2004*

Learning Assessment											
	Bloom's Level of Thinking	Continuous Learning Assessment (50% weightage)								Final Examination (50% weightage)	
		CLA – 1 (10%)		CLA – 2 (15%)		CLA – 3 (15%)		CLA – 4 (10%)			
		Theory	Practice	Theory	Practice	Theory	Practice	Theory	Practice	Theory	Practice
Level 1	Remember Understand	*40 %*	-	*30 %*	-	*30 %*	-	*30 %*	-	*30%*	-
Level 2	Apply Analyze	*40 %*	-	*40 %*	-	*40 %*	-	*40 %*	-	*40%*	-
Level 3	Evaluate Create	*20 %*	-	*30 %*	-	*30 %*	-	*30 %*	-	*30%*	-
	Total	100 %		100 %		100 %		100 %		100 %	

CLA – 4 can be from any combination of these: Assignments, Seminars, Tech Talks, Mini-Projects, Case-Studies, Self-Study, MOOCs, Certifications, and Conf. Paper etc.

Course Designers		
Experts from Industry	Experts from Higher Technical Institutions	Internal Experts
1. Mr.Jegan Amirthalingam, Senior Educator, KPIT a..jegan@kpit.com	*1. Mr. Arockiya Vijay, SRMIST, arockiaj1@srmist.edu.in*	*1. Mr. Srividya K, SRMIST*
		2. Mr.Jesu Godwin D, SRMIST

Course Code	18AEE412T	Course Name	STATE SPACE ANALYSIS AND DIGITAL CONTROL SYSTEM	Course Category	E	Professional Elective	L	T	P	C
							3	0	0	3

Pre-requisite Courses	Nil	Co-requisite Courses	18AEE317J	Progressive Courses	Nil
Course Offering Department	Automobile Engineering	Data Book / Codes/Standards	Nil		

Course Learning Rationale (CLR):	*The purpose of learning this course is to:*
CLR-1 :	*Define and understand the basics of discrete systems and digital control*
CLR-2 :	*Design and implement digital controllers for discrete time models*
CLR-3 :	*Formulate state space models for dynamics system*
CLR-4 :	*Acquire the fundamentals of pole placement design and state observers*
CLR-5 :	*Explore the techniques involved in optimal control design*

Course Learning Outcomes (CLO):	*At the end of this course, learners will be able to:*	Learning 1: Level of Thinking (Bloom)	Learning 2: Expected Proficiency (%)	Learning 3: Expected Attainment (%)	PLO 1: Engineering Knowledge	PLO 2: Problem Analysis	PLO 3: Design & Development	PLO 4: Analysis, Design, Research	PLO 5: Modern Tool Usage	PLO 6: Society & Culture	PLO 7: Environment & Sustainability	PLO 8: Ethics	PLO 9: Individual & Team Work	PLO 10: Communication	PLO 11: Project Mgt. & Finance	PLO 12: Life Long Learning	PLO 13: PSO - 1	PLO 14: PSO - 2	PLO 15: PSO – 3
CLO-1 :	*List and recognize the various discrete systems and digital control*	1	90	85	H	M	M	M	L	L	L	L	M	M	L	M	H	M	M
CLO-2 :	*Identify and solve the various digital controllers for discrete time models*	2	90	85	H	H	M	H	M	M	M	L	M	L	M	H	H	H	M
CLO-3 :	*Experiment on the various state space models for dynamics systems*	2	85	80	H	H	M	H	M	M	M	L	M	L	M	H	H	H	M
CLO-4 :	*Relate and use the pole placement design and state observers*	2	85	80	H	H	M	H	M	M	M	L	M	L	M	H	H	H	M
CLO-5 :	*Investigate and implement the optimal control design*	3	85	80	H	H	H	H	M	H	H	M	M	M	M	H	H	H	H

		Signal Processing in Digital Control	Models of Digital Control Systems and Algorithm	Control System Analysis With State Variable Methods	Pole Placement Design and State Observers	Lyapunov Stability Analysis and Optimal Control
Duration (hour)		09	09	09	09	09
S-1	SLO-1	*Introduction Signal Processing*	*Introduction to Z transform*	*Introduction to state space analysis*	*State feedback Overview*	*Basic stability definitions*
	SLO-2	*Control system terminologies*	*Z domain specification*	*State variable representation of system*	*Stability improvement by state feedback*	*Theorems on stability*
S-2	SLO-1	*Classical approach to analog controller design*	*Z-domain description of sampled continuous time plant*	*State variable representation.*	*Introduction to Pole Placement*	*Sign definiteness of functions and matrices*
	SLO-2	*Classical approach to analog controller design. Cont*	*Z-domain description of sampled continuous time plant. Cont*	*State space analysis of systems overview*	*Necessary and sufficient conditions for arbitrary pole-placement*	*Lyapunov Stability Theorems for linear and nonlinear systems*
S-3	SLO-1	*Introduction to digital control system*	*Implementation of Digital controllers*	*State space analysis of systems. Cont*	*Voltage Source Inverters-Single phase inverters*	*Lyapunov's first or indirect method*
	SLO-2	*Configuration of basic digital control system scheme*	*PI,PD,PID controllers*	*Conversion of transfer function to state variable model*	*State regulator design*	*Lyapunov's second or direct method*
S-4	SLO-1	*Basic discrete time signals*	*Tunable PID controller*	*Transfer function to state variable model numerical Examples*	*State regulator design.*	*Lyapunov function candidate and Matrix Equation*
	SLO-2	*Time domain models of discrete time system*	*Tunable PID Speed Control problem*	*Transfer function to state variable model numerical Examples. Cont*	*State observers*	*Parameter Optimization*
S-5	SLO-1	*Transfer function Overview*	*Conversion of Canonical state variable to transfer function model*	*Conversion of Canonical state variable to transfer function model*	*Design of state observers*	*Optimal control examples*
	SLO-2	*Transfer function Models*	*Digital temperature control*	*Conversion of Canonical state variable to transfer function model Numerical Examples*	*State observers for linear systems*	*Performance indices*
S-6	SLO-1	*Transfer function Models.*	*Concepts of controllability*	*State observers for linear systems*	*State observers for non- linear systems*	*Quadratic Performance index*
	SLO-2	*Introduction to Stability analysis*	*Z-plane specification for control system design*	*State observers for linear systems Examples*	*State observers examples.*	*Quadratic Performance index example*
S-7	SLO-1	*Stability on z-plane and the Jury stability criterion*	*Z-plane specification for control system design.*	*Concept of observability Numerical examples*	*Digital control system with state feedback*	*Performance indices examples*

	SLO-2	*Sampling as impulse Modulation*	*Introduction to digital compensator*	*State feedback with integral control*	*State feedback with integral control*	*Quadratic Performance index example State regulator design*
S-8	SLO-1	*Practical aspects on the choice of sampling rate*	*Digital compensator design using frequency response*	*Multivariable control system overview.*	*Dead beat control concept*	*State regulator design through Lyapunov equation*
	SLO-2	*Principles of Discretization*	*Digital compensator design using frequency response.*	*Multivariable control system Numerical Examples*	*Multilevel inverters.*	*Duality and Observability*
S-9	SLO-1	*Routh Stability criterion*	*Digital compensator design using root locus plots*	*Digital state space Models*	*Dead beat control by state feedback and Dead beat observers*	*Optimal state regulator through the matrix riccati equation*
	SLO-2	*Routh Stability criterion-.*	*Digital compensator design using root locus plots.*	*Digital state space Models Examples*	*System identification and adaptive control*	*Optimal digital control systems*

Learning Resources	1. *M G opal "Digital Control and State Variable Methods", 4th edition, Tata McGraw Hill Education Pvt.Ltd. 2012* 2. *Kats uhiko Ogata "Discrete time control system" 2nd edition ,Prentice Hall Pvt.Ltd,2012* 3. *J.Nagrath and M.Gopal, "Control System Engineering", New Age International publishers, 5th Edition, 2007.*	2. *Richard.C.Dorf and Robert.H.Bishop, "Modern Control System" 12th edition Pearson Prentice Hall, 2013.* 3. *Benjamin.C.Kuo, "Automatic control systems", Prentice Hall of India, 7th Edition,1995.*

Learning Assessment

	Bloom's Level of Thinking	Continuous Learning Assessment (50% weightage)								Final Examination (50% weightage)	
		CLA – 1 (10%)		CLA – 2 (15%)		CLA – 3 (15%)		CLA – 4 (10%)			
		Theory	Practice	Theory	Practice	Theory	Practice	Theory	Practice	Theory	Practice
Level 1	Remember Understand	*40 %*	-	*30 %*	-	*30 %*	-	*30 %*	-	*30%*	-
Level 2	Apply Analyze	*40 %*	-	*40 %*	-	*40 %*	-	*40 %*	-	*40%*	-
Level 3	Evaluate Create	*20 %*	-	*30 %*	-	*30 %*	-	*30 %*	-	*30%*	-
	Total	100 %		100 %		100 %		100 %		100 %	

CLA – 4 can be from any combination of these: Assignments, Seminars, Tech Talks, Mini-Projects, Case-Studies, Self-Study, MOOCs, Certifications, and Conf. Paper etc.

Course Designers

Experts from Industry	Experts from Higher Technical Institutions	Internal Experts
1. Mr.Jegan Amirthalingam, Senior Educator, KPIT a.jegan@kpit.com	*1. Mr. Arockiya Vijay, SRMIST, arockiaj1@srmist.edu.in*	*1. Mr.Jesu Godwin D, SRMIST*
	2. Dr. P. Sathish Kumar,Jiangsu University, China sathishkumar8989@gmail.com	*2. Mr. E. Joshua Paul, SRMIST*

Course Code	18AEE413T	Course Name	MODEL BASED SYSTEM DESIGN	Course Category	E	Professional Elective	L	T	P	C
							3	0	0	3

Pre-requisite Courses	18AEE317J	Co-requisite Courses	Nil	Progressive Courses	Nil
Course Offering Department	Automobile Engineering	Data Book / Codes/Standards	Nil		

Course Learning Rationale (CLR):	The purpose of learning this course is to:
CLR-1 :	*Define and Understand the concept of V-development approach in automotive controller design*
CLR-2 :	*Distinguish and demonstrate the different modelling techniques used in model based system design*
CLR-3 :	*Understand the architecture of ECU and Rapid prototyping Hardware*
CLR-4 :	*Understand the concept of real time simulation and HIL simulation*
CLR-5 :	*Create models of physical systems using design of experiment methods*

Course Learning Outcomes (CLO):	At the end of this course, learners will be able to:	Learning 1: Level of Thinking (Bloom)	Learning 2: Expected Proficiency (%)	Learning 3: Expected Attainment (%)	PLO 1: Engineering Knowledge	PLO 2: Problem Analysis	PLO 3: Design & Development	PLO 4: Analysis, Design, Research	PLO 5: Modern Tool Usage	PLO 6: Society & Culture	PLO 7: Environment & Sustainability	PLO 8: Ethics	PLO 9: Individual & Team Work	PLO 10: Communication	PLO 11: Project Mgt. & Finance	PLO 12: Life Long Learning	PLO 13: PSO - 1	PLO 14: PSO - 2	PLO 15: PSO – 3
CLO-1 :	*Identify and Build mathematical models for components in a system.*	1	90	85	H	M	M	M	L	L	L	L	M	M	L	M	H	M	M
CLO-2 :	*Investigate on the continuous refinement and improvement to generate accurate models*	2	90	85	H	H	M	H	M	M	M	L	M	L	M	H	H	H	M
CLO-3 :	*Experiment and run Hardware-in-the-Loop Simulations (HIL)*	2	85	80	H	H	M	H	M	M	M	L	M	L	M	H	H	H	M
CLO-4 :	*Relate and apply basic control algorithms to a real physical system*	2	85	80	H	H	M	H	M	M	M	L	M	L	M	H	H	H	M
CLO-5 :	*Apply verification and validation methods to a physical system model*	3	85	80	H	H	H	H	M	H	H	M	M	M	M	H	H	H	H

		Model Based Design Approach	Modelling Techniques and development	ECU Architecture and Design	Real-time Simulation	Model Based System Design Application
Duration (hour)		09	09	09	09	09
S-1	SLO-1	*Introduction to design process*	*Introduction to graphical modelling*	*Rapid Prototyping hardware architecture and features*	*Introduction to real-time simulation*	*Introduction to model based system design software tools*
	SLO-2	*Design validation and verification and requirements*	*State Flow Modelling*	*Programming analog ,digital interface*	*Standalone Plant Simulation*	*Overview of Simulink and Sim driveline*
S-2	SLO-1	*Design process implementation*	*State machines Modelling*	*Protocol interface and implementing controller*	*Standalone Controller Simulation*	*Modelling a series hybrid electric vehicle in Sim drive line*
	SLO-2	*Introduction to model based design*	*Algorithmic models*	*ECU Design - Need for ECUs*	*Plant and controller simulation on single target*	*Modelling a series hybrid electric vehicle in Sim drive line.Cont*
S-3	SLO-1	*Model based design in functional level*	*Transfer function modelling*	*Advances in ECUs for automotive application*	*Plant and controller simulation on single target.Cont*	*Driver model in Simulink*
	SLO-2	*Model based design in Architecture level*	*State space modelling*	*Requirements for ECU design*	*RT simulation by Separating the plant from the controller*	*Battery model in Simulink*
S-4	SLO-1	*Model based design in implementation level*	*Event based Modelling*	*Design complexities of ECU*	*Real-time simulation.Cont*	*Modelling electric motor in Simulink*
	SLO-2	*Key barriers in adaptation of model based engineering*	*Statistical modelling for system identification*	*Selection of sensors for ECU design*	*Controller and Plant on real time target*	*Modelling speed tracking controller model in Simulink*
S-5	SLO-1	*Introduction to V-development cycle*	*Mathematical Modelling for automotive applications*	*Selection of interfaces for ECU design*	*Controller and Plant on real time target Cont.*	*Modelling of a single cylinder IC engine in powertrain block set*
	SLO-2	*V-developments cycle significance*	*Simple motor and generator model*	*Selection of actuators for ECU design*	*V and V using HIL RT Model*	*Modelling of a single cylinder IC engine in powertrain block set.Cont*
S-6	SLO-1	*V-development cycle in automotive domain*	*Simple IC engine model, Controller model*	*Selection of actuators for ECU design .Cont*	*V and V using HIL RT Model case study*	*Modeling of an IC engine controller in powertrain block set*
	SLO-2	*Rapid control prototyping*	*IC engine Controller model*	*ECU Hardware -Architecture of an advanced Microcontroller*	*Implementation of communication interfaces*	*Modeling of an IC engine controller in powertrain blockset.Cont*
S-7	SLO-1	*Model-in-loop simulation*	*Quarter car model*	*Overview of on chip peripherals*	*Verification of communication interfaces*	*Virtual modelling of electrified powertrains*

	SLO-2	*Software-in-loop simulation*	*Cruise control model*	*ECU on chip peripherals.Cont*	*A/D Outputs implementation*	*Virtual modelling of electrified powertrains.Cont*
S-8	SLO-1	*Hardware-in-loop simulation*	*Motor model and development.*	*ECU protocol interfaces*	*Control algorithm implementation*	*Development a hybrid vehicle model*
	SLO-2	*Processor in the loop simulation*	*Generator model Development.*	*GPIO on the advanced Microcontroller ECU*	*Timing requirements in control algorithm*	*Development a hybrid vehicle model. Cont*
S-9	SLO-1	*Vehicle in the loop simulation*	*Motor controller model and development.*	*Overview of ECU programming*	*Verification of timing requirements in control algorithm*	*Supervisory logic implementation of Hybrid vehicle.*
	SLO-2	*Constraints in HIL,MIL,SIL,PIL*	*Motor controller model and development. Cont*	*ECU interface challenges*	*Control algorithm optimization*	*HIL simulation of Hybrid vehicle.*

Learning Resources	*1. Pete r Wilson and H.AlanMantooth "Model based Engineering for complex Electronics system" 2013,Newness* *2. Web course by Zachariah chambers and Marc Herniter –Rose Hulman institute of technology on "Introduction to model based design and Advanced model based design."* *3.Rashid M.H., "Power Electronics Circuits, Devices and Applications", Prentice Hall India, 3rd Edition, New Delhi, 2004*

Learning Assessment

	Bloom's Level of Thinking	Continuous Learning Assessment (50% weightage)								Final Examination (50% weightage)	
		CLA – 1 (10%)		CLA – 2 (15%)		CLA – 3 (15%)		CLA – 4 (10%)			
		Theory	Practice	Theory	Practice	Theory	Practice	Theory	Practice	Theory	Practice
Level 1	Remember Understand	*40 %*	-	*30 %*	-	*30 %*	-	*30 %*	-	*30%*	-
Level 2	Apply Analyze	*40 %*	-	*40 %*	-	*40 %*	-	*40 %*	-	*40%*	-
Level 3	Evaluate Create	*20 %*	-	*30 %*	-	*30 %*	-	*30 %*	-	*30%*	-
	Total	100 %		100 %		100 %		100 %		100 %	

CLA – 4 can be from any combination of these: Assignments, Seminars, Tech Talks, Mini-Projects, Case-Studies, Self-Study, MOOCs, Certifications, and Conf. Paper etc.

Course Designers

Experts from Industry	Experts from Higher Technical Institutions	Internal Experts
1. Mr.Jegan Amirthalingam, Senior Educator, KPIT a.jegan@kpit.com	*1. Dr. P. Sathish Kumar,Jiangsu University, China sathishkumar8989@gmail.com*	*1. Mr. Srividya K, SRMIST*
2. Jonny N, BGR Energy systems, jonnynallathampi@gmail.com	*2. Mr. Arockiya Vijay, SRMIST, arockiaj1@srmist.edu.in*	*2. Mr.Jesu Godwin D, SRMIST*

Course Code	18AEE414J	Course Name	MODELLING AND CONTROL OF ELECTRIC AND HYBRID VEHICLES	Course Category	E	Professional Elective	L	T	P	C
							2	0	2	3

Pre-requisite Courses	18AEE317J	Co-requisite Courses	Nil	Progressive Courses	Nil
Course Offering Department	Automobile Engineering	Data Book / Codes/Standards	Nil		

Course Learning Rationale (CLR):	*The purpose of learning this course is to:*
CLR-1 :	*State and classify the electric and hybrid power train technologies*
CLR-2 :	*Investigate and interpret the performance characteristics of EV / HEV power train components*
CLR-3 :	*Classify and test the various EV / HEV energy storage technologies*
CLR-4 :	*Develop and relate the various Energy management control techniques for EV and HEV vehicles*
CLR-5 :	*Formulate and implement the Vehicle Dynamics Control Systems for EV and HEV vehicles*

Course Learning Outcomes (CLO):	*At the end of this course, learners will be able to:*	Learning 1: Level of Thinking (Bloom)	2: Expected Proficiency (%)	3: Expected Attainment (%)	PLO 1: Engineering Knowledge	2: Problem Analysis	3: Design & Development	4: Analysis, Design, Research	5: Modern Tool Usage	6: Society & Culture	7: Environment & Sustainability	8: Ethics	9: Individual & Team Work	10: Communication	11: Project Mgt. & Finance	12: Life Long Learning	13: PSO - 1	14: PSO - 2	15: PSO – 3
CLO-1 :	*Compare and operate the different electric and hybrid vehicle power train configuration.*	*1,2*	*90*	*85*	*H*	*M*	*M*	*M*	*L*	*L*	*M*	*L*	*L*	*L*	*L*	*M*	*H*	*M*	*M*
CLO-2 :	*Demonstrate and design the EV / HEV power train model and its components.*	*2,3*	*85*	*80*	*H*	*H*	*H*	*H*	*M*	*M*	*H*	*L*	*M*	*M*	*L*	*M*	*H*	*H*	*H*
CLO-3 :	*Identify and examine the storage batteries, fuel cells and ultra capacitors used in vehicles.*	*1,2*	*85*	*80*	*H*	*M*	*M*	*M*	*L*	*L*	*M*	*L*	*L*	*L*	*L*	*M*	*H*	*H*	*M*
CLO-4 :	*Construct and solve the EV / HEV power and energy management systems.*	*2,3*	*85*	*80*	*H*	*H*	*H*	*H*	*L*	*M*	*H*	*L*	*M*	*M*	*L*	*M*	*H*	*H*	*M*
CLO-5 :	*Design the driver, vehicle, environmental model of EV/HEV dynamics control system*	*2,3*	*85*	*80*	*H*	*H*	*H*	*H*	*M*	*M*	*H*	*L*	*L*	*M*	*L*	*M*	*H*	*H*	*H*

			Electric and Hybrid Power train Technologies	Modelling and Characteristics of EV/HEV Power train Components	Energy Storage	Energy, Power Management Systems And Techniques For EV and HEV
Duration (hour)		12	12	12	12	12
S-1	SLO-1	*Introduction to Battery Electric Vehicles (BEV's) – Power train Configuration, Traction*	*Electric Motor Performance characteristics – Power and torque generation*	*Electro chemical batteries- Electro chemical reactions*	*Power /Energy management controllers*	*Fundamentals of Vehicle Dynamics Control (VDC) Systems –Driver Model*
	SLO-2	*Introduction to Battery Electric Vehicles (BEV's) – Energy sources and storage*	*Electric Motor Performance characteristics – Efficiency, DC Motors*	*Electro chemical batteries- Electro chemical reactions*	*Power /Energy management controllers. Cont*	*Fundamentals of Vehicle Dynamics Control (VDC) Systems –Driver Model*
S-2	SLO-1	*Fuel Cell Electric vehicle (FCEV) technologies*	*Electric Motor Performance characteristics – Induction AC motors, Steady state Performance analysis*	*Battery technologies – Lead acid battery*	*Battery Management system (BMS) for EV and HEV*	*Fundamentals of Vehicle Dynamics Control (VDC) Systems –Vehicle Model.*
	SLO-2	*Fuel Cell Electric vehicle (FCEV) technologies*	*Electric Motor Performance characteristics – Permanent Magnet AC Motors ,BLDC motors*	*Battery technologies –Nickel based batteries*	*Battery Management system (BMS) for EV and HEV*	*Fundamentals of Vehicle Dynamics Control (VDC) Systems –Vehicle Model*
S 3-4	SLO-1 SLO-2	*Lab 1: Introduction Lab*	*Lab 4: Data acquisition using data loggers and virtual instrumentation hardware*	*Lab 7: Testing and validation of Electric Vehicle Battery*	*Lab 10: Direction control of Electric Vehicle motors*	*Lab 13: Revision Lab*
S-5	SLO-1	*Hybrid Electric Vehicles- Degree of Hybridization, Parallel hybrid*	*Battery Performance Characteristics- Battery Capacity, Open circuit terminal voltages*	*Lithium based batteries –Lithium polymer*	*Rule based Control Strategies for HEV and PHEV –Deterministic Rule-based ,Fuzzy rule based control strategies*	*Fundamentals of Vehicle Dynamics Control (VDC) Systems –Environment Model*
	SLO-2	*Hybrid Electric Vehicles-Series Hybrid*	*Battery Performance Characteristics-Charge and Discharge rates*	*Lithium based batteries –Lithium polymer*	*Rule based Control Strategies for HEV and PHEV –Deterministic Rule-based, Fuzzy rule based control strategies.*	*Fundamentals of Vehicle Dynamics Control (VDC) Systems –Environment Model.*
S-6	SLO-1	*Hybrid Electric Vehicles-Power split*	*Battery Performance Characteristics-SOC, SOD, DOD*	*Lithium based batteries –Lithium ion*	*Optimization based Control Strategies – Optimization Problem formulation*	*Working principle of VDC Systems*
	SLO-2	*Hybrid Electric Vehicles-compound Hybrid Configuration*	*Battery Performance Characteristics-Battery Energy Density, power density*	*Lithium based batteries –Lithium ion*	*Optimization based Control Strategies – Optimization Problem formulation.*	*Working principle of VDC Systems.*

S 7-8	SLO-1 / SLO-2	*Lab 2: Introduction to Virtual Instrumentation and Rapid control prototyping hardware*	*Lab 5: Interfacing Analog input ,Signal conditioning using control hardware*	*Lab 8: Testing and Validation of Electric Motor for power assisted Steering system*	*Lab 11: Electronic differential Design for Electric Vehicles*	*Lab 14: Lab Model Examination*
S-9	SLO-1	*Plug-in Hybrid Electric Vehicles (PHEV's)*	*Battery Performance Characteristics-Specific energy and Specific Power*	*Ultra-capacitors –Basic principle, Performance, Ultra High speed flywheels*	*Global Energy/Power Management Optimization*	*VDC System Overview*
	SLO-2	*Hybrid Hydraulic vehicles (HHV)*	*Inverters and Motor drives*	*Ultra-capacitors –Basic principle, Performance, Ultra High speed flywheels*	*Real-time Energy/Power Management Optimization.*	*VDC implementation on Electric and Hybrid Vehicles-structure of the control system*
S-10	SLO-1	*Pneumatic Hybrid Vehicles (PHVs)*	*Inverters and Motor drives*	*Fuel cells –Principle, working , requirements and specifications*	*Optimization techniques*	*VDC implementation on Electric and Hybrid Vehicles-structure of the control system.*
	SLO-2	*Power/Energy Management System*	*Regenerative Braking Characteristics*	*Fuel cells –Principle, working , requirements and specifications*	*Optimization techniques*	*Control system Design and simulation study*
S 11-12	SLO-1 / SLO-2	*Lab 3:Control prototyping using graphical programming methods Control prototyping using graphical programming methods*	*Lab 6: Control of actuators with Rapid control prototyping hardware*	*Lab 9: Speed control for Electric Vehicle motors*	*Lab 12: Revision*	*Lab 15: Evaluation & Discussion*

Learning Resources	1. *Amir Khajepour, M. Saber Fallah, AvestaGoodarzi-"Electric and Hybrid Vehicles Technologies, Modeling and Control" - A Mechatronic Approach-Wiley Publication,2014* 2. *Iqbal Husain, "Electric and Hybrid vehicles Design Fundamentals" , CRC Press,second edition 2013* 3. *James Larminie, John Lowry, "Electric vehicle technology Explained" secondEdition, Wiley Publication, 2012*	4. *Ali Emadi, MehrdadEhsani, John M. Muller,"Vehicular Electric Power Systems" Marcel Dekker, Inc., 2004* 5. *Electric vehicle Laboratory Manual* 6. *NI Systems "Compact Rio" Lab Manual*

Learning Assessment

	Bloom's Level of Thinking	Continuous Learning Assessment (50% weightage)								Final Examination (50% weightage)	
		CLA – 1 (10%)		CLA – 2 (15%)		CLA – 3 (15%)		CLA – 4 (10%)			
		Theory	Practice	Theory	Practice	Theory	Practice	Theory	Practice	Theory	Practice
Level 1	Remember / Understand	*40 %*	-	*30 %*	-	*30 %*	-	*30 %*	-	*30%*	-
Level 2	Apply / Analyze	*40 %*	-	*40 %*	-	*40 %*	-	*40 %*	-	*40%*	-
Level 3	Evaluate / Create	*20 %*	-	*30 %*	-	*30 %*	-	*30 %*	-	*30%*	-
	Total	100 %		100 %		100 %		100 %		100 %	

CLA – 4 can be from any combination of these: Assignments, Seminars, Tech Talks, Mini-Projects, Case-Studies, Self-Study, MOOCs, Certifications, and Conf. Paper etc.

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		2. Mr.Jesu Godwin D, SRMIST

Course Code	18AEE415T	Course Name	VEHICLE STABILITY AND CONTROL SYSTEMS	Course Category	E	Professional Elective	L	T	P	C
							3	0	0	3

Pre-requisite Courses	18AEE317J	Co-requisite Courses	Nil	Progressive Courses	Nil
Course Offering Department	Automobile Engineering	Data Book / Codes/Standards	Nil		

Course Learning Rationale (CLR):	*The purpose of learning this course is to:*
CLR-1 :	*Define the concepts of vehicle stability and fundamentals of vehicle dynamics.*
CLR-2 :	*Design and Develop Vehicle, Road and driver models.*
CLR-3 :	*Understand Longitudinal and Lateral stability control schemes*
CLR-4 :	*Distinguish between the effects of Longitudinal and Lateral stability*
CLR-5 :	*Interpret the relation between vertical dynamics and ride stability control*

Course Learning Outcomes (CLO):	*At the end of this course, learners will be able to:*	Learning			Program Learning Outcomes (PLO)														
		1	2	3	1	2	3	4	5	6	7	8	9	10	11	12	13	14	15
		Level of Thinking (Bloom)	Expected Proficiency (%)	Expected Attainment (%)	Engineering Knowledge	Problem Analysis	Design & Development	Analysis, Design, Research	Modern Tool Usage	Society & Culture	Environment & Sustainability	Ethics	Individual & Team Work	Communication	Project Mgt. & Finance	Life Long Learning	PSO - 1	PSO - 2	PSO – 3
CLO-1 :	*Use and Relate fundamental mathematical concepts to create a Vehicle Model*	*1,2*	*90*	*85*	*H*	*H*	*H*	*H*	*M*	*L*	*L*	*L*	*M*	*M*	*H*	*H*	*L*	*L*	*M*
CLO-2 :	*Identify and Optimize parameters like driver behavior and road quality as inputs to check vehicle stability*	*2,3*	*85*	*80*	*H*	*H*	*H*	*H*	*H*	*M*	*M*	*L*	*H*	*M*	*L*	*M*	*M*	*H*	*M*
CLO-3 :	*Recognize the effects of Longitudinal and Lateral stability*	*1,2*	*85*	*80*	*H*	*H*	*H*	*H*	*H*	*L*	*M*	*M*	*H*	*M*	*H*	*H*	*H*	*H*	*H*
CLO-4 :	*Design and check a vehicle for longitudinal and lateral stability*	*2,3*	*85*	*80*	*H*	*H*	*H*	*H*	*H*	*M*	*M*	*H*	*H*	*H*	*M*	*H*	*M*	*H*	*M*
CLO-5 :	*Create mathematical models of suspension behavior and control*	*2,3*	*85*	*80*	*H*	*H*	*H*	*H*	*H*	*M*	*M*	*M*	*M*	*M*	*M*	*H*	*M*	*M*	*M*

		Introduction to Vehicle Stability	Vehicle, Road and Driver Modeling	Longitudinal Dynamics and Control	Lateral Dynamics and Control	Vertical Dynamics and Control
Duration (hour)		9	9	9	9	9
S-1	SLO-1	*Introduction to stability of motion*	*Introduction to Vehicle Modeling*	*Introduction to longitudinal control*	*Automated lane keeping*	*Introduction to Automotive Suspension*
	SLO-2	*Concept and analysis of stability in motion*	*Introduction to Vehicle Modeling*	*Adaptive Cruise Control*	*Steering control for automated lane keeping*	*Passive suspension*
S-2	SLO-1	*Static stability*	*Vehicle Modeling*	*Collision avoidance system*	*Lane keeping with Bicycle model*	*Quarter Car model – passive suspension*
	SLO-2	*Dynamic stability*	*Vehicle Modeling. Cont*	*Automated Highway systems*	*Lane keeping with Bicycle model - state feedback*	*Active suspension system*
S-3	SLO-1	*Mathematical forms for vehicle dynamic equations*	*Friction coefficient*	*Cruise controller design*	*Steady state error from dynamic equation*	*Tradeoffs and Limitation of Active suspension*
	SLO-2	*Mathematical forms for vehicle dynamic equations*	*Calculation of forces*	*PI Controller for first order plant*	*Steady state error from dynamic equation. Cont*	*Performance variable of quarter car suspension*
S-4	SLO-1	*Eigen values*	*Tire modelling*	*PI Controller for second order plant*	*Unity feedback loop system*	*Natural Frequencies for the Quarter Car*
	SLO-2	*Eigen values. Cont*	*Tire Characteristics*	*PID Cruise-controller design for second order actuator*	*Unity feedback loop system. Cont*	*Mode Shapes for the Quarter Car*
S-5	SLO-1	*Routh's stability*	*Effect of Wheel radius*	*Autonomous cruise control –Speed control*	*Loop analysis with a proportional controller*	*Approximate Transfer Functions Using Decoupling*
	SLO-2	*Routh's stability criterion. Cont*	*Effect of Wheel radius. Cont*	*Autonomous cruise control –Headway control*	*Loop analysis with a proportional controller. Cont*	*Approximate Transfer Functions Using Decoupling. Cont*
S-6	SLO-1	*Co-ordinates of vehicle dynamics model*	*Two track models*	*Adaptive cruise control –Cruise control with preview based on onsite information*	*Loop analysis with a lead compensator*	*Verification Using the Complete Quarter Model*
	SLO-2	*Notation of vehicle dynamics model*	*Reduced two track non-linear model*	*Adaptive cruise control –Cruise control with preview based on onsite information*	*Loop analysis with a lead compensator. Cont*	*Verification Using the Complete Quarter Model. Cont*
S-7	SLO-1	*Longitudinal vehicle motion –During acceleration*	*Road Model – Requirements of road model*	*Vehicle Platooning*	*Simulation of performance with Lead compensator*	*Optimal passive Suspension with 2DOF model*

	SLO-2	*Longitudinal vehicle motion –During Braking*	*Course path of a Road Models*	*String stability*	*Simulation of performance with Lead compensator. Cont*	*Optimal active Suspension with 2DOF model. Cont*
S-8	SLO-1	*Vertical vehicle motion*	*Road surface quality*	*ACC –Autonomous control with constant spacing*	*Overview of four wheel steering*	*Linear Quadratic control*
	SLO-2	*One DOF quarter car model*	*Wind Strength - Effects*	*ACC –Autonomous control with constant time gap policy*	*Four wheel steering system numerical example*	*LQR Applications - active suspension*
S-9	SLO-1	*Lateral vehicle motion –Bicycle model*	*Human factors in driver automation*	*String stability of CTG spacing Policy*	*Yaw rate and acceleration response*	*LQR formulation for active suspension design*
	SLO-2	*Bicycle model in steady state cornering*	*Simple PID driver Model*	*String stability of CTG spacing Policy. Cont*	*Lane Change Maneuver – 2WS VS 4WS*	*LQR formulation for active suspension design. Cont*

Learning Resources	1. *Dean Karnopp "Vehicle Dynamics, Stability, and Control", 2nd edition, CRC Press, 2013* 2. *A.GalipUlsoy, HeuiPeng, Melih C "Automotive Control System", Cambridge University Press 2012*	3. *Rajesh Rajamani "Vehicle Dynamics and Control", Second Edition, Springer 2012* 4. *Kiencke U and Nielsen L "Automotive Control Systems for Engine, Driveline and Vehicle" 2nd edition, Springer 2005*

Learning Assessment

	Bloom's Level of Thinking	Continuous Learning Assessment (50% weightage)								Final Examination (50% weightage)	
		CLA – 1 (10%)		CLA – 2 (15%)		CLA – 3 (15%)		CLA – 4 (10%)#			
		Theory	Practice	Theory	Practice	Theory	Practice	Theory	Practice	Theory	Practice
Level 1	Remember Understand	*40 %*	-	*30 %*	-	*30 %*	-	*30 %*	-	*30%*	-
Level 2	Apply Analyze	*40 %*	-	*40 %*	-	*40 %*	-	*40 %*	-	*40%*	-
Level 3	Evaluate Create	*20 %*	-	*30 %*	-	*30 %*	-	*30 %*	-	*30%*	-
	Total	100 %		100 %		100 %		100 %		100 %	

CLA – 4 can be from any combination of these: Assignments, Seminars, Tech Talks, Mini-Projects, Case-Studies, Self-Study, MOOCs, Certifications, and Conf. Paper etc.

Course Designers

Experts from Industry	Experts from Higher Technical Institutions	Internal Experts
1. *Mr.Jegan Amirthalingam, Senior Educator, KPIT a.jegan@kpit.com*	*1. Dr. P. Sathish Kumar,Jiangsu University, China sathishkumar8989@gmail.com*	*1. Mr. Dennie John, SRMIST*
2. *Jonny N, BGR Energy systems, jonnynallathampi@gmail.com*	*2. Mr. Arockiya Vijay, SRMIST, arockiaj1@srmist.edu.in*	*2. Mr.Jesu Godwin D, SRMIST*

Course Code	18AEE416T	Course Name	AUT0MOTIVE FAULT DIAGNOSTICS	Course Category	C	Professional Elective	L	T	P	C
							3	0	0	3

Pre-requisite Courses	Nil	Co-requisite Courses	Nil	Progressive Courses	Nil
Course Offering Department	Automobile Engineering	Data Book / Codes/Standards	Nil		

Course Learning Rationale (CLR):	*The purpose of learning this course is to:*
CLR-1 :	*Understand the importance and procedure of fault diagnostics in for automotive field.*
CLR-2 :	*Familiarize the fault diagnostics using tools and equipment*
CLR-3 :	*Know about various case studies in fault diagnosis*

Course Learning Outcomes (CLO):	*At the end of this course, learners will be able to:*	Learning 1: Level of Thinking (Bloom)	Learning 2: Expected Proficiency (%)	Learning 3: Expected Attainment (%)	PLO 1: Engineering Knowledge	PLO 2: Problem Analysis	PLO 3: Design & Development	PLO 4: Analysis, Design, Research	PLO 5: Modern Tool Usage	PLO 6: Society & Culture	PLO 7: Environment & Sustainability	PLO 8: Ethics	PLO 9: Individual & Team Work	PLO 10: Communication	PLO 11: Project Mgt. & Finance	PLO 12: Life Long Learning	PLO 13: PSO - 1	PLO 14: PSO - 2	PLO 15: PSO – 3
CLO-1 :	*Understand the concept of fault diagnosis*	2	85	75	H	M	H	L	H	M	M	H	H	M	L	H	H	H	H
CLO-2 :	*Understand about on and off board diagnostics*	2	80	75	H	M	H	H	H	M	M	H	H	M	L	M	H	H	H
CLO-3 :	*Perform fault diagnosis in automobiles*	2	90	85	H	H	H	H	L	M	M	H	M	M	M	H	H	H	M
CLO-4 :	*Understand the various advances in fault diagnosis*	2	85	80	H	M	H	H	H	H	H	H	H	H	M	H	H	H	H
CLO-5 :	*Perform electrical systems diagnosis in automobiles*	2	80	75	H	M	M	M	H	H	H	H	H	H	M	H	H	H	H

Duration (hour)		Introduction Fault Diagnosis	On and off Board Diagnostics	Engine System Diagnosis	Chassis and Brake System Diagnosis	Electrical Systems Diagnosis
		9	9	9	9	9
S-1	SLO-1	*Introduction To Fault Diagnosis,*	*Introduction To ON and OFF Board Diagnostics*	*Introduction Engine Systems Diagnostics*	*Introduction To Engine System Diagnostics*	*Introduction to electrical components and Circuits*
	SLO-2	*Safe Working Practices And Techniques*				
S-2	SLO-1	*Diagnostics On Paper*	*Introduction To Oscilloscope Diagnostics*	*Engine Operation And Fuel System*	*Anti-Lock Braking System Diagnostics*	*Sensing, signal conditioning overview*
	SLO-2	*Systems And Standards*				
S-3	SLO-1	*Mechanical And Electrical Diagnostic Techniques*	*Sensors Associated With Oscilloscope Diagnostics*	*Ignition System And Emission System*	*Traction Control System Diagnostics*	*Multiplexing, Demultiplexing overview*
	SLO-2					
S-4	SLO-1	*Faults Codes*	*Actuators Associated With Oscilloscope Diagnostics*	*Electronic Fuel Injection Diagnostics*	*Traction Control System Diagnostics - Steering*	*Lighting System Faults*
	SLO-2					
S-5	SLO-1	*On - And - Off Board Diagnostics*	*On-Board Diagnostics Various Perspectives*	*Starting And Charging System Diagnostics*	*Traction Control System Diagnostics - Tires*	*Auxiliary Faults*
	SLO-2					
S-6	SLO-1	*Data Sources*	*Petrol/Gasoline On-Board Diagnostics*	*Power Flow Control And Energy Efficiency Analysis*	*Transmission Systems Diagnostics*	*In-Car Entertainment Security And Communications Implementation*
	SLO-2	*Tools And Equipment's*				
S-7	SLO-1	*Oscilloscopes*	*On-Board Sensors*	*Engine Management And Faultfinding Information*	*Diagnostics On Steering*	*Body-Electrical Systems, Instruments System Faults*
	SLO-2	*Scanners/Fault Code Readers,*				
S-8	SLO-1	*Engine Analyzers*	*On-Board Actuators*	*Air Supply, Exhaust System Diagnostics*	*Diagnostics On Tires*	*Heating Ventilation And Air Conditioning electrical faults*
	SLO-2					
S-9	SLO-1	*Application Methods And Procedure*	*Sensors And Actuators Comparative Case Study*	*Cooling And Lubrication System*	*Case Study On Diagnostics Of Sub-Assemblies*	*Cruise Control, Air Bags Electrical faults*
	SLO-2					

Learning Resources	
	1. *Tom denton "Advanced automotive fault diagnosis", Elsevier butterworth-heinemannlinacre house, jordan hill, oxford ox2 8dp, uk - isbn-10: 0-75-066991-8* 2. *Tom Denton "Automotive Electronics Handbook", McGraw-Hill Publishing Co.; 2nd Revised edition 1999, ISBN10:0070344531* 3. *Routledge "Automobile Electrical and Electronic Systems", 4 edition 2012, ISBN10:0080969429* 4. *Newnes "Understanding Automotive Electronics", 6th Revised edition 2003,ISBN10:0750675993*

Learning Assessment											
	Bloom's Level of Thinking	Continuous Learning Assessment (50% weightage)								Final Examination (50% weightage)	
		CLA – 1 (10%)		CLA – 2 (15%)		CLA – 3 (15%)		CLA – 4 (10%)#			
		Theory	Practice	Theory	Practice	Theory	Practice	Theory	Practice	Theory	Practice
Level 1	Remember Understand	*40 %*	-	*30 %*	-	*30 %*	-	*30 %*	-	*30%*	-
Level 2	Apply Analyze	*40 %*	-	*40 %*	-	*40 %*	-	*40 %*	-	*40%*	-
Level 3	Evaluate Create	*20 %*	-	*30 %*	-	*30 %*	-	*30 %*	-	*30%*	-
	Total	100 %		100 %		100 %		100 %		100 %	

CLA – 4 can be from any combination of these: Assignments, Seminars, Tech Talks, Mini-Projects, Case-Studies, Self-Study, MOOCs, Certifications, and Conf. Paper etc.

Course Designers		
Experts from Industry	Experts from Higher Technical Institutions	Internal Experts
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2. Jonny N, BGR Energy systems, jonnynallathampi@gmail.com		*2. Mr.Jesu Godwin D, SRMIST*

Course Code	18AEE417T	Course Name	ELECTRONIC ENGINE MANAGEMENT SYSTEM	Course Category	E	Professional Elective	L	T	P	C
							3	0	0	3

Pre-requisite Courses	Nil	Co-requisite Courses	Nil	Progressive Courses	Nil
Course Offering Department	Automobile Engineering	Data Book / Codes/Standards	Nil		

Course Learning Rationale (CLR):	*The purpose of learning this course is to:*
CLR-1 :	*Understand the components and operation of engine management systems.*
CLR-2 :	*Learn about the various Engine sensors and actuators*
CLR-3 :	*Learn about the various SI engine electronic ignition and injection systems*
CLR-4 :	*Understand the various CI engine electronic ignition and injection systems*
CLR-5 :	*Understand and study the engine emission control systems.*
CLR-6 :	*Understand the concept of on board diagnostic systems and system data*

Course Learning Outcomes (CLO):	*At the end of this course, learners will be able to:*	Learning			Program Learning Outcomes (PLO)														
		1	2	3	1	2	3	4	5	6	7	8	9	10	11	12	13	14	15
		Level of Thinking (Bloom)	Expected Proficiency (%)	Expected Attainment (%)	Engineering Knowledge	Problem Analysis	Design & Development	Analysis, Design, Research	Modern Tool Usage	Society & Culture	Environment & Sustainability	Ethics	Individual & Team Work	Communication	Project Mgt. & Finance	Life Long Learning	PSO - 1	PSO - 2	PSO – 3
CLO-1 :	*Apply knowledge on modern engine control strategies*	*2*	*75*	*73*	*H*	*L*	*M*	*M*	*L*	*L*	*L*	*L*	*L*	*L*	*L*	*L*	*H*	*M*	*L*
CLO-2 :	*Analyze basic electrical and electronic devices and sensors, Ignition and Fuel Injection Systems involved in SI engine management*	*1*	*80*	*78*	*H*	*H*	*L*	*L*	*L*	*L*	*M*	*L*	*M*	*L*	*L*	*M*	*H*	*L*	*L*
CLO-3 :	*Analyze basic electrical and electronic devices and sensors, Ignition and Fuel Injection Systems involved in CI engine management*	*2*	*75*	*73*	*H*	*L*	*M*	*M*	*L*	*L*	*L*	*L*	*L*	*L*	*L*	*L*	*H*	*M*	*L*
CLO-4 :	*Understand the role of various actuators in engine management*	*2*	*85*	*80*	*H*	*L*	*H*	*H*	*L*	*L*	*M*	*L*	*L*	*L*	*L*	*M*	*H*	*L*	*L*
CLO-5 :	*Describe the key Computer controlled engine Systems*	*2*	*75*	*72*	*H*	*L*	*M*	*M*	*L*	*L*	*L*	*L*	*M*	*L*	*L*	*L*	*H*	*M*	*L*
CLO-6 :	*Access, and interpret on board diagnostic system information*	*2*	*75*	*73*	*H*	*L*	*M*	*M*	*L*	*L*	*L*	*L*	*M*	*L*	*L*	*L*	*H*	*M*	*L*

Duration (hour)		Fundamentals of Automotive Electronics and control	Sensors and Actuators	SI Engine Management	CI Engine Management	Digital Engine Control System
		9	9	9	9	9
S-1	SLO-1	*Introduction to Electronic Engine management System*	*Inductive, Hall Effect sensors*	*Layout and working of SI engine management systems*	*Introduction to CI engine management*	*Engine Mapping*
	SLO-2					
S-2	SLO-1	*Open and Closed loop control strategies*	*Thermistor, Piezo Electric sensors*	*Group and sequential injection techniques*	*Fuel injection system parameters affecting combustion*	*Effect of Air-fuel ratio/Spark timing/Exhaust gas Re circulation*
	SLO-2		*Piezo resistive based sensors*			
S-3	SLO-1	*Electronic Fuel Injection Systems*	*Throttle position, Mass air flow sensors*	*Contactless (Breaker less) Electronic ignition system*	*Noise in CI engines*	*knock control algorithm*
	SLO-2					
S-4	SLO-1	*Single-Point, Multi-Point Fuel Injection systems*	*Crank shaft position and Cam position sensors*	*Solid state ignition system*	*Emissions from CI engines*	*EGR Control algorithm*
	SLO-2					
S-5	SLO-1	*Electronic ignition systems*	*Engine Speed sensor, Knock Sensor*	*K - Jetronic, L - Jetronic fuel injection system*	*Electronically controlled Unit injection system*	*Integrated engine control system*
	SLO-2					
S-6	SLO-1	*Starter Motor working*	*Exhaust oxygen level sensor (two step, linear lambda and wide band)*	*Cold start and warm up phases, idle speed control*	*Common rail Diesel injection system*	*Electromagnetic compatibility*
	SLO-2	*Introduction to Engine control*				
S-7	SLO-1	*PI,PD,PID Control*	*Manifold temperature and pressure sensors*	*Acceleration and full load enrichment, Deceleration fuel cut off, Fuel control maps*	*Diesel injection system components Principle and working*	*EMI suppression techniques*
	SLO-2	*Look up tables*				
S-8	SLO-1	*Fuzzy logic control technique*	*Solenoid and stepper motor*	*Electronic spark timing and control, Spark advance ,Spark Retardation*	*Fuel pump, Fuel injector*	*On board diagnostics Tool*
	SLO-2	*Adaptive control techniques*				
S-9	SLO-1	*SI and CI Engine Control*	*Relay (four and five pin)*	*Closed loop control of knock*	*Rail pressure limiter, Flow meter, EGR valve*	*Trouble shooting on EMS and On board diagnostics system*
	SLO-2	Combustion Performance and emission Parameters				

Learning Resources	1. *Understanding Automotive Electronics 8th Edition Authors: William Ribbens Paperback ISBN: 9780128104347 Imprint: Butterworth-Heinemann Published Date: 18th June 2017* 2. *Tom Denton "Automotive Electronics Handbook", - - McGraw-Hill Publishing Co.; 2nd Revised edition, 1999, ISBN10:0070344531*	3. *Diesel–Engine Management Hardcover – 20 Jan 2006 by Robert Bosch GmbH (Author), SAE Publications* 4. *Gasoline Engine Management (Bosch Professional Automotive Information) Paperback – 13 Aug 2014, SAE Publications* 5. *Automotive Fuel and Emissions Control Systems, 4th Edition James D. Halderman ©2016 | Pearson*

Learning Assessment											
	Bloom's Level of Thinking	Continuous Learning Assessment (50% weightage)								Final Examination (50% weightage)	
		CLA – 1 (10%)		CLA – 2 (15%)		CLA – 3 (15%)		CLA – 4 (10%)#			
		Theory	Practice	Theory	Practice	Theory	Practice	Theory	Practice	Theory	Practice
Level 1	Remember Understand	*40 %*	-	*30 %*	-	*30 %*	-	*30 %*	-	*30%*	-
Level 2	Apply Analyze	*40 %*	-	*40 %*	-	*40 %*	-	*40 %*	-	*40%*	-
Level 3	Evaluate Create	*20 %*	-	*30 %*	-	*30 %*	-	*30 %*	-	*30%*	-
	Total	100 %		100 %		100 %		100 %		100 %	

CLA – 4 can be from any combination of these: Assignments, Seminars, Tech Talks, Mini-Projects, Case-Studies, Self-Study, MOOCs, Certifications, and Conf. Paper etc.

Course Designers		
Experts from Industry	Experts from Higher Technical Institutions	Internal Experts
1. Mr.Jegan Amirthalingam, Senior Educator, KPIT a.jegan@kpit.com	*1. Dr, Teoh Yew Heng, University Sains, Malaysia, yewhengteoh@usm.my*	*1. Mr. S.Kiran, SRMIST*
2. Mr.G.Giri Atalon giri@atalon.co.in	*2. Mr. Sam Jebakumar, SRM IST, jebakumj@srmist.edu.in*	*2. Mr.Jesu Godwin D, SRMIST*

ACADEMIC CURRICULA

Professional Elective Courses

BIOTECHNOLOGY

Regulations - 2018

SRM INSTITUTE OF SCIENCE AND TECHNOLOGY

(Deemed to be University u/s 3 of UGC Act, 1956)

Kattankulathur, Kancheepuram, Tamil Nadu, India

Course Code	18BTE301T	Course Name	DEVELOPMENTAL BIOLOGY	Course Category	E	Professional Elective	L	T	P	C
							3	0	0	3

Pre-requisite Courses	Nil	Co-requisite Courses	Nil	Progressive Courses	Nil
Course Offering Department	Biotechnology	Data Book / Codes/Standards	Nil		

Course Learning Rationale (CLR):	*The purpose of learning this course is to:*
CLR-1 :	*Describe the mechanisms of developmental patterning and organization*
CLR-2 :	*Discuss fertilization, gametogenesis and sex determination*
CLR-3 :	*Compare developmental patterns among metazoan, drosophila and zebrafish*
CLR-4:	*Explain somites and their derivatives.*
CLR-5:	*Describe metamorphosis and organogenesis*
CLR-6:	*Analyze birth defects and endocrine disruptors*

Course Learning Outcomes (CLO):	*At the end of this course, learners will be able to:*	Learning 1: Level of Thinking (Bloom)	Learning 2: Expected Proficiency (%)	Learning 3: Expected Attainment (%)	PLO 1: Engineering Knowledge	PLO 2: Problem Analysis	PLO 3: Design & Development	PLO 4: Analysis, Design, Research	PLO 5: Modern Tool Usage	PLO 6: Society & Culture	PLO 7: Environment & Sustainability	PLO 8: Ethics	PLO 9: Individual & Team Work	PLO 10: Communication	PLO 11: Project Mgt. & Finance	PLO 12: Life Long Learning	PLO 13: PSO - 1	PLO 14: PSO - 2	PLO 15: PSO – 3
CLO-1 :	*Analyze the mechanisms of cell to cell communication*	*1*	*80*	*80*	*L*	*H*	*H*	*H*		*M*	*L*	*H*	*H*	*H*	*H*	*H*	*L*	*H*	*H*
CLO-2 :	*Describe the fundamental organization of reproduction and flowering in plants*	*2*	*85*	*75*	*M*	*H*	*H*	*M*			*M*	*H*	*L*	*H*	*H*	*H*	*L*	*H*	*H*
CLO-3 :	*Explain the concepts and experiments in the early development, cleavage and axis formation*	*2*	*75*	*80*	*M*	*H*	*M*	*H*	*M*	*M*		*M*	*H*	*H*	*H*	*H*	*L*	*H*	*H*
CLO-4 :	*Recognize the various pathways of organogenesis*	*2*	*85*	*80*	*L*	*H*	*H*	*H*			*H*	*L*	*L*	*H*	*H*	*H*	*M*	*H*	*H*
CLO-5 :	*Discuss about the various endocrine receptors*	*3*	*85*	*75*	*L*	*H*	*H*	*M*		*M*	*H*	*H*	*H*	*L*	*H*	*H*	*H*	*H*	*H*
CLO-6 :	*Explain the concepts of development in health and diseases*	*2*	*80*	*80*	*M*	*H*	*H*	*H*	*L*	*H*	*M*	*M*	*H*	*H*	*H*	*H*	*H*	*H*	*H*

Duration (hour)		9	9	9	9	9
S-1	SLO-1	*Mechanisms of Developmental Organization*	*Sex determination*	*Early Development: Cleavage, Gastrulation and Axis formation*	*Building with mesoderm*	*Development in health diseases*
	SLO-2	*The cycle of life*	*Chromosomal sex determination*	*Developmental Patterns among the Metazoa*	*Endoderm*	*Genetic errors of human development*
S-2	SLO-1	*Epigenesis and cleavage*	*Mammalian Pattern of sex determination*	*Early development in the Nematode C. elegans*	*Organogenesis*	*Birth defects*
	SLO-2	*Evolutionary embryology*	*Genetic mechanisms*	*Early Drosophila Development*	*Paraxial mesoderm*	*Endocrine disruptors*
S-3	SLO-1	*Cell Specification:*	*Wnt family and signaling*	*Early Zebrafish Development*	*The somites and their derivatives*	*BPA and reproductive health*
	SLO-2	*Mechanisms of Developmental Patterning*	*Hormonal regulation of sexual phenotype*	*Early Development in Mammals*	*Intermediate and lateral plate mesoderm*	*Cancer*
S-4	SLO-1	*Autonomous and conditional specification*	*Environmental sex determination*	*Building with Ectoderm: The vertebrate nervous system and Epidermis*	*Heart, Blood, and Kidneys*	*Defects in paracrine pathways*
	SLO-2	*Cell identities*	*Gametogenesis*	*Neural tube formation and patterning*	*Development of the tetrapod limb*	*Cancer and stem cell hypothesis*
S-5	SLO-1	*Differential Gene Expression*	*Spermatogenesis*	*Brain growth*	*The endoderm*	*Development and the environment*
	SLO-2	*Mechanisms of Cell Differentiation*	*OOgenesis*	*Neural crest cells*	*The tubes and organs for digestion*	*Diet-induced polyphenisms*
S-6	SLO-1	*Differential RNA processing*	*Fertilization*	*Axonal specificity*	*Organs and tubes for respiration*	*Developmental symbiosis*
	SLO-2	*Cell-to-Cell communication*	*Structure of gametes*	*Ectodermal Placodes*	*Postembryonic development*	*Biotic regulation*
S-7	SLO-1	*Juxtacrine signaling*	*Translocation and capacitation*	*Epidermis*	*Metamorphosis*	*Abiotic regulation*
	SLO-2	*Mechanisms of Morphogenesis*	*Thermotaxis and chemotaxis*	*Cell Signaling*	*The hormonal reactivation and development*	*Symbiotic regulation of development*
S-8	SLO-1	*Cadherins and cell adhesions*	*Fusion of genetic material*	*Fibroblast growth factors*	*Regeneration*	*Development and Evolution*
	SLO-2	*Stem cells: Their potential and their niches*	*Activation of mammalian egg*	*RTK pathway*	*Aging and senescence*	*Developmental mechanisms*
S-9	SLO-1	*Human model systems*	*Flowering*	*The Hedgehog family*	*Differentiation of dermal, ground, and vascular tissues in plants*	*Evolutionary changes*
	SLO-2	*Development in Plants*	*Reproduction in Plants*	*The TGF-β superfamily*	*Techniques in embryology*	*Mechanisms of evolutionary changes*

Learning Resources	1. *Scott F. Gilbert, Michael J. F. Barresi. Developmental Biology, Sinauer Associates-Oxford University Press; 11 edition, 2016* 2. *JMW Slack Essentials of Developmental Biology 3rd Edition Wiley-Blackwell;.2012*

Learning Assessment											
	Bloom's Level of Thinking	Continuous Learning Assessment (50% weightage)								Final Examination (50% weightage)	
		CLA – 1 (10%)		CLA – 2 (15%)		CLA – 3 (15%)		CLA – 4 (10%)#			
		Theory	Practice	Theory	Practice	Theory	Practice	Theory	Practice	Theory	Practice
Level 1	Remember Understand	*40 %*	-	*30%*	-	*30%*	-	*30%*	-	*30%*	-
Level 2	Apply Analyze	*40 %*	-	*40%*	-	*40%*	-	*40%*	-	*40%*	-
Level 3	Evaluate Create	*20 %*	-	*30%*	-	*30%*	-	*30%*	-	*30%*	-
	Total	100 %		100 %		100 %		100 %		100 %	

CLA – 4 can be from any combination of these: Assignments, Seminars, Tech Talks, Mini-Projects, Case-Studies, Self-Study, MOOCs, Certifications, Conf. Paper etc.,

Course Designers		
Experts from Industry	Experts from Higher Technical Institutions	Internal Experts
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Course Code	18BTE302T	Course Name	CELLULAR AND MOLECULAR NEUROSCIENCE	Course Category	E	Professional Elective	L	T	P	C
							3	0	0	3

Pre-requisite Courses	Nil	Co-requisite Courses	Nil	Progressive Courses	Nil
Course Offering Department	Biotechnology	Data Book / Codes/Standards	Nil		

Course Learning Rationale (CLR):	*The purpose of learning this course is to:*
CLR-1 :	*Recall the brain function from its organization*
CLR-2 :	*Discuss Molecular signaling in neurons*
CLR-3 :	*Compare Neural basis of senses*
CLR-4:	*Explain different methods for studying neuro-immune functions*
CLR-5:	*Describethe cortical structures pertaining to emotions and feelings*
CLR-6:	*Analyze genetic* variation and inheritance pertaining to nervous system disorders

Course Learning Outcomes (CLO):	*At the end of this course, learners will be able to:*	Learning 1: Level of Thinking (Bloom)	Learning 2: Expected Proficiency (%)	Learning 3: Expected Attainment (%)	PLO 1: Engineering Knowledge	PLO 2: Problem Analysis	PLO 3: Design & Development	PLO 4: Analysis, Design, Research	PLO 5: Modern Tool Usage	PLO 6: Society & Culture	PLO 7: Environment & Sustainability	PLO 8: Ethics	PLO 9: Individual & Team Work	PLO 10: Communication	PLO 11: Project Mgt. & Finance	PLO 12: Life Long Learning	PLO 13: PSO - 1	PLO 14: PSO - 2	PLO 15: PSO – 3
CLO-1 :	*Analyze the role of genes in brain development and functions*	*1*	*80*	*80*	*L*	*H*	*H*	*H*		*M*	*L*	*H*	*H*	*H*	*H*	*H*	*L*	*H*	*H*
CLO-2 :	*Describe the fundamental organization of brain and its functions.*	*2*	*85*	*75*	*M*	*H*	*H*	*M*			*M*	*H*	*L*	*H*	*H*	*H*	*L*	*H*	*H*
CLO-3 :	*Explain the concepts and experiments in the ion channels and NEUROTRANSMITTERS*	*2*	*75*	*80*	*M*	*H*	*M*	*H*	*M*	*M*		*M*	*H*	*H*	*H*	*H*	*L*	*H*	*H*
CLO-4 :	*Recognize the various pathways of sensory system*	*2*	*85*	*80*	*L*	*H*	*H*	*H*			*H*	*L*	*L*	*H*	*H*	*H*	*M*	*H*	*H*
CLO-5 :	*Discuss the different methods in the neuroendocrine and immune interactions*	*3*	*85*	*75*	*L*	*H*	*H*	*M*		*M*	*H*	*H*	*H*	*L*	*H*	*H*	*H*	*H*	*H*
CLO-6 :	*Explain the concepts of nervous system disorder and the diseases associated with it*	*2*	*80*	*80*	*M*	*H*	*H*	*H*	*L*	*H*	*M*	*M*	*H*	*H*	*H*	*H*	*H*	*H*	*H*

Duration (hour)		9	9	9	9	9
S-1	SLO-1	*Genetics of nervous system*	*Electrical signals*	*Somatic sensory system-Pain*	*Cognition-Speech and Language*	*Diseases and injuries of the nervous system*
	SLO-2	*Advent of genomics in the assembly of brain*	*Long-distance transmission of Electrical signals*	*Touch and Proprioception*	*Overview of cortical structures*	*Alzheimer's disease*
S-2	SLO-1	*Model organisms in neuroscience*	*The ionic basis of resting membrane potential*	*Pain and its pathways*	*Sleep and Wakefulness*	*Hutington's disease*
	SLO-2	*Development of the nervous system*	*Voltage-dependent membrane permeability*	*Visual and Vestibular pathways*	*The circadian cycle of sleep and wakefulness*	*Neuromuscular Disorders: Myasthenia gravis*
S-3	SLO-1	*Molecular basis of neural induction*	*Ion channels and transporters*	*Retinal circuitry*	*Emotions-Memory*	*Basal ganglia disorders: Parkinson's disease*
	SLO-2	*Initial differentiation of neurons and glia*	*Diversity of ion channels*	*Phototransduction*	*Early theories of emotional brain*	*Pharmacological targets of Parkinsons disease*
S-4	SLO-1	*Cellular Components of the Nervous system*	*Synaptic transmission-Neurotransmitters and their receptors*	*Motor neuron circuits-Motor neuron control by the CNS*	*Kluver-Bucy syndrome*	*Spinal Cord Injury*
	SLO-2	*Neurons and Glia*	*Chemical and electrical synapses*	*Motor units*	*Brain reward circuitry*	*Traumatic Brain Injury (TBI)*
S-5	SLO-1	*Organization of nerves*	*Molecular signaling in neurons*	*The Corticospinal and Corticobulbar Tracts*	*Learning*	*chronic traumatic encephalopathy*
	SLO-2	*Pre synaptic terminals*	*Activation of signaling pathways*	*Upper motor neurons*	*Memory consolidation and Priming*	*Stroke*
S-6	SLO-1	*Neural Circuits*	*Second messengers*	*Disorders of basal ganglia*	*Cognition-Speech and Language*	*Blood Supply to Brain*
	SLO-2	*Myotactic reflex*	*Nuclear signaling*	*Molecular mechanisms involved in synapse formation*	*Sex and Sexuality*	*Transient Ischemic Attack*
S-7	SLO-1	*Organization of the Nervous system*	*Synaptic plasticity*	*Molecular basis of trophic interactions*	*Neuroanatomical basis for brain functions.*	*Acute stroke treatment*
	SLO-2	*Divisons of nervous system*	*Short and long-term synaptic plasticity*	*Construction and modification of neural circuits*	*Hypothalamus and endocrine system*	*Prevention of stroke*
S-8	SLO-1	*Central nervous system*	*Synaptic transmission-Neurotransmitters and their receptors*	*Repair and Regeneration in nervous system*	*Hormones of endocrine system and its regulation*	*Dementia*
	SLO-2	*Peripheral nervous system*	*Properties of neurotransmitters*	*Hypoxia/Ischemia in mammalian brain*	*Interactions between neuroendocrine system and immune system*	*Mild cognitive impairment*

S-9	SLO-1	*Structural and Functional analysis of the Nervous system*	*Receptors of neurotransmitters*	*Axon Growth after Brain Injury*	*Neural-Immune interactions in the periphery*	*Alzheimer's dementia*
	SLO-2	*Cellular diversity of nervous system*	*Unconventional neurotransmitters*	*Goat brain dissection*	*Nervous-immune system role in health and disease*	*Prevention and treatment*

Learning Resources	1. *Dale Purves, George J. Augustine, David Fitzpatrick, William C. Hall, Anthony-Samuel LaMantia, Leonard E. White, "Neuroscience," Sinauer Associates, Inc., 6th Edition, 2017.* 2. *Eric R. Kandel, James H. Schwartz, Thomas M. Jessell, "Principles of Neural Science," McGraw-Hill, 5th Edition, 2012.*

Learning Assessment

	Bloom's Level of Thinking	Continuous Learning Assessment (50% weightage)								Final Examination (50% weightage)	
		CLA – 1 (10%)		CLA – 2 (15%)		CLA – 3 (15%)		CLA – 4 (10%)#			
		Theory	Practice	Theory	Practice	Theory	Practice	Theory	Practice	Theory	Practice
Level 1	Remember Understand	*40 %*	-	*30%*	-	*30%*	-	*30%*	-	*30%*	-
Level 2	Apply Analyze	*40 %*	-	*40%*	-	*40%*	-	*40%*	-	*40%*	-
Level 3	Evaluate Create	*20 %*	-	*30%*	-	*30%*	-	*30%*	-	*30%*	-
	Total	100 %		100 %		100 %		100 %		100 %	

CLA – 4 can be from any combination of these: Assignments, Seminars, Tech Talks, Mini-Projects, Case-Studies, Self-Study, MOOCs, Certifications, Conf. Paper etc.,

Course Designers

Experts from Industry	Experts from Higher Technical Institutions	Internal Experts
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Dr. Karthik Periyasamy, Scientist I, Aurozymes Unit, Aurobindo Pharma Limited, Hyderabad, karthikmpk@gmail.com	*Prof. R. B. Narayanan, SVCE, Chennai, rbn@svce.ac.in*	*Dr.R.Vasantharekha, SRMIST*

Course Code	18BTE303T	Course Name	METABOLIC DISORDERS	Course Category	E	Professional Elective	L	T	P	C
							3	0	0	3

Pre-requisite Courses	18BTC101J	Co-requisite Courses	Nil	Progressive Courses	Nil
Course Offering Department	Biotechnology	Data Book / Codes/Standards	Nil		

Course Learning Rationale (CLR):	*The purpose of learning this course is to:*
CLR-1 :	*Learn about the basic principles of metabolic regulation*
CLR-2 :	*Understand the importance of genetics in medicine and in metabolic diseases.*
CLR-3 :	*Learn about the role of enzymes in various metabolic disorders*
CLR-4:	*The common genetic diseases in our society and the reason for it.*
CLR-5:	*Learn about various treatment strategies of metabolic disorders.*
CLR-6:	*Learn about the basic principles of metabolic regulation*

Course Learning Outcomes (CLO):	*At the end of this course, learners will be able to:*	Learning 1: Level of Thinking (Bloom)	Learning 2: Expected Proficiency (%)	Learning 3: Expected Attainment (%)
CLO-1 :	*understand the metabolic principles*	*2*	*80*	*70*
CLO-2 :	*able to solve the metabolic problems of specific nutrients*	*2*	*85*	*75*
CLO-3 :	*able to apply knowledge in metabolic control*	*2*	*75*	*80*
CLO-4 :	*Know the importance of genetics in medicine and in metabolic diseases.*	*2*	*85*	*80*
CLO-5 :	*Realize how genetic diseases are common in our society and the reason for it.*	*3*	*85*	*80*
CLO-6 :	*Understand the various treatment strategies of metabolic disorders*	*2*	*80*	*75*

Program Learning Outcomes (PLO)

	1 Engineering Knowledge	2 Problem Analysis	3 Design & Development	4 Analysis, Design, Research	5 Modern Tool Usage	6 Society & Culture	7 Environment & Sustainability	8 Ethics	9 Individual & Team Work	10 Communication	11 Project Mgt. & Finance	12 Life Long Learning	13 PSO - 1	14 PSO - 2	15 PSO – 3
CLO-1	*L*	*M*	*L*	*H*	*H*	*H*			*H*	*H*	*H*	*H*	*L*	*M*	*L*
CLO-2	*L*	*M*	*H*	*H*	*H*	*H*	*M*		*H*	*H*	*H*	*H*	*L*	*M*	*H*
CLO-3	*L*	*H*	*M*	*H*	*H*	*H*	*L*		*H*	*H*	*H*	*H*	*L*	*H*	*M*
CLO-4	*L*	*H*	*L*	*H*	*H*	*H*	*H*		*H*	*H*	*H*	*H*	*L*	*H*	*L*
CLO-5	*L*	*M*	*L*	*H*	*H*	*H*	*H*	*M*	*H*	*H*	*H*	*H*	*L*	*M*	*L*
CLO-6	*L*	*H*	*H*	*H*	*H*	*H*	*M*		*H*	*H*	*H*	*H*	*L*	*H*	*H*

Duration (hour)		15	15	15	15	15
S-1	SLO-1 SLO-2	*Introduction to metabolic disorders*	*Carbohydrate metabolic pathways and its associated deficiencies*	*Nitrogen metabolism and its target organs Aminoacid synthesis transport and storage*	*Inborn error of lipid metabolism*	*Disorders of Fat soluble vitamins*
S-2	SLO-1 SLO-2	*Principles of metabolic regulation- Garrod's hypothesis*	*Glycolysis*	*Metabolism of branched chain aminoacids Phenylketonuria, tyrosinemia, homocystinuria, maple syrup urine disease, Alkaptonuria, Albinism*	*Hyperlipidemia*	*Disorders of water soluble vitamins*
S-3	SLO-1 SLO-2	*Regulation of enzyme activity Covalent modifications and reversible modifications*	*Glycogenesis*	*Amino acid transport disorders: Cystinuria, Dicarboxylic aminoaciduria, Hartnup disease*	*Hypercholesterolemia and its associated disorders*	*Disorders of coenzymes*
S 4-5	SLO-1 SLO-2	*phosphorylation, dephosphorylation,*	*Glycogenolysis, Gluconeogenesis*	*Inborn error of purine metabolism*	*Hypolipoproteinemia*	*Disorders of cofactors*
S-6	SLO-1 SLO-2	*adenylation and disulphide reduction*	*Congenital disorders of Glycosylation*	*adenylosuccinatelyase deficiency, adenosine monophosphate deaminase deficiency*	*Tangier disease*	*Biotinidase deficiency*
S-7	SLO-1 SLO-2	*Overview of inherited metabolic disease processes*	*Galactosaemia Fructosaemia*	*Nucleotide salvage - Lesch-Nyhan syndrome*	*Lipodystrophy*	*Holocarboxylase synthetase deficiency*
S-8	SLO-1 SLO-2	*Accumulation of substrate*	*Lactose intolerance*	*adenine phosphoribosyltransferase deficiency - Adenosine deaminase deficiency, Xanthinuria – Pyrimidine metabolism*	*Lipid storage disorders: Sphingolipidoses: ganglioside- globoside- sphingomyelin- sphingosine- sulfatide-related*	*Pantothenate kinase-associated neurodegeneration*
S 9-10	SLO-1 SLO-2	*Accumulation of minor metabolites*	*Glycogen storage diseases*	*Inborn error of pyrimidine metabolism: Oroticaciduria*	*Fatty-acid metabolism disorders, biotinidase deficiency, malonicaciduria*	*Methylmalonic academia*
S-11	SLO-1 SLO-2	*Deficiency of product, Secondary metabolic phenomena*	*Insulin, glucose homeostasis and diabetes mellitus*	*Miller syndrome, Dihydropyrimidine dehydrogenase deficiency*	*Sjögren–Larsson syndrome*	*Familial isolated vitamin E deficiency*
S-12	SLO-1 SLO-2	*Introduction to metabolic disorders*	*Carbohydrate metabolic pathways and its associated deficiencies*	*Nitrogen metabolism and its target organs Aminoacid synthesis transport and storage*	*Inborn error of lipid metabolism*	*Disorders of Fat soluble vitamins*

S-13	SLO-1	*Principles of metabolic regulation- Garrod's hypothesis*	*Glycolysis*	*Metabolism of branched chain aminoacids Phenylketonuria, tyrosinemia, homocystinuria, maple syrup urine disease, Alkaptonuria, Albinism*	*Hyperlipidemia*	*Disorders of water soluble vitamins*
	SLO-2					
S 14-15	SLO-1	*Regulation of enzyme activity Covalent modifications and reversible modifications*	*Glycogenesis*	*Amino acid transport disorders: Cystinuria, Dicarboxylic aminoaciduria, Hartnup disease*	*Hypercholesterolemia and its associated disorders*	*Disorders of coenzymes*
	SLO-2					

Learning Resources	*1. Robert K. Murray, Darryl K. Granner, Peter A. Mayes, Harper's Illustrated Biochemistry 30th Edition, 2003* *2. Enid Gilbert-Barness, Lewis A. Barness, Philip M. Farrell." Metabolic Diseases: Foundations of Clinical Management, Genetics, and Pathology", IOS Press BV, Netherlands, Second Edition, 2017*

Learning Assessment

	Bloom's Level of Thinking	Continuous Learning Assessment (50% weightage)								Final Examination (50% weightage)	
		CLA – 1 (10%)		CLA – 2 (15%)		CLA – 3 (15%)		CLA – 4 (10%)#			
		Theory	Practice	Theory	Practice	Theory	Practice	Theory	Practice	Theory	Practice
Level 1	Remember Understand	*40 %*	-	*30%*	-	*30%*	-	*30%*	-	*30%*	-
Level 2	Apply Analyze	*40 %*	-	*40%*	-	*40%*	-	*40%*	-	*40%*	-
Level 3	Evaluate Create	*20 %*	-	*30%*	-	*30%*	-	*30%*	-	*30%*	-
	Total	100 %		100 %		100 %		100 %		100 %	

CLA – 4 can be from any combination of these: Assignments, Seminars, Tech Talks, Mini-Projects, Case-Studies, Self-Study, MOOCs, Certifications, Conf. Paper etc.,

Course Designers

Experts from Industry	Experts from Higher Technical Institutions	Internal Experts
Dr. Giridharan Appaswamy, Lifecell International (P) Limited, Chennai, giridharan.a@lifecell.in	*Prof. Karunagaran D, IITM, Chennai, karuna@iitm.ac.in*	*Dr. K.M. Ramkumar, SRMIST*
Dr. Karthik Periyasamy, Aurobindo Pharma Limited, Hyderabad, karthikmpk@gmail.com	*Dr. Sib Sankar Roy, CSIR-IICB, Kolkatta, sibsankar@iicb.res.in*	*Dr. Koustav Sarkar, SRMIST*

Course Code	18BTE304T	Course Name	INFECTIOUS DISEASES	Course Category	E	Professional Elective	L	T	P	C
							3	0	0	3

Pre-requisite Courses	Nil	Co-requisite Courses	Nil	Progressive Courses	Nil
Course Offering Department	Biotechnology	Data Book / Codes/Standards	Nil		

Course Learning Rationale (CLR):	*The purpose of learning this course is to:*
CLR-1 :	*Discuss about the different infections and infectious diseases*
CLR-2 :	*Describe details of bacterial infections and bacterial diseases*
CLR-3 :	*Explain different viral infections, viral diseases and vaccines*
CLR-4:	*State about the protozoan and fungal infections and diseases associated with them*
CLR-5:	*Record the different strategies to combat common infectious diseases and the impact of infectious diseases.*
CLR-6:	*Identify newer approaches/alternative methods for controlling infectious diseases*

Course Learning Outcomes (CLO):	*At the end of this course, learners will be able to:*	Learning 1: Level of Thinking (Bloom)	2: Expected Proficiency (%)	3: Expected Attainment (%)	Program Learning Outcomes (PLO) 1: Engineering Knowledge	2: Problem Analysis	3: Design & Development	4: Analysis, Design, Research	5: Modern Tool Usage	6: Society & Culture	7: Environment & Sustainability	8: Ethics	9: Individual & Team Work	10: Communication	11: Project Mgt. & Finance	12: Life Long Learning	13: PSO - 1	14: PSO - 2	15: PSO – 3
CLO-1 :	*Demonstrate general understating of the infectious diseases and their causative agents*	*1*	*80*	*80*	*H*	*H*	*H*	*H*		*M*	*L*	*H*	*H*	*H*	*H*	*H*	*H*	*H*	*H*
CLO-2 :	*Illustrate the bacterial infections and ways to tackle different bacterial diseases.*	*2*	*85*	*75*	*H*	*H*	*H*	*H*			*M*	*H*	*H*	*H*	*H*	*H*	*H*	*H*	*H*
CLO-3 :	*Interpret the viral infections, vaccine development and challenges*	*2*	*75*	*80*	*M*	*H*	*M*	*H*	*M*	*M*		*M*	*H*	*H*	*H*	*H*	*H*	*H*	*H*
CLO-4 :	*Discuss about the protozoan and fungal infections and methods to combat them*	*2*	*85*	*80*	*H*	*H*	*H*	*H*			*H*	*L*	*H*	*H*	*H*	*H*	*H*	*H*	*H*
CLO-5 :	*Categorize the infectious diseases and their social impact*	*3*	*85*	*75*	*H*	*H*	*H*	*H*		*M*	*H*	*H*	*H*	*L*	*H*	*H*	*H*	*H*	*H*
CLO-6 :	*Analyze the reimmerging infections and their control*	*2*	*80*	*80*	*H*	*H*	*H*	*H*	*L*	*M*	*M*	*M*	*H*	*H*	*H*	*H*	*H*	*H*	*H*

Duration (hour)		9	9	9	9	9
S-1	SLO-1	*Origin of Infection*	*Introduction to pathogenic and non pathogenic bacteria*	*History of viral infections*	*Introduction to Protozoan Diseases*	*Antibacterial: Antibiotics*
	SLO-2	*Evolution of infectious diseases*	*Common bacterial diseases in humans*	*Different Viral diseases*	*Different protozoan diseases*	*Mode of actions of antibiotics*
S-2	SLO-1	*Concept of Infection: Immunity*	*Basic mechanism of Bacterial pathogenesis*	*Viral pathogenesis*	*Severity of protozoan diseases*	*Antibiotic resistance*
	SLO-2	*Immune surveillance*	*Bacterial survival in host cells-Quoram sensing*	*Viral life cycle*	*General mode of action of protozoa*	*MDR and XDR strains*
S-3	SLO-1	*Concept of Infection: Virulence*	*Bacterial virulence factors: Microbial structures*	*Virus genomes and structure*	*Pathogenesis of protozoan diseases: Case study: Plasmodium*	*Antivirals: Vaccines*
	SLO-2	*Concept of Pathogenesis*	*Bacterial virulence factors: Microbial structures: Toxins*	*Host –virus interactions*	*Host response to Prozoan*	*Impact of vaccine in viral disease control*
S-4	SLO-1	*Causative agents of infectious diseases- Virus*	*Host response to Bacterial infection*	*Host Immune reaction against viruses*	*Molecular signaling against Protozoa*	*Challenges in viral vaccine developments*
	SLO-2	*Causative agents of infectious diseases- Bacteria*	*Molecular cell signaling involved in Bacterial diseases*	*Viral evasion of host immune surveillance*	*Hypersensitivity and autoimmunity associated with Protozoan infections*	*Antiviral compounds*
S-5	SLO-1	*Causative agents of infectious diseases- Protozoa and Parasites*	*Host Immune response to bacteria*	*Antiviral pathways*	*General fungal diseases*	*Antimalarial drug development*
	SLO-2	*Causative agents of infectious diseases- Other causative agents*	*Bacterial immune evasion: Molecular Mimicry*	*Mutations in viral genome*	*Mode of action of fungal diseases*	*Mode of action of antimalarial drugs*
S-6	SLO-1	*Disease epidemiology*	*Strategies for antibacterial therapy: Antibiotics*	*Viral diseases and antibody response*	*Immune response against fungal infection*	*Development of Vaccine for Malaria*
	SLO-2	*Steps involved in epidemiology*	*Other antibacterial compounds*	*Vaccine against viral diseases*	*Case study: Candidiasis*	*Challenges for the development of antimalarial drugs*
S-7	SLO-1	*Epidemiological case studies-Bacteria*	*Gut bacteria and their role in pathogenesis*	*Antivirals compounds for viral infections*	*Infection caused by Yeast*	*Infectious diseases and life style*
	SLO-2	*Epidemiological case studies-Bacteria*	*Bacterial vaccines*	*Challenges in vaccine production against certain virtues*	*Mode of action of Yeast infection*	*Beneficial gut microflora*

S-8	SLO-1	*Epidemiological case studies-Virus*	*Case study: E. Coli infection*	*Case study: Influenza*	*Case study: Ring warm*	*Neglected diseases*
	SLO-2	*Epidemiological case studies-Virus*	*Case study: Tuberculosis*	*Case study: Dengue*	*Strategies to combat Protozoan infections*	*Reemerging infectious diseases*
S-9	SLO-1	*Trends in Current epidemiology-Bacterial infections*	*Case study: Pneumonia*	*Case study: HPV*	*Strategies to combat fungal and yeast infections*	*Sexually transmitted diseases and awareness*
	SLO-2	*Trends in Current epidemiology-Viral infections*	*Case study: Helicobacter and gastric cancer*	*Case study: HIV and AIDS*	*Zoonotic diseases*	*Infectious disease and social issues*

Learning Resources	*1. Brenda A. Wilson, Abigail A. Salyers, Dixie D. Whitt, Malcolm E. Winkler, "Bacterial pathogenesis: a molecular approach": 3rd Edition- ASM Press, 2011.* *2. Alan Cann, "Principles of Molecular Virology": 6th Edition-Academic Press, 2015* *3. Vincent Racaniello, "Principles of Virology":4th Edition- ASM Press, 2015* *4. Tracey Lamb, "Immunity to Parasitic Infections": Willy Blackwell, 2012.* *5. Malcolm D. Richardson, David W. Warnock, "Fungal Infection: Diagnosis and Management": 4th Edition- Willy Blackwell, 2012.*

Learning Assessment

	Bloom's Level of Thinking	Continuous Learning Assessment (50% weightage)								Final Examination (50% weightage)	
		CLA – 1 (10%)		CLA – 2 (15%)		CLA – 3 (15%)		CLA – 4 (10%)#			
		Theory	Practice	Theory	Practice	Theory	Practice	Theory	Practice	Theory	Practice
Level 1	Remember Understand	*40 %*	-	*30%*	-	*30%*	-	*30%*	-	*30%*	-
Level 2	Apply Analyze	*40 %*	-	*40%*	-	*40%*	-	*40%*	-	*40%*	-
Level 3	Evaluate Create	*20 %*	-	*30%*	-	*30%*	-	*30%*	-	*30%*	-
	Total	100 %		100 %		100 %		100 %		100 %	

CLA – 4 can be from any combination of these: Assignments, Seminars, Tech Talks, Mini-Projects, Case-Studies, Self-Study, MOOCs, Certifications, Conf. Paper etc.,

Course Designers		
Experts from Industry	Experts from Higher Technical Institutions	Internal Experts
Dr. G. N. Ramchand, Saksin Life sciences Pvt Ltd, Chennai, ramchand@saksinlife.com	*Prof. K Subramaniam, IITM, Chennai, suubu@iitm.ac.in*	*Dr Suvankar Ghorai*
Dr. Karthik Periyasamy, Scientist I, Aurozymes Unit, Aurobindo Pharma Limited, Hyderabad, karthikmpk@gmail.com	*Dr. Saumya Raychaudhuri, IMTECH, Chandigarh Saumya@imtech.res.in*	*Dr. Koustav Sarkar*

Course Code	18BTE401T	Course Name	CANCER BIOLOGY	Course Category	E	Professional Elective	L	T	P	C
							3	0	0	3

Pre-requisite Courses	Nil	Co-requisite Courses	Nil	Progressive Courses	Nil
Course Offering Department	Biotechnology	Data Book / Codes/Standards	Nil		

Course Learning Rationale (CLR):	*The purpose of learning this course is to:*
CLR-1 :	*Describe the genes, risk factors in tumor progression*
CLR-2 :	*Discuss epigenetics, DNA damage and repair in cancer*
CLR-3 :	*Recall the molecular signaling mechanisms in cancer*
CLR-4:	*Explain different methods for studying neuro-immune functions*
CLR-5:	*Describe the role of stem cells in cancer treatment*
CLR-6:	*Analyze the role of nuclear medicine and alkaloids in cancer*

Course Learning Outcomes (CLO):	*At the end of this course, learners will be able to:*	Learning 1: Level of Thinking (Bloom)	Learning 2: Expected Proficiency (%)	Learning 3: Expected Attainment (%)	PLO 1: Engineering Knowledge	PLO 2: Problem Analysis	PLO 3: Design & Development	PLO 4: Analysis, Design, Research	PLO 5: Modern Tool Usage	PLO 6: Society & Culture	PLO 7: Environment & Sustainability	PLO 8: Ethics	PLO 9: Individual & Team Work	PLO 10: Communication	PLO 11: Project Mgt. & Finance	PLO 12: Life Long Learning	PLO 13: PSO - 1	PLO 14: PSO - 2	PLO 15: PSO – 3
CLO-1 :	*Analyze the role of diet in different forms of cancer*	*1*	*80*	*80*	*L*	*H*	*H*	*H*		*M*	*L*	*H*	*H*	*H*	*H*	*H*	*L*	*H*	*H*
CLO-2 :	*Describe the fundamental assays in hazard identification*	*2*	*85*	*75*	*M*	*H*	*H*	*M*			*M*	*H*	*L*	*H*	*H*	*H*	*L*	*H*	*H*
CLO-3 :	*Explain the concepts and experiments in cancer development*	*2*	*75*	*80*	*M*	*H*	*M*	*H*	*M*	*M*		*M*	*H*	*H*	*H*	*H*	*L*	*H*	*H*
CLO-4 :	*Recognize the various pathways of cancer and pain*	*2*	*85*	*80*	*L*	*H*	*H*	*H*			*H*	*L*	*L*	*H*	*H*	*H*	*M*	*H*	*H*
CLO-5 :	*Discuss the different methods in the neuroendocrine and immune interactions in cancer*	*3*	*85*	*75*	*L*	*H*	*H*	*M*		*M*	*H*	*H*	*H*	*L*	*H*	*H*	*H*	*H*	*H*
CLO-6 :	*Explain the concepts of cancer detection and therapy*	*2*	*80*	*80*	*M*	*H*	*H*	*H*	*L*	*H*	*M*	*M*	*H*	*H*	*H*	*H*	*H*	*H*	*H*

Duration (hour)		9	9	9	9	9
S-1	SLO-1	*Basic concepts of cancer: Oncogenes and tumor suppressor genes*	*DNA structure and stability*	*Signal transduction*	*Stem cells and cancer*	*Cancer therapy and detection*
	SLO-2	*Risk factors, Pathogenesis, treatment and future prospects*	*Spontaneous DNA damage*	*Growth factors and receptors*	*Self- renewal and its molecular mechanisms*	*Modalities of treatment*
S-2	SLO-1	*The cell cycle*	*DNA repair*	*EGF growth factor receptor signaling*	*Hedgehog signaling pathway*	*Nuclear medicine*
	SLO-2	*cyclin and cyclin dependent kinases*	*Clinical applications of DNA repair biomarkers*	*Ras activation*	*Polycomb group proteins*	*Chemotherapeutic agents*
S-3	SLO-1	*Mechanisms of CdK regulation.*	*Epigenetics*	*Activation of MAPK pathways*	*Therapeutic strategies*	*Plant alkaloids*
	SLO-2	*Tumor suppressor genes*	*Epigenome and its implications*	*Oncogenes*	*Tumor micro environment in cancer*	*Antibiotics*
S-4	SLO-1	*Knudson's two-hit hypothesis*	*Carcinogenesis*	*Immune system*	*Macrophages and tumor progression*	*Hormonal agents*
	SLO-2	*P53 and control of cell cycle*	*Causes of cancer*	*Effector mechanisms in cancer immunity*	*SMAD signaling centers*	*Biological therapy*
S-5	SLO-1	*Molecular pathways of p53*	*Cancer risk factors*	*NF-KB signaling pathway*	*Invasion and metastasis*	*Immunotherapy and hematopoietic growth factors*
	SLO-2	*Myc transcription factor*	*Types of carcinogens*	*JAK/STAT and cancer*	*Cell adhesion molecules*	*Cancer prevention and early detection*
S-6	SLO-1	*Powers of Myc oncoprotein*	*Bacteria and cancer*	*Neuroendocrine system*	*Angiogenesis*	*Screening techniques and diagnostic tests*
	SLO-2	*Role of myc oncoprotein in regulating pRb*	*Hormones and cancer*	*Neurotransmitters and GPCR signaling*	*Tumor angiogenesis and neovasculature*	*Imaging and cancer*
S-7	SLO-1	*TGF role in cancer*	*Ecogenetics and cancer risk*	*Estrogen signaling pathways*	*VEGF signal transduction*	*X-Ray CT, MRI, and radio imaging*
	SLO-2	*pRb's role in cancer*	*Mutations*	*Growth factors, and growth factor receptors*	*Angiogenic inhibitors*	*Optical imaging*
S-8	SLO-1	*Tumor suppressor genes*	*Carcinogen metabolism*	*Wnt signaling*	*Vascular targets*	*Tumor vasculature metabolism*
	SLO-2	*Cell cycle and cancer*	*Biotransformation and cancer risk*	*Implications in cancer therapy*	*Pain and physiology of pain perception*	*Contrast agents in cancer molecular imaging*
S-9	SLO-1	*Different forms of cancer*	*Cancer prevention*	*Apoptosis and Cancer*	*Neuropathic cancer pain*	*Bioinformatics for pathway interaction*
	SLO-2	*Diet and cancer*	*Hazard identification assays*	*Bcl-2 and cancer*	*Pain therapy*	*Population screening challenge*

Learning Resources	1. *Lauren Pecorino, Molecular Biology of Cancer: Mechanisms, Targets, and Therapeutics, Oxford University Press; 4th edition, 2016* 2. *Robert A. Weinberg, The Biology of Cancer Garland Science; 2nd edition , 2013* 3. *John Mendelsohn, Peter M. Howley, Mark A. Israel, Joe W. Gray, Craig B. Thompson. The Molecular Basis of Cancer, Saunders; 4 edition, 2014*

Learning Assessment

	Bloom's Level of Thinking	Continuous Learning Assessment (50% weightage)								Final Examination (50% weightage)	
		CLA – 1 (10%)		CLA – 2 (15%)		CLA – 3 (15%)		CLA – 4 (10%)#			
		Theory	Practice	Theory	Practice	Theory	Practice	Theory	Practice	Theory	Practice
Level 1	Remember Understand	*40 %*	-	*30%*	-	*30%*	-	*30%*	-	*30%*	-
Level 2	Apply Analyze	*40 %*	-	*40%*	-	*40%*	-	*40%*	-	*40%*	-
Level 3	Evaluate Create	*20 %*	-	*30%*	-	*30%*	-	*30%*	-	*30%*	-
	Total	100 %		100 %		100 %		100 %		100 %	

CLA – 4 can be from any combination of these: Assignments, Seminars, Tech Talks, Mini-Projects, Case-Studies, Self-Study, MOOCs, Certifications, Conf. Paper etc.,

Course Designers

Experts from Industry	Experts from Higher Technical Institutions	Internal Experts
Dr. G. N. Ramchand, Saksin Life sciences Pvt Ltd, Chennai, ramchand@saksinlife.com	*Prof.. K Subramaniam, IITM, Chennai, subbu@iitm.ac.in*	*Dr. S.ThyagaRajan, SRMIST*
Dr. Karthik Periyasamy, Scientist I, Aurozymes Unit, Aurobindo Pharma Limited, Hyderabad, karthikmpk@gmail.com	*Prof. R. B. Narayanan, SVCE, Chennai, rbn@svce.ac.in*	*Dr.R.Vasantharekha, SRMIST*

Course Code	18BTE402T	Course Name	PHYSIOLOGY OF STRESS AND ITS MANAGEMENT	Course Category	E	Professional Elective	L	T	P	C
							3	0	0	3

Pre-requisite Courses	Nil	Co-requisite Courses	Nil	Progressive Courses	Nil
Course Offering Department	Biotechnology	Data Book / Codes/Standards	Nil		

Course Learning Rationale (CLR):	*The purpose of learning this course is to:*
CLR-1 :	*Describe the homeostasis and control systems in stress*
CLR-2 :	*Discuss stress neuroendocrinology*
CLR-3 :	*Recall the behavioral response to stress*
CLR-4:	*Explain different disorders of stress*
CLR-5:	*Describe the role of age and emotion in stress*
CLR-6:	*Analyze the role of education I managing stress*

Course Learning Outcomes (CLO):	*At the end of this course, learners will be able to:*	Learning 1: Level of Thinking (Bloom)	Learning 2: Expected Proficiency (%)	Learning 3: Expected Attainment (%)	PLO 1: Engineering Knowledge	PLO 2: Problem Analysis	PLO 3: Design & Development	PLO 4: Analysis, Design, Research	PLO 5: Modern Tool Usage	PLO 6: Society & Culture	PLO 7: Environment & Sustainability	PLO 8: Ethics	PLO 9: Individual & Team Work	PLO 10: Communication	PLO 11: Project Mgt. & Finance	PLO 12: Life Long Learning	PLO 13: PSO - 1	PLO 14: PSO - 2	PLO 15: PSO – 3
CLO-1 :	*Analyze the role of endocrine and immune system in stress*	*1*	*80*	*80*	*L*	*H*	*H*	*H*		*M*	*L*	*H*	*H*	*H*	*H*	*H*	*L*	*H*	*H*
CLO-2 :	*Describe the role of brain and neurotransmitters in stress*	*2*	*85*	*75*	*M*	*H*	*H*	*M*			*M*	*H*	*L*	*H*	*H*	*H*	*L*	*H*	*H*
CLO-3 :	*Explain the concepts and experiments in stress and stressors*	*2*	*75*	*80*	*M*	*H*	*M*	*H*	*M*	*M*		*M*	*H*	*H*	*H*	*H*	*L*	*H*	*H*
CLO-4 :	*Recognize the various pathways of stress related disorders*	*2*	*85*	*80*	*L*	*H*	*H*	*H*			*H*	*L*	*L*	*H*	*H*	*H*	*M*	*H*	*H*
CLO-5 :	*Discuss the different methods in the management of stress*	*3*	*85*	*75*	*L*	*H*	*H*	*M*		*M*	*H*	*H*	*H*	*L*	*H*	*H*	*H*	*H*	*H*
CLO-6 :	*Explain the concepts of diet, exercise and life style in managing stress*	*2*	*80*	*80*	*M*	*H*	*H*	*H*	*L*	*H*	*M*	*M*	*H*	*H*	*H*	*H*	*H*	*H*	*H*

Duration (hour)		9	9	9	9	9
S-1	SLO-1	*Homeostasis and control systems*	*Stress neuroendocrinology*	*Behavioral responses to stress*	*Stress of Boredom*	*Awareness about managing stress.*
	SLO-2	*Endocrine system*	*limbic forebrain*	*Behavioral sources of stress*	*Anxiety disorders*	*Extra role in behavior*
S-2	SLO-1	*HPA axis*	*Noradrenergic system*	*Impairment of response inhibition*	*Panic disorder*	*Managing stress and behavior*
	SLO-2	*Limbic modulation of HPA axis*	*Corticotropin releasing hormone*	*lack of motivation*	*Social anxiety disorder*	*Extra role in education settings*
S-3	SLO-1	*Nervous system and stress disorder*	*CRF family with role in HPA axis*	*Aggressive behavior*	*Cognitive behavior therapy*	*Relaxation.*
	SLO-2	*Hippocampus and depression*	*Intracellular signaling mediating external signals of stress*	*Physiological components of stress response*	*Post-traumatic syndromes*	*Effective communication.*
S-4	SLO-1	*Parasymapthetic system*	*Catecholamines and MAP kinases*	*Interactions of behavioral and physiological components*	*Evolution and treatment*	*Intervention of caregivers*
	SLO-2	*Fight/flight responses*	*microRNAs-Telomeres*	*Environmental factors*	*Distress*	*Institutional care*
S-5	SLO-1	*Rest/digest responses*	*Role of micro-RNA in fear conditioning*	*Impact of environmental factors on stress*	*Psychological concomitants of distress*	*Managing anger and coping with anxiety.*
	SLO-2	*Immune system*	*Neural circuitry of stress, fear and anxiety*	*Differential exposure*	*Chronic stress.*	*Psychophysiological and biological perspective*
S-6	SLO-1	*Innate Immunity*	*Serotonergic systems modulates anxiety*	*Vulnerability of environmental stressors*	*Fear.*	*Meditation model*
	SLO-2	*Adaptive immunity*	*Locus coeruleus facilitate stress*	*Psychological stressors*	*Emotional inhibition*	*Eating behavior and healthy lifestyle*
S-7	SLO-1	*Stress and its underpinnings*	*Neurons and central autonomic control*	*Historical and general considerations*	*Aggressive behavior and social stress.*	*Human research related to stress in food intake*
	SLO-2	*Kinds of stress*	*Stress-Hippocampal neurogenesis.*	*Conceptual developments*	*Acute and chronic stress models*	*Mechanisms relating stress to eating*
S-8	SLO-1	*Norepinephrine in stress*	*Neurons modulate HPA axis*	*Methodological considerations*	*Aging and psychological stress.*	*Exercise*
	SLO-2	*Noradrenergic control of stress*	*Epigenetics and stress and neural network*	*Cognition and stress*	*Age-related disease*	*Time management and stress reduction plan*
S-9	SLO-1	*Allostasis*	*Epigenetics and stress response*	*Cognitive origin of stress*	*Stress response and central role of brain*	*General principles of prevention*
	SLO-2	*Allostatic load*	*Transgenerational effects of epigenetic stress markers*	*Cognitive consequences of stress*	*Job-related stress.*	*Physical and mental well-being*

Learning Resources	1. *George Fink. Stress: Concepts, Cognition, Emotion, and Behavior: Handbook in Stress. Academic Press. First edition. 2016* 2. *George Fink, Stress: Neuroendocrinology and neurobiology; Academic Press. First edition. 2017*

Learning Assessment

	Bloom's Level of Thinking	Continuous Learning Assessment (50% weightage)								Final Examination (50% weightage)	
		CLA – 1 (10%)		CLA – 2 (15%)		CLA – 3 (15%)		CLA – 4 (10%)#			
		Theory	Practice	Theory	Practice	Theory	Practice	Theory	Practice	Theory	Practice
Level 1	Remember Understand	*40 %*	-	*30%*	-	*30%*	-	*30%*	-	*30%*	-
Level 2	Apply Analyze	*40 %*	-	*40%*	-	*40%*	-	*40%*	-	*40%*	-
Level 3	Evaluate Create	*20 %*	-	*30%*	-	*30%*	-	*30%*	-	*30%*	-
	Total	100 %		100 %		100 %		100 %		100 %	

CLA – 4 can be from any combination of these: Assignments, Seminars, Tech Talks, Mini-Projects, Case-Studies, Self-Study, MOOCs, Certifications, Conf. Paper etc.,

Course Designers

Experts from Industry	Experts from Higher Technical Institutions	Internal Experts
Dr. G. N. Ramchand, Saksin Life sciences Pvt Ltd, Chennai, ramchand@saksinlife.com	*Prof.. K Subramaniam, IITM, Chennai, subbu@iitm.ac.in*	*Dr. S.ThyagaRajan, SRMIST*
Dr. Karthik Periyasamy, Scientist I, Aurozymes Unit, Aurobindo Pharma Limited, Hyderabad, karthikmpk@gmail.com	*Prof. R. B. Narayanan, SVCE, Chennai, rbn@svce.ac.in*	*Dr.R.Vasantharekha, SRMIST*

Course Code	18BTE305T	Course Name	PHARMACEUTICAL BIOTECHNOLOGY	Course Category	E	Professional Elective	L	T	P	C
							3	0	0	3

Pre-requisite Courses	18BTC101J	Co-requisite Courses	Nil	Progressive Courses	Nil
Course Offering Department	Biotechnology	Data Book / Codes/Standards	Nil		

Course Learning Rationale (CLR):	*The purpose of learning this course is to:*
CLR-1 :	*Appraise the changes the drug and human system undergoes when consumed*
CLR-2 :	*Demonstrate the parameters that affect the action of drug in human system*
CLR-3 :	*Relate the different type of adverse drug reactions and drug abuse*
CLR-4:	*Explain the mechanism of action, toxicity and uses of antibiotics and anti-tubercular drugs*
CLR-5:	*Describe the regulation of drugs in Indian Government and its initiatives in promoting Indian System of medicine*
CLR-6:	*Distinguish various parameters to be considered during drug discovery process*

Course Learning Outcomes (CLO):	*At the end of this course, learners will be able to:*	Learning 1: Level of Thinking (Bloom)	2: Expected Proficiency (%)	3: Expected Attainment (%)
CLO-1 :	*Select appropriate target, drug-like candidates based on desired pharmacokinetic and pharmacodynamic parameters*	*1*	*80*	*80*
CLO-2 :	*Estimate the dose of drug to be administered for individuals*	*2*	*85*	*75*
CLO-3 :	*Explain the logical usage of drugs and suggest appropriate treatment*	*2*	*75*	*80*
CLO-4 :	*Justify the choice of drugs for microbial infection in an individual*	*2*	*85*	*80*
CLO-5 :	*Underline the significance of stringent laws pertaining to manufacturing, distribution and sale of drugs in India*	*3*	*85*	*75*
CLO-6 :	*Illustrate the process of pre-clinical investigation of drug designing*	*2*	*80*	*80*

Program Learning Outcomes (PLO)

	1 Engineering Knowledge	2 Problem Analysis	3 Design & Development	4 Analysis, Design, Research	5 Modern Tool Usage	6 Society & Culture	7 Environment & Sustainability	8 Ethics	9 Individual & Team Work	10 Communication	11 Project Mgt. & Finance	12 Life Long Learning	13 PSO - 1	14 PSO - 2	15 PSO – 3
CLO-1	M	H	L	H			L	H	L	L	L	H	H	H	H
CLO-2	M	H	L	H			L	H	M	L	H	H	H	H	
CLO-3	L	H	M	H		M		H	H	H	H	H	H	H	H
CLO-4	H	H	H	H			H	H	H	H	H	H	H	H	H
CLO-5	H	H	H	H	H	M	H	H	H	H	H	H	H	H	H
CLO-6	H	H	H	H	M	M	M	H	H	H	H	H	H	H	H

Duration (hour)		9	9	9	9	9
S-1	SLO-1	*Basic concepts*	*Plateau principle*	*Pharmacovigilance*	*Mechanism of action of Tetracyclines*	*Mechanism of action of Amphoterycin B*
	SLO-2	*Pharmacopoeia and Essential Drugs*	*Target level strategy*	*Casualty assessment*	*Uses, Spectrum of activity, toxicity of Tetracyclines*	*Spectrum of activity and adverse effects of Amphoterycin B*
S-2	SLO-1	*Local routes of drug administration*	*Prolongation of drug action*	*Side, secondary and toxic effects of drugs*	*Mechanism of action of aminoglycoside antibiotics*	*Mechanism of action of Griseofulvin*
	SLO-2	*Systemic routes of drug administration*	*Target delivery devices*	*Accidental overdose of drugs and the treatment*	*Classification, Uses of aminoglycosides*	*Mechanism of action of Imidazoles and Triazoles anti-fungal agents*
S-3	SLO-1	*Influence of pH on transport of molecules across membranes*	*Principles of drug action*	*Drug Intolerance and Drug allergy*	*Mechanism of action of Macrolide antibiotics*	*Indian Drug Regulatory System*
	SLO-2	*Passsive transport and facilitated transport*	*Mechanism of drug action on enzymes*	*Drug abuse and Treatment*	*Classification of Macrolide antibiotics*	*Drug Regulatory body - CDSCO*
S-4	SLO-1	*Absorption of Drugs*	*Mechanism of drug action on Ion channels*	*Classification of anti-microbial agents based on chemical structure*	*Spectrum of activity of Macrolide antibiotics*	*Hierarchy at CDSCO*
	SLO-2	*Bioavailability*	*Mechanism of drug action on transporters*	*Classification of anti-microbial agents based on mechanism of action*	*Uses and toxicity of Macrolide antibiotics*	*Good clinical Practices*
S-5	SLO-1	*Distribution and Redistribution of drugs*	*Action-Effect sequence*	*Drug modification and alteration of target site by microorganisms*	*Treatment of Urinary tract infections*	*Role of Pharmacists in Drug regulation*
	SLO-2	*Tissue storage, placental & brain transport*	*Transducer mechanism*	*Reduction in drug accumulation and alteration of metabolic pathway by microorganisms*	*Structure, adverse effects of Isoniazid*	*Functions of State Drug-Inspectors*
S-6	SLO-1	*Biotransformation of drugs and types*	*Dose-Response Relationship*	*Mechanism of action of Co-trimoxazole*	*Mechanism of action of Isoniazid*	*Functions of CDSCO*
	SLO-2	*Cytochrome P450*	*Therapeutic efficiency*	*Uses and adverse effects of cotrimoxazole*	*Structure, adverse effects of Rifampicin*	*Functions of Central Drug-Inspectors*
S-7	SLO-1	*Non-synthetic biotransformation reactions*	*Synergystic drug action*	*Mechanism of action of Fluoroquinolones*	*Mechanism of action of Rifampicin*	*Ayurvedic Formulary of India*

	SLO-2	*Synthetic biotransformation of drugs*	*Antagonistic drug action*	*Classification, Uses and adverse effects of Fluoroquinolones*	*Structure, Mechanism of action, adverse effects of Pyrazinamide*	*Ayurvedic Dosage Forms*
S-8	SLO-1	*Inhibition of drug metabolism*	*Fixed dose combination of drugs*	*Structure of beta-lactum antibiotics*	*Structure, Mechanism of action, adverse effects of Ethambutol*	*Ayurvedic Pharmacopoeia of India*
	SLO-2	*Induction of microsomal enzymes*	*Factors modifying drug action*	*Classification of beta-lactum antibiotics*	*Tuberculosis in pregnant and lactating women*	*Ayurvedic, Unani, Siddha drugs undertaken by British commission*
S-9	SLO-1	*Routes of excretion of drugs*	*Pharmacogenetics and Pharmacogenomics*	*Uses of beta-lactum antibiotics*	*Tuberculosis in HIV infected individuals in India*	*Indian Government Initiatives to promote Ayurvedic products*
	SLO-2	*Rate of Clearance and Plasma half-life*	*Drug dosage in individuals with hepatic, renal, heart and thyroid problems*	*Adverse effects of beta-lactum antibiotics*	*Mycobacterium Avium Complex infections in India*	*Indian Government Initiatives to promote Unani and Siddha products*

Learning Resources	1. *Rang and Dale, "Pharmacology", Churchill Livingstone, 2007.* 2. *Tripathi.K.D, "Essentials of Medical Pharmacology", Jaypee Brothers Medical Publishers, New Delhi, 7th Edition, 2013.* 3. *http://www.cdsco.nic.in/forms/contentpage1.aspx?lid=1888* 4. *cdsco.nic.in/writereaddata/guidance%20documents.pdf*

Learning Assessment

	Bloom's Level of Thinking	Continuous Learning Assessment (50% weightage)								Final Examination (50% weightage)	
		CLA – 1 (10%)		CLA – 2 (15%)		CLA – 3 (15%)		CLA – 4 (10%)#			
		Theory	Practice	Theory	Practice	Theory	Practice	Theory	Practice	Theory	Practice
Level 1	Remember Understand	*40 %*	-	*30%*	-	*30%*	-	*30%*	-	*30%*	-
Level 2	Apply Analyze	*40 %*	-	*40%*	-	*40%*	-	*40%*	-	*40%*	-
Level 3	Evaluate Create	*20 %*	-	*30%*	-	*30%*	-	*30%*	-	*30%*	-
	Total	100 %		100 %		100 %		100 %		100 %	

CLA – 4 can be from any combination of these: Assignments, Seminars, Tech Talks, Mini-Projects, Case-Studies, Self-Study, MOOCs, Certifications, Conf. Paper etc.,

Course Designers

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Dr. Karthik Periyasamy, Scientist I, Aurozymes Unit, Aurobindo Pharma Limited, Hyderabad, karthikmpk@gmail.com	*Prof. R. B. Narayanan, SVCE, Chennai, rbn@svce.ac.in*	*Mr. M. K. Jaganathan, SRMIST*

Course Code	18BTE306T	Course Name	BIOINFORMATICS	Course Category	E	Professional Elective	L	T	P	C
							3	0	0	3

Pre-requisite Courses	Nil	Co-requisite Courses	Nil	Progressive Courses	Nil
Course Offering Department	Biotechnology	Data Book / Codes/Standards	Nil		

Course Learning Rationale (CLR):	*The purpose of learning this course is to:*
CLR-1 :	*Analyze the databases in bioinformatics*
CLR-2 :	*Use sequence alignment to find similar sequences*
CLR-3 :	*Use alignment to build hierarchical lineages*
CLR-4:	*Apply principles of bioinformatics to build tertiary structures of proteins*
CLR-5:	*Analyze motifs and patterns*
CLR-6:	*Analyze uses of Python programming in Bioinformatics applications*

Course Learning Outcomes (CLO):	*At the end of this course, learners will be able to:*	Learning 1: Level of Thinking (Bloom)	Learning 2: Expected Proficiency (%)	Learning 3: Expected Attainment (%)	PLO 1: Engineering Knowledge	PLO 2: Problem Analysis	PLO 3: Design & Development	PLO 4: Analysis, Design, Research	PLO 5: Modern Tool Usage	PLO 6: Society & Culture	PLO 7: Environment & Sustainability	PLO 8: Ethics	PLO 9: Individual & Team Work	PLO 10: Communication	PLO 11: Project Mgt. & Finance	PLO 12: Life Long Learning	PLO 13: PSO - 1	PLO 14: PSO - 2	PLO 15: PSO – 3
CLO-1 :	*Describe the applications of bioinformatics to build databases for universal usage*	*1*	*80*	*80*	*H*	*H*	*H*	*H*		*M*	*L*	*H*	*H*	*H*	*H*	*H*	*H*	*H*	*H*
CLO-2 :	*Explain the concepts and tools to build alignment between similar sequences of DNA or Protein*	*2*	*85*	*75*	*H*	*H*	*H*	*H*			*M*	*H*	*H*	*H*	*H*	*H*	*H*	*H*	*H*
CLO-3 :	*Recognize the pattern of lineages and evolution*	*2*	*80*	*80*	*M*	*H*	*M*	*H*	*M*	*M*		*M*	*H*	*H*	*H*	*H*	*H*	*H*	*H*
CLO-4 :	*Discuss the different methods in the construction the structure of a protein*	*2*	*85*	*80*	*M*	*H*	*H*	*H*			*H*	*M*	*H*	*H*	*H*	*H*	*H*	*H*	*H*
CLO-5 :	*Analyze the importance of conserved regions in a molecular sequence*	*3*	*85*	*75*	*M*	*H*	*H*	*H*		*M*	*H*	*M*	*H*	*L*	*H*	*H*	*H*	*H*	*H*
CLO-6 :	*Explain the basic concepts and principles of Programming in Python for bioinformatics*	*3*	*80*	*80*	*H*	*H*	*H*	*H*	*L*	*M*	*M*	*M*	*H*	*H*	*H*	*H*	*H*	*H*	*H*

Duration (hour)		9	9	9	9	9
S-1	SLO-1	*Bioinformatics significance*	*Introduction on databases & biological databases*	*Sequence alignment*	*Motifs and Patterns prediction*	*Introduction of Python and text editors*
	SLO-2	*Applications of bioinformatics*	*Uses of biological databases*	*Global Pairwise Alignment Algorithm*	*Databases for motif prediction*	*String datatype*
S-2	SLO-1	*Internet basics: Connecting to internet*	*Primary sequence databases, Nucleotide*	*Solving problems*	*Databases for patterns and blocks*	*Tuples datatype*
	SLO-2	*Internet Protocols*	*Protein sequence database*	*Local Pairwise Alignment Algorithm*	*Secondary Database Searching*	*Lists datatype*
S-3	SLO-1	*HTML script*	*Primary structure databases*	*Database searching*	*Secondary structure prediction*	*Flow control: If else*
	SLO-2	*Webpage creation*	*PDB file format*	*BLAST*	*Tools for secondary structure prediction*	*For loop*
S-4	SLO-1	*Human genome project*	*Fasta, GCG, VFF etc..*	*FASTA*	*Specialized secondary structure prediction*	*While loop*
	SLO-2	*Uses of human genome project*	*Secondary databases*	*Multiple Sequence Alignment:*	*Tertiary structure prediction*	*Reading and Writing files*
S-5	SLO-1	*The NCBI data model: Introduction*	*secondary sequence databases*	*Progressive and Iterative Alignment*	*Comparative modelling*	*Modules in Python*
	SLO-2	*SEQ-Ids*	*secondary structure databases*	*Tools for pairwise alignment*	*Abinitio modelling*	*Functions*
S-6	SLO-1	*BIOSEQs and BIOSEQ-SETs*	*SCOP*	*tools for multiple sequence alignment*	*Validation of tertiary structure*	*Regular expressions: Syntax*
	SLO-2	*SEQ-ANNOT and SEQ-DESCR*	*CATH*	*Application of Multiple Sequence Alignment*	*tools for homology modeling*	*Regex examples*
S-7	SLO-1	*Genbank database*	*Composite protein databases*	*Databases Of Multiple Alignment*	*tools for structure validation*	*Biopython*
	SLO-2	*Genbank Flat file*	*Metabolic databases*	*Molecular Phylogeny*	*Structure visualization tools*	*Advantages of python in bioinformatics*
S-8	SLO-1	*Sequence submission to Genbank*	*SNP databases*	*Methods of phylogeny*	*rasmol*	*Components of biopython: Alphabet*
	SLO-2	*Online and offline tools*	*Whole genome , medelian disease databases*	*types of trees*	*Chemical structure building tools*	*Seq, Seq object, SeqUtils*
S-9	SLO-1	*Entrez , INSDC*	*chemical structure databases*	*Tools for phylogeny*	*file formats for small molecules*	*Align and clustalw with Biopython*
	SLO-2	*Other databases in NCBI*	*bibliographic databases*	*PAM and BLOSUM*	*file format conversion tools*	*BLAST Running and Processing with Biopython*

Learning Resources	1. Andreas D Baxevanis & B F Francis, "Bioinformatics- A practical guide to analysis of Genes & Proteins", John Wiley, 2002 2. T K Attwood, D J Parry-Smith," Introduction to Bioinformatics", Pearson Education, 1st Edition, 11th Reprint 2005. 3. Jin Xiong, "Essential Bioinformatics", Cambridge University Press, 2006 4. Sebastian Bassi, "Python for Bioinformatics", 2nd Edition CRC Press, 2017.

Learning Assessment

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		CLA – 1 (10%)		CLA – 2 (15%)		CLA – 3 (15%)		CLA – 4 (10%)#			
		Theory	Practice	Theory	Practice	Theory	Practice	Theory	Practice	Theory	Practice
Level 1	Remember Understand	*40 %*	-	*30%*	-	*30%*	-	*30%*	-	*30%*	-
Level 2	Apply Analyze	*40 %*	-	*40%*	-	*40%*	-	*40%*	-	*40%*	-
Level 3	Evaluate Create	*20 %*	-	*30%*	-	*30%*	-	*30%*	-	*30%*	-
	Total	100 %		100 %		100 %		100 %		100 %	

CLA – 4 can be from any combination of these: Assignments, Seminars, Tech Talks, Mini-Projects, Case-Studies, Self-Study, MOOCs, Certifications, Conf. Paper etc.,

Course Designers

Experts from Industry	Experts from Higher Technical Institutions	Internal Experts
Mr. Raghu R.Schrondinger, raghu.rangaswamy@schrodinger.com	*Dr.G. Ramesh kumar, AU-KBC Research Centre, gramesh@au-kbc.org*	*Dr. Priya Swaminathan, SRM Institute of Science & Technology, priya.s@ktr.srmuniv.ac.in*
Dr. Karthik Periyasamy, Scientist I, Aurozymes Unit, Aurobindo Pharma Limited, Hyderabad, karthikmpk@gmail.com	*Prof. R. B. Narayanan, SVCE,Chennai, rbn@svce.ac.in*	*Mr. M.K.Jagannathan, SRM Institute of Science & Technology, jaganathan.m@ktr.srmuniv.ac.in*

Course Code	18BTE307T	Course Name	DRUG DISCOVERY AND DRUG DESIGNING	Course Category	E	Professional Elective	L	T	P	C
							3	0	0	3

Pre-requisite Courses	Nil	Co-requisite Courses	Nil	Progressive Courses	Nil
Course Offering Department	Biotechnology	Data Book / Codes/Standards			

Course Learning Rationale (CLR):	*The purpose of learning this course is to:*
CLR-1 :	*State the basic concepts of drug discovery and drug design processes*
CLR-2 :	*State the basic concepts of target identification and target characterization*
CLR-3 :	*Explain about the various computational tools in drug discovery*
CLR-4:	*Discuss about the pharmacophore Model and QSAR*
CLR-5:	*Discuss about the quantum mechanics in drug design, De novo and future developments in drug design*
CLR-6:	*Explain the basic concepts of drug discovery and drug design processes and computational tools used in the drug designing.*

Course Learning Outcomes (CLO):	*At the end of this course, learners will be able to:*	Learning 1 Level of Thinking (Bloom)	Learning 2 Expected Proficiency (%)	Learning 3 Expected Attainment (%)	PLO 1 Engineering Knowledge	2 Problem Analysis	3 Design & Development	4 Analysis, Design, Research	5 Modern Tool Usage	6 Society & Culture	7 Environment & Sustainability	8 Ethics	9 Individual & Team Work	10 Communication	11 Project Mgt. & Finance	12 Life Long Learning	13 PSO - 1	14 PSO - 2	15 PSO – 3
CLO-1 :	*Explain basic concepts of drug design processes for a various number of drug development scenarios.*	*1*	*85*	*80*	*L*	*H*	*H*	*H*	*H*		*M*	*M*	*H*			*H*	*H*	*H*	*H*
CLO-2 :	*Explain the basic concept of target identification and target characterization*	*1*	*85*	*80*	*L*	*H*	*H*	*H*	*H*		*H*		*H*			*H*	*H*	*H*	*H*
CLO-3 :	*Compare the different computational tools for drug designing and the computer software used in the drug designing.*	*2*	*80*	*70*	*M*	*H*	*H*	*H*	*H*		*H*		*H*			*H*	*H*	*H*	*H*
CLO-4 :	*Explain the basic concepts of pharmacophore Model and QSAR.*	*1*	*80*	*70*	*M*	*H*	*H*	*H*	*H*		*H*		*H*			*H*	*H*	*H*	*H*
CLO-5 :	*Summarize the basic concepts of Quantum Mechanics in drug designing and De nova ligand synthesis.*	*1*	*85*	*80*	*M*	*H*	*H*	*H*	*H*		*H*		*H*			*H*	*H*	*H*	*H*
CLO-6 :	*Summarize the basic concepts in the drug design process and the computational techniques used in the drug design process.*	*1*	*80*	*70*	*M*	*H*	*H*	*H*	*H*		*H*		*H*			*H*	*H*	*H*	*H*

Duration (hour)		9	9	9	9	9
S-1	SLO-1	*Introduction to the drug discovery process*	*Target Identification: Primary Sequence and Metabolic Pathway,*	*introduction to computational tools in drug discovery*	*what is a pharmacophore Model*	*Quantum Mechanics in drug designing*
	SLO-2	*The sequence of research activities in the development of new drug*	*Crystallography and 2D NMR, Homology Models and Protein Folding in target identification*	*Introduction to Homology Model Building*	*Components of a Pharmacophore Model*	*When quantum mechanics is superior to molecular mechanics?*
S-2	SLO-1	*Terminology related to drug testing: "hits," "leads," "drug candidates," "drugs,"*	*Analysis of Target Mechanism: Kinetics and Crystallography, Automated Crevice Detection,*	*Importance of sequence similarity in homology modeling*	*Creating a Pharmacophore Model from the Active Compounds*	*Quantum Mechanics Algorithms*
	SLO-2	*Criteria that may be necessary to move a compound series onto the lead development stage*	*Transition Structures and Reaction Coordinates.*	*Steps for Building a Homology Model*	*Advantages of pharmacophore searching*	*Quantum Mechanics Software used in drug designing*
S-3	SLO-1	*Compound Testing: Biochemical Assays*	*Introduction to Molecular Dynamics Simulations*	*Homology Model creation*	*Creating a Pharmacophore Model from the Active Site*	*Modeling systems with metal atoms*
	SLO-2	*Compound Testing: Cell-Based Assays,*	*Molecular dynamics in target characterization*	*Homology Model validation*	*Example of Pharmacophore Model from the Active Site*	*Increased accuracy*
S-4	SLO-1	*Compound Testing: Animal Testing*	*Pharmacophore identification*	*Molecular Mechanics: Brief Introduction to Molecular Mechanics*	*Searching Compound Databases*	*Computing reaction paths*
	SLO-2	*alternatives to animal testing*	*Deriving and using 3D pharmacophores*	*How molecular mechanics are utilized in drug design.*	*Reliability of search Results*	*Computing spectra*
S-5	SLO-1	*Compound Testing: Human Clinical Trials*	*The Drug Design Process for a Known Protein Target: The Structure-Based Design Process*	*Force Fields for Drug Design*	*QSAR*	*Structure-based De novo Ligand synthesis*
	SLO-2	*Phases in clinical trials*	*The Drug Design Process for a Known Protein Target: Initial Hits and Compound Refinement, ADMET*	*common force fields and their usage*	*Conventional QSAR versus 3D-QSAR*	*Example of De novo Ligand synthesis*

S-6	SLO-1	*Effect of Molecular Structure on Activity*	*What is Drug Resistance*	*Introduction to Molecular Docking*	*The QSAR Process*	*Nonquantitative predictions*
	SLO-2	*Effect of Molecular Structure on Bioavailability*	*Mechanisms of resistance to the drug*	*Search Algorithms in Molecular Docking*	*Descriptors*	*Quantitative predictions*
S-7	SLO-1	*Drug Side Effects and Toxicity*	*The Drug Design Process for an Unknown Target: The Ligand-Based Design Process*	*The Docking Process: Preparation of Protein and Ligand*	*Automated QSAR Programs*	*Future Developments in Drug Design: Individual Patient Genome Sequencing*
	SLO-2	*Multiple Drug Interactions*	*The Drug Design Process for an Unknown Target: Initial Hits and Compound Refinement, ADMET*	*Setting the Bounding Box*	*QSAR versus Other Fitting Methods*	*Analysis of the Entire Proteome*
S-8	SLO-1	*Metrics for Drug-Likeness*	*Drug Design for Other Targets*	*Docking Options and Running the Docking Calculation*	*The 3D-QSAR Process*	*Drugs Customized for Ethnic Group or Individual Patient*
	SLO-2	*The Lipinski rule of fives*	*Drug design issues that arise in situations other than competitive inhibition of proteins.*	*Analysis of docking Results*	*Criteria are used to construct conformers*	*Application of Genetic Manipulation in drug designing*
S-9	SLO-1	*Exceptions to the Rules*	*Targets inside cells*	*Docking software*	*3D-QSAR Software Packages*	*Cloning and Stem Cells in drug design*
	SLO-2	*Examples of successful drugs that do not obey the "rules."*	*Targets within the central nervous system*	*An important criterion for selecting a docking program.*	*Advantage and disadvantages of 3D-QSAR Software*	*Longevity*

Learning Resources	*1. Young, "Computational Drug Design: a Guide for Computational and Medicinal Chemists", Wiley, 2009* *2. Andrew Leach, "Molecular Modeling: Principles and applications," 2nd edition, Pearson Education, 1996* *3. Andrew Leach, "An introduction to Chemoinformatics," Springer, 2007* *4. Rick NG, "Drugs: From Discovery to Approval," John Wiley & Sons, 2004.* *5. Paul S Charifson, "Practical Application of Computer-Aided Drug Design," Informa Health Care, 1997.*

Learning Assessment

	Bloom's Level of Thinking	Continuous Learning Assessment (50% weightage)								Final Examination (50% weightage)	
		CLA – 1 (10%)		CLA – 2 (15%)		CLA – 3 (15%)		CLA – 4 (10%)#			
		Theory	Practice	Theory	Practice	Theory	Practice	Theory	Practice	Theory	Practice
Level 1	Remember Understand	*40 %*	-	*30%*	-	*30%*	-	*30%*	-	*30%*	-
Level 2	Apply Analyze	*40 %*	-	*40%*	-	*40%*	-	*40%*	-	*40%*	-
Level 3	Evaluate Create	*20 %*	-	*30%*	-	*30%*	-	*30%*	-	*30%*	-
	Total	100 %		100 %		100 %		100 %		100 %	

CLA – 4 can be from any combination of these: Assignments, Seminars, Tech Talks, Mini-Projects, Case-Studies, Self-Study, MOOCs, Certifications, Conf. Paper etc.,

Course Designers

Experts from Industry	Experts from Higher Technical Institutions	Internal Experts
Dr. G. N. Ramchand, Saksin Life sciences Pvt Ltd, Chennai, ramchand@saksinlife.com	*Prof. K Subramaniam, IITM, Chennai, suubu@iitm.ac.in*	*Mr. Jaganathan. M. K. SRMIST*
Dr. Karthik Periyasamy, Scientist I, Aurozymes Unit, Aurobindo Pharma Limited, Hyderabad, karthikmpk@gmail.com	*Prof. R. B. Narayanan, SVCE, Chennai, rbn@svce.ac.in*	*Dr. S. Priyaswaminathan. SRMIST*

Course Code	18BTE308T	Course Name	MARINE BIOTECHNOLOGY	Course Category	E	Professional Elective	L	T	P	C
							3	0	0	3

Pre-requisite Courses	Nil	Co-requisite Courses	Nil	Progressive Courses	Nil
Course Offering Department	Biotechnology	Data Book / Codes/Standards	Nil		

Course Learning Rationale (CLR):	*The purpose of learning this course is to:*
CLR-1 :	*Learn the knowledge of the living and non-living resources.*
CLR-2 :	*Analyze the pharmacological potency of toxins.*
CLR-3 :	*Apply the biopolymers from various sources.*
CLR-4:	*Understand the commercialization of marine and aquaculture resources.*
CLR-5:	*Control measures of various marine pollution.*
CLR-6:	*Analyze the techniques on the resource management.*

Course Learning Outcomes (CLO):	*At the end of this course, learners will be able to:*	Learning 1: Level of Thinking (Bloom)	Learning 2: Expected Proficiency (%)	Learning 3: Expected Attainment (%)	PLO 1: Engineering Knowledge	PLO 2: Problem Analysis	PLO 3: Design & Development	PLO 4: Analysis, Design, Research	PLO 5: Modern Tool Usage	PLO 6: Society & Culture	PLO 7: Environment & Sustainability	PLO 8: Ethics	PLO 9: Individual & Team Work	PLO 10: Communication	PLO 11: Project Mgt. & Finance	PLO 12: Life Long Learning	PLO 13: PSO - 1	PLO 14: PSO - 2	PLO 15: PSO – 3
CLO-1 :	*Describe the economically important marine resources and their wealth.*	*1*	*80*	*80*	*M*	*H*	*H*	*H*	*H*		*H*	*H*	*H*	*H*	*H*	*H*	*H*	*H*	*H*
CLO-2 :	*Explain the natural toxins.*	*2*	*85*	*75*	*M*	*H*	*H*	*H*	*H*		*H*	*H*	*H*	*H*	*H*	*H*	*H*	*H*	*H*
CLO-3 :	*Distinguish the availability of bioactive compounds.*	*2*	*80*	*80*	*H*	*H*	*H*	*H*	*H*		*H*	*H*	*H*	*H*	*H*	*H*	*H*	*H*	*H*
CLO-4 :	*Analyze the useful natural products.*	*2*	*85*	*80*	*M*	*H*	*M*	*M*	*H*		*M*	*H*	*H*	*H*	*H*	*H*	*H*	*H*	*H*
CLO-5 :	*Know the degradation process for discharged wastes.*	*3*	*85*	*75*	*M*	*M*	*H*	*H*	*H*		*H*	*H*	*H*	*H*	*H*	*H*	*H*	*H*	*H*
CLO-6 :	*Explain the diseases of cultivable animals and its controlling measures.*	*2*	*80*	*80*	*M*	*H*	*H*	*H*	*H*		*H*	*H*	*H*	*H*	*H*	*H*	*H*	*H*	*H*

Duration (hour)		9	9	9	9	9
S-1	SLO-1	*Zonation of the Sea*	*Toxic marine animals*	*Bioactive compounds*	*Oil spills and accidents*	*Shrimp diseases*
	SLO-2	*Motion of the Ocean*	*Octopus, venomous spines, stings*	*Biopolymers, Omega-3 fatty acids*	*Fate of spilled oil*	*Monodon baculovirus, vibriosis, larval mycosis*
S-2	SLO-1	*Living resources*	*Sources of toxins*	*Free radicals*	*Biosurfactants*	*Fish diseases*
	SLO-2	*Corals, seaweeds and mangroves*	*TTX, conotoxin*	*Antioxidant enzymes, peptides*	*Microbes in biodegradation*	*Rhabdovirus, erythrodermatitis, gill disease*
S-3	SLO-1	*Non-living resources*	*Various effects of toxin*	*Biopolymers*	*Harmful blooms*	*Antibiotics in aquaculture*
	SLO-2	*Oil, gas and salts*	*Intoxication, stings*	*Collagen, gelatin*	*Blue-green algal bloom, red tides*	*Oxytetracycline, enrofloxacin*
S-4	SLO-1	*Economically important animals*	*Puffer fish toxins*	*Anticoagulant substances*	*Marine harmful biotoxins*	*Immunostimulants*
	SLO-2	*FInfishes*	*Tetrodotoxin*	*Heparin*	*Impacts of bloom*	*Objectives and characteristics of immunostimulants*
S-5	SLO-1	*Penaeid shrimps*	*Intoxication of puffer toxin*	*Biomaterials*	*Pesticide pollution*	*Common immunostimulants*
	SLO-2	*Penaeus indicus*	*Pharmacological effects*	*Chitin, Chitosan*	*Organochlorine, organophosphate esters*	*Muramyl dipeptide, levamisole*
S-6	SLO-1	*Non-penaeid shrimps*	*Molluscan venoms*	*Poly unsaturated fatty acids*	*Heavy metal pollution*	*Tools to diagnose the disease*
	SLO-2	*Metapenaeus brevicornis*	*Conotoxin*	*Omega 3-fatty acids*	*Minamata disease*	*Agar gel precipitation, fluorescent antibody test*
S-7	SLO-1	*Marine crabs*	*Pharmacology of conotoxin*	*Applications of Omega 3-fatty acids*	*Chemical and biological modification*	*Water quality management*
	SLO-2	*Portunidae crabs*	*Clinical effects of conotoxin*	*Antiinflammatory, cardiovascular, diabetes*	*Biosorption, factors affecting*	*Temperature*
S-8	SLO-1	*Edible Oysters*	*Seafood poisoning*	*Fat soluble pigments*	*Solid waste pollution*	*Salinity*
	SLO-2	*Oyster reefs*	*Ciguateratoxin*	*Carotenoids*	*Plastic waste degradation*	*Dissolved oxygen, pH*
S-9	SLO-1	*Pearl Oysters*	*Sources of ciguateratoxin*	*Sources of carotenoids*	*Microbes for degradation*	*Nutrients*
	SLO-2	*Pinctada species*	*Jacks, sturgeon, grouper, snappers*	*Micro algae, sponges, mollusks, crustaceans*	*Factors affecting degradation*	*Ammonia*

Learning Resources	1. *Milton Fingerman and Rachakonda Nagabhushanam, "Recent Advances in Marine Biotechnology (Series) Biomaterials and Bioprocessing", Science Publishers, 2009.* 2. *Proksch and Werner E.G.Muller, "Frontiers in Marine Biotechnology", Horizon Bioscience, 2006.* 3. *Le Gal, Y., Ulber, R, "Marine Biotechnology I: Advances in Biochemical Engineering/Biotechnology", (Series editor: T. Scheper) Springer-Verlag Berlin Heidelberg. Vol. 96, 2005.* 4. *Le Gal, Y., Ulber, R "Marine Biotechnology II: Advances in Biochemical engineering/Biotechnology", (Series editor: T. Scheper) Springer-Verlag Berlin Heidelberg. Vol. 97, 2005.*

Learning Assessment

	Bloom's Level of Thinking	Continuous Learning Assessment (50% weightage)								Final Examination (50% weightage)	
		CLA – 1 (10%)		CLA – 2 (15%)		CLA – 3 (15%)		CLA – 4 (10%)#			
		Theory	Practice	Theory	Practice	Theory	Practice	Theory	Practice	Theory	Practice
Level 1	Remember Understand	*40 %*	-	*30%*	-	*30%*	-	*30%*	-	*30%*	-
Level 2	Apply Analyze	*40 %*	-	*40%*	-	*40%*	-	*40%*	-	*40%*	-
Level 3	Evaluate Create	*20 %*	-	*30%*	-	*30%*	-	*30%*	-	*30%*	-
	Total	100 %		100 %		100 %		100 %		100 %	

CLA – 4 can be from any combination of these: Assignments, Seminars, Tech Talks, Mini-Projects, Case-Studies, Self-Study, MOOCs, Certifications, Conf. Paper etc.,

Course Designers

Experts from Industry	Experts from Higher Technical Institutions	Internal Experts
Dr. G. N. Ramchand, Saksin Life sciences Pvt Ltd, Chennai, ramchand@saksinlife.com	*Prof. K Subramaniam, IITM, Chennai, subbu@iitm.ac.in*	*Dr.R.A.Nazeer, SRMIST*
Dr. Karthik Periyasamy, Scientist I, Aurozymes Unit, Aurobindo Pharma Limited, Hyderabad, karthikmpk@gmail.com	*Prof. R. B. Narayanan, SVCE, Chennai, rbn@svce.ac.in*	*Dr.R.Jaiganesh, SRMIST*

Course Code	18BTE403T	Course Name	VACCINE BIOTECHNOLOGY	Course Category	E	Professional Elective	L	T	P	C
							3	0	0	3

Pre-requisite Courses	18BTC106J	Co-requisite Courses	Nil	Progressive Courses	Nil
Course Offering Department	Biotechnology	Data Book / Codes/Standards	Nil		

Course Learning Rationale (CLR):	*The purpose of learning this course is to:*
CLR-1 :	*Understand the conventional strategies in vaccine production*
CLR-2 :	*Develop an understanding in the vaccine production techniques*
CLR-3 :	*Categorise the types of vaccine*
CLR-4:	*analyze different methods of vaccine delivery*
CLR-5:	*Comprehend the guidelines for vaccine management*
CLR-6:	*Analyze the immunization of an organism against antigen*

Course Learning Outcomes (CLO):	*At the end of this course, learners will be able to:*	Learning 1: Level of Thinking (Bloom)	Learning 2: Expected Proficiency (%)	Learning 3: Expected Attainment (%)	PLO 1: Engineering Knowledge	PLO 2: Problem Analysis	PLO 3: Design & Development	PLO 4: Analysis, Design, Research	PLO 5: Modern Tool Usage	PLO 6: Society & Culture	PLO 7: Environment & Sustainability	PLO 8: Ethics	PLO 9: Individual & Team Work	PLO 10: Communication	PLO 11: Project Mgt. & Finance	PLO 12: Life Long Learning	PLO 13: PSO - 1	PLO 14: PSO - 2	PLO 15: PSO – 3
CLO-1 :	*Acquire theoretical knowledge on conventional strategies in vaccine production*	*1*	*80*	*80*	*H*	*H*	*H*	*H*		*M*	*L*	*H*	*H*	*H*	*H*	*H*	*H*	*H*	*H*
CLO-2 :	*Exemplify the students with vaccine production techniques*	*2*	*85*	*75*	*H*	*H*	*H*	*H*	*M*		*M*	*H*	*H*	*H*	*H*	*H*	*H*	*H*	*H*
CLO-3 :	*Distinguish various types of vaccine*	*2*	*75*	*80*	*M*	*H*	*M*	*H*	*M*	*M*		*M*	*H*	*H*	*H*	*H*	*H*	*H*	*H*
CLO-4 :	*Devise various methods for vaccine delivery*	*2*	*85*	*80*	*H*	*H*	*H*	*H*	*M*		*H*	*L*	*H*	*H*	*H*	*H*	*H*	*H*	*H*
CLO-5 :	*Explain the guidelines for vaccine production and delivery*	*3*	*85*	*75*	*H*	*H*	*H*	*H*		*M*	*H*	*H*	*H*	*L*	*H*	*H*	*H*	*H*	*H*
CLO-6 :	*Illustrate the basic concepts of vaccination and prophylaxis*	*2*	*80*	*80*	*H*	*H*	*H*	*H*	*L*	*M*	*M*	*M*	*H*	*H*	*H*	*H*	*H*	*H*	*H*

Duration (hour)		9	9	9	9	9
S-1	SLO-1	*History of vaccine development*	*Technology related to monitoring seed lot for better production*	*Types of vaccines*	*Immunomodulators*	*Guidelines for vaccine management*
	SLO-2	*Types of Immunity*	*Temperature Monitoring*	*Vaccine efficacy*	*Innovative methods of delivering immunogens*	*Regulatory issues in vaccine development*
S-2	SLO-1	*Conventional strategies for vaccine improvement*	*Sterilization*	*Inactivated toxins*	*liposomes*	*Regulatory bodies for vaccine management*
	SLO-2	*Current development in vaccines*	*Environmental strategies for better production*	*Inactivated whole bacteria*	*Mechanism of liposome formation*	*Environmental effects of recombinant vaccines*
S-3	SLO-1	*Types of vaccines*	*quality assurance and related areas in vaccine production*	*Inactivated whole virus*	*Classification of liposomes*	*Disease security and biosecurity principles*
	SLO-2	*Live vaccine*	*Analysis of vaccine efficiency*	*Live attenuated bacteria*	*Methods of liposomes preparation*	*Assessing and Monitoring Safety of Vaccines*
S-4	SLO-1	*Attenuated vaccine*	*Vaccine Production techniques*	*Live attenuated viruses*	*Characterisation of liposomes*	*OIE – structure and mission*
	SLO-2	*subunit vaccine*	*growing the microorganisms in maximum titre*	*Subunit vaccines*	*Therapeutic applications of liposomes*	*OIE guidelines for vaccine seed lot management*
S-5	SLO-1	*Peptide vaccine*	*Steps involved in vaccine production*	*Polysaccharide vaccines*	*role of liposomes in delivering vaccines*	*OIE guidelines for the method of vaccine production*
	SLO-2	*killed vaccine*	*Selecting the strain for vaccine production*	*Conjugated vaccines*	*Advantages & disadvantages of liposomes*	*OIE Guidelines for Production facility*
S-6	SLO-1	*Types of adjuvants*	*Culturing bacteria*	*Recombinant DNA vaccines*	*Microspheres*	*Documentation of the manufacturing process*
	SLO-2	*Mode of action of adjuvants*	*Culturing virus*	*Differences between traditional and recombinant vaccine*	*Types of microspheres*	*Guidelines for manufacture of vaccine with an example*
S-7	SLO-1	*PRR ligands*	*Isolation and purification of microbes*	*Edible vaccines*	*Methods of preparing microspheres*	*In process control and batch control*
	SLO-2	*Methods to access vaccine efficacy*	*Inactivation of Microorganism*	*Plasma derived vaccines*	*Characterisation and applications of microspheres*	*organization and responsibilities*
S-8	SLO-1	*Quality control in vaccine production*	*Preservation techniques*	*Virus like particles*	*ISCOMS-Properties of ISCOM based vaccines*	*documentation and evaluation of data*

	SLO-2	Preservation of industrially important microbes	Preservation of industrially important microorganisms	HPV L1 VLP vaccine	Types of ISCOM	Test on final products
S-9	SLO-1	monitoring of microorganisms	Preservation using low temperature	Nanoparticles in vaccine delivery	components of ISCOM	General manufacturing recommendations
	SLO-2	Seed lot systems	freeze drying	Induction of immune responses by nanoparticle based vaccine	Induction of antibody responses by ISCOMs	Final product release tests

Learning Resources	1. *Ronald W. Ellis, "New Vaccine Technologies", Landes Bioscience, 2001.* 2. *Noel Mowat, "Vaccine manual: The production and quality control of veterinary vaccines for use in developing countries", Daya books, 1999.* 3. *Cheryl Barton, "Advances in Vaccine Technology and Delivery", Espicom Business Intelligence, 2009.*

Learning Assessment

	Bloom's Level of Thinking	Continuous Learning Assessment (50% weightage)								Final Examination (50% weightage)	
		CLA – 1 (10%)		CLA – 2 (15%)		CLA – 3 (15%)		CLA – 4 (10%)#			
		Theory	Practice	Theory	Practice	Theory	Practice	Theory	Practice	Theory	Practice
Level 1	Remember Understand	40 %	-	30%	-	30%	-	30%	-	30%	-
Level 2	Apply Analyze	40 %	-	40%	-	40%	-	40%	-	40%	-
Level 3	Evaluate Create	20 %	-	30%	-	30%	-	30%	-	30%	-
	Total	100 %		100 %		100 %		100 %		100 %	

CLA – 4 can be from any combination of these: Assignments, Seminars, Tech Talks, Mini-Projects, Case-Studies, Self-Study, MOOCs, Certifications, Conf. Paper etc.,

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Course Code	18BTE404T	Course Name	MOLECULAR BASIS OF DRUG ACTION	Course Category	E	Professional Elective	L	T	P	C
							3	0	0	3

Pre-requisite Courses	Nil	Co-requisite Courses	Nil	Progressive Courses	Nil
Course Offering Department	Biotechnology	Data Book / Codes/Standards			

Course Learning Rationale (CLR):	*The purpose of learning this course is to:*
CLR-1 :	*State the basic knowledge of drug targets and molecular cloning of these targets.*
CLR-2 :	*Discuss the recent advancement and development in human drug target : G-protein coupled receptors.*
CLR-3 :	*Discuss the recent advancement and development in human drug target : ion channels*
CLR-4:	*Discuss the recent advancement and development in human drug target : transporter proteins*
CLR-5:	*Explain how an individual's genetic makeup influences their response to therapeutic drugs.*
CLR-6:	*Discuss about the drug targets and their role in health and disease.*

Course Learning Outcomes (CLO):	*At the end of this course, learners will be able to:*	Learning 1 Level of Thinking (Bloom)	2 Expected Proficiency (%)	3 Expected Attainment (%)	1 Engineering Knowledge	2 Problem Analysis	3 Design & Development	4 Analysis, Design, Research	5 Modern Tool Usage	6 Society & Culture	7 Environment & Sustainability	8 Ethics	9 Individual & Team Work	10 Communication	11 Project Mgt. & Finance	12 Life Long Learning	13 PSO - 1	14 PSO - 2	15 PSO – 3
CLO-1 :	*Summaries about the drug targets and method to clone drug targets.*	1	85	80	L	H	H	H	H		M	M	H			H	H	H	H
CLO-2 :	*Explain about G protein coupled receptors.*	1	80	70	L	H	H	H	H		H		H			H	H	H	H
CLO-3 :	*Explain about various ion channels.*	1	80	75	L	H	H	H	H		H		H			H	H	H	H
CLO-4 :	*Explain about various transporters*	1	85	80	L	H	H	H	H		H		H			H	H	H	H
CLO-5 :	*Discuss how an individual's genetic makeup influences their response to therapeutic drugs.*	1	80	70	L	H	H	H	H		H	H	H			H	H	H	H
CLO-6 :	*Summaries about the drug targets and their role in health and disease.*	2	85	80	L	H	H	H	M		H	M	H			H	H	H	H

Duration (hour)		9	9	9	9	9
S-1	SLO-1	*Introduction to molecular pharmacology*	*Introduction to GPCRs and Heterotrimeric G-protein*	*introduction to ion channels*	*introduction Transporter proteins*	*Types of genetic variation*
	SLO-2	*Outline of molecular pharmacology based approaches used to interrogate drug targets.*	*molecular structure of GPCR*	*Classification of ion channels*	*classification of Transporter proteins*	*Thiopurine S-methyltransferase, and Cardiac K+channel polymorphisms*
S-2	SLO-1	*Molecular pharmacology vs traditional pharmacology*	*Classification of GPCR*	*introduction to Voltage-gated ion channels*	*Transporter families of pharmacological interest*	*Polymorphisms affecting drug metabolism*
	SLO-2	*Importance of molecular pharmacology.*	*Activation of GPCR*	*structure of Voltage-gated ion channels*	*The major facilitator superfamily (MFS)*	*Different Scenario how the polymorphisms affecting drug metabolism*
S-3	SLO-1	*Nature of the Drug targets*	*Signal transduction pathways - phospholipase C and adenylyl cyclase*	*Voltage-gated ion channels in health and disease*	*MFS in health*	*Methods for detecting genetic polymorphisms*
	SLO-2	*Future drug targets*	*Measurement of phospholipase C and adenylyl cyclase activation*	*Voltage-gated ion channels and neurotransmission*	*Role MFS in disease*	*PCR-RFLP analysis and Large-scale SNP analysis*
S-4	SLO-1	*Introduction to molecular cloning – from DNA to drug discovery*	*Desensitization and down-regulation of GPCR signalling*	*Voltage-gated ion channels and muscle contraction*	*The neurotransmitter: sodium symporter (NSS)*	*Genetic variation in drug transporters*
	SLO-2	*The relevance of recombinant DNA technology to pharmacology/drug discovery*	*Role of GPCR phosphorylation in desensitisation*	*Voltage-gated Ca2+ channels*	*Gltph transporters*	*Multi-drug resistance protein MDR1 (P-glycoprotein)*
S-5	SLO-1	*The 'cloning' of drug targets*	*Constitutive GPCR activity*	*Voltage-gated Na+ channels*	*Leucine Transporter(LeuTAa)*	*Multi-drug resistance associated protein (MRP) transporters*
	SLO-2	*Cloning using peptide sequence(s)*	*Promiscuous G-protein coupling*	*Voltage-gated K+ channels*	*NSS in health and disease*	*Organic anion-transporting polypeptide (OATP) transporters*
S-6	SLO-1	*Synthesis of cDNA, and construction of a cDNA library*	*Agonist-directed signalling*	*Other types of voltage-gated ion channels*	*Sodium antiporters*	*Genetic variation in G protein coupled receptors*
	SLO-2	*screening of a cDNA library*	*Allosteric modulators of GPCR function*	*CatSper channels*	*NhaA Na+:H+ antiporter (NhaA) family*	*Genetic variation within the adrenergic receptor family*

S-7	SLO-1	*Cloning using a specific antibody, a functional assay and Polymerase chain reaction.*	*Pharmacological chaperones for GPCRs*	*Ligand-gated ion channels*	*The cell penetrating peptides (CPP)*	*β1-adrenergic receptor single nucleotide polymorphisms*
	SLO-2	*What information can DNA cloning provide?*	*Some key examples of GPCR mutations and their associated disease*	*Pentameric ligand-gated ion channel family*	*CPP in health and disease*	*Are β1AR SNPs risk factors for heart failure?*
S-8	SLO-1	*Pharmacologic profile of the 'cloned' and the 'native' drug target*	*GPCR dimerisation*	*Nicotinic acetylcholine receptors*	*ATPase transporters*	*β2AR SNPs and asthma*
	SLO-2	*'cloned' and the 'native' drug target*	*Methods to study GPCR dimerisation*	*5-HT3 receptor channels and GABAA receptors*	*ATPase transporters in health and disease*	*β2AR SNPs and cardiovascular function*
S-9	SLO-1	*Reverse pharmacology*	*GPCR splice variants 1*	*P2X receptor structure, signalling and pharmacology*	*Role of transporters in drug pharmacokinetics*	*Functional consequences of the Trp64Arg SNP*
	SLO-2	*Reverse pharmacology illustrated on orphan GPCRs*	*Clinical and pathophysiological relevance of GPCR splice variants*	*Therapeutic potential of P2X receptors*	*Role of transporters in cellular homeostasis*	*β3AR Trp64Arg SNP: disease associations*

Learning Resources	1. *Chris Lloyd Mills, Fiona Freeman, Christian Thode, Shiva Sivasubramaniam, John Dickenson, "Molecular pharmacology : from DNA to drug discovery ",Wiley-Blackwell, 2012.* 2. *Michael Palmer, Alice Chan, Thorsten Dieckmann, John Honek, "Biochemical Pharmacology", Wiley, 2012.* 3. *Terry Kenakin, "Pharmacology in drug discovery: understanding drug response", Mica Haley, 2016.* 4. *Rang and Dale, "Pharmacology", Churchill Livingstone, 2007.*

Learning Assessment

	Bloom's Level of Thinking	Continuous Learning Assessment (50% weightage)								Final Examination (50% weightage)	
		CLA – 1 (10%)		CLA – 2 (15%)		CLA – 3 (15%)		CLA – 4 (10%)#			
		Theory	Practice	Theory	Practice	Theory	Practice	Theory	Practice	Theory	Practice
Level 1	Remember Understand	*40 %*	-	*30%*	-	*30%*	-	*30%*	-	*30%*	-
Level 2	Apply Analyze	*40 %*	-	*40%*	-	*40%*	-	*40%*	-	*40%*	-
Level 3	Evaluate Create	*20 %*	-	*30%*	-	*30%*	-	*30%*	-	*30%*	-
	Total	100 %		100 %		100 %		100 %		100 %	

CLA – 4 can be from any combination of these: Assignments, Seminars, Tech Talks, Mini-Projects, Case-Studies, Self-Study, MOOCs, Certifications, Conf. Paper etc.,

Course Designers

Experts from Industry	Experts from Higher Technical Institutions	Internal Experts
Dr. G. N. Ramchand, Saksin Life sciences Pvt Ltd, Chennai, ramchand@saksinlife.com	*Prof.. K Subramaniam, IITM, Chennai, suubu@iitm.ac.in*	*Mr. Jaganathan. M. K. SRMIST*
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Course Code	18BTE309T	Course Name	PLANT NUTRITION AND PHYSIOLOGY	Course Category	E	Professional Elective	L	T	P	C
							3	0	0	3

Pre-requisite Courses	Nil	Co-requisite Courses	Nil	Progressive Courses	Nil
Course Offering Department	Biotechnology	Data Book / Codes/Standards	Nil		

Course Learning Rationale (CLR):	*The purpose of learning this course is to:*
CLR-1 :	*Understand the food production can be limited by the availability of fresh water and nutrients*
CLR-2 :	*Analyze the role of proton pumps in plant nutrition*
CLR-3 :	*Illustrate the flow of each of the macronutrients from soil into the plant body*
CLR-4:	*Compare and evaluate the symptoms of macronutrient deficiencies*
CLR-5:	*Study the roles of plants and soil microbes on global nutrient cycles*
CLR-6:	*Interpret the plant responses to deficiency, limitation and a toxic level of a micronutrient*

Course Learning Outcomes (CLO):	*At the end of this course, learners will be able to:*	Learning 1	2	3	Program Learning Outcomes (PLO) 1	2	3	4	5	6	7	8	9	10	11	12	13	14	15
		Level of Thinking (Bloom)	Expected Proficiency (%)	Expected Attainment (%)	Engineering Knowledge	Problem Analysis	Design & Development	Analysis, Design, Research	Modern Tool Usage	Society & Culture	Environment & Sustainability	Ethics	Individual & Team Work	Communication	Project Mgt. & Finance	Life Long Learning	PSO - 1	PSO - 2	PSO – 3
CLO-1 :	*Describe the Plant-water relations, uptake and transport*	*1*	*80*	*80*	*M*	*H*	*H*	*H*	*M*	*H*	*H*	*H*	*H*	*H*	*H*	*H*	*H*	*H*	*H*
CLO-2 :	*Explain the contributions of two different transporters to plant salinity tolerance*	*2*	*85*	*75*	*M*	*M*	*H*	*H*	*-*	*H*	*H*	*H*	*H*	*H*	*H*	*H*	*H*	*H*	*H*
CLO-3 :	*Recognize the positive and negative impacts of the use of chemically synthesized fertilizers*	*2*	*75*	*80*	*M*	*-*	*M*	*H*	*M*	*H*	*H*	*-*	*H*	*H*	*H*	*H*	*H*	*H*	*H*
CLO-4 :	*Discuss the different ways to calculate Nutrient use efficiency*	*2*	*85*	*80*	*-*	*H*	*H*	*H*	*-*	*H*	*H*	*L*	*H*	*H*	*H*	*H*	*H*	*H*	*H*
CLO-5 :	*Explain the important of influx and efflux transporters*	*3*	*85*	*75*	*M*	*H*	*H*	*H*	*H*	*H*	*H*	*-*	*H*	*M*	*H*	*H*	*H*	*H*	*H*
CLO-6 :	*Gain knowledge about the biological functions of each of the micronutrients*	*2*	*80*	*80*	*M*	*M*	*H*	*H*	*-*	*H*	*H*	*M*	*H*	*M*	*H*	*H*	*H*	*H*	*H*

Duration (hour)		9	9	9	9	9
S-1	SLO-1	*Plant Nutrition*	*Nutrient uptake and transport*	*Overview*	*Potassium*	*Introduction*
	SLO-2	*Water & mineral nutrients*	*Overview*	*Plant nutrient requirements and fertilizers*	*The ashes in the pot, potash*	*Micronutrients and Metals*
S-2	SLO-1	*Mineral nutrients*	*Energizing the membrane*	*Macronutrients - N, P, K, S,Mg, and Ca*	*Potassium uptake and remobilization*	*Nutrients movement*
	SLO-2	*Macronutrients & micronutrients*	*Plasma membrane proton ATPases*	*The most abundant mineral element in a plant*	*Biphasic uptake response*	*The apo- and symplast & membrane transporters*
S-3	SLO-1	*Water uptake and transport*	*Vacuolar pumps*	*Nitrogen metabolism*	*Sulfur*	*Iron*
	SLO-2	*Physical laws*	*Vacuolar H+-ATPase and Vacuolar H+-PPase*	*Uptake, assimilation and remobilization*	*Global cycles and cells*	*Abundant, important, and largely insoluble*
S-4	SLO-1	*Membrane-bound water channels*	*Potassium Uptake*	*Nitrogen regulation*	*Sulfur uptake*	*Copper*
	SLO-2	*Aquaporins*	*Uptake & response*	*Nitrogen sensing, signaling and deficit responses*	*SULTR transporters*	*Critical for aerobic life*
S-5	SLO-1	*Movement of water*	*Potassium Transport*	*Strategies to mitigate the environmental consequences of N fertilizers*	*Sulfur – metabolic regulation*	*Zinc*
	SLO-2	*Water moves through Soil – Plant – Atmosphere Continuum (SPAC)*	*Co-transporters, channels, The guard cell model*	*Field-based practices and breeding*	*Addressing S-deficiency in plants*	*Deficiency common in plants and people*
S-6	SLO-1	*Water uptake in roots*	*Potassium Homeostasis*	*The most diverse set of functions*	*Magnesium*	*Manganese*
	SLO-2	*From soil to stele*	*K+ mobilization is critical for K+ homeostasis*	*Phosphorus*	*Magnesium in rocks and cells*	*Central to the water-splitting, oxygen-evolving reaction*
S-7	SLO-1	*SPAC*	*Sodium Toxicity, Transport, and Tolerance*	*Phosphate acquisition*	*Mg - Uptake and assimilation*	*Zinc: Deficiency common in plants and people, Nickel: Necessary but rarely limiting*
	SLO-2	*Flow of water through the xylem*	*The challenges of soil salinization*	*Mining & foraging*	*MRS/ MGT family*	*Manganese: Central to the water-splitting, oxygen-evolving reaction. Metal tolerance and metal hyper accumulation*

S-8	SLO-1	*SPAC*	*Sodium toxicity and tolerance*	*Phosphate uptake & transport*	*Calcium*	*Toxic metals and metalloids*
	SLO-2	*From leaf to air*	*Halophytes and salt-tolerant plants*	*PHT1 family*	*Low free cytosolic levels*	*Arsenic, Cadmium, Aluminum*
S-9	SLO-1	*Water deficit*	*Ion pumps, channels*	*Strategies*	*Calcium uptake and transport*	*Essential micronutrient*
	SLO-2	*Plant responses*	*Transporters contribute to Na+ tolerance*	*Improve crop plant phosphorus use efficiency*	*Calcium signaling*	*Boron, Silicon, Chlorine, Selenium*

Learning Resources	1. *Lincoln Taiz and Eduardo Zeiger, "Plant Physiology", Third edition. Panima Publishing Corporation, 2003.* 2. *Teaching Tools in Plant Biology: Lecture Notes. The Plant Cell (online) http://www.plantcell.org/content/teaching-tools-plant-biology*

Learning Assessment

	Bloom's Level of Thinking	Continuous Learning Assessment (50% weightage)								Final Examination (50% weightage)	
		CLA – 1 (10%)		CLA – 2 (15%)		CLA – 3 (15%)		CLA – 4 (10%)#			
		Theory	Practice	Theory	Practice	Theory	Practice	Theory	Practice	Theory	Practice
Level 1	Remember Understand	*40 %*	-	*30%*	-	*30%*	-	*30%*	-	*30%*	-
Level 2	Apply Analyze	*40 %*	-	*40%*	-	*40%*	-	*40%*	-	*40%*	-
Level 3	Evaluate Create	*20 %*	-	*30%*	-	*30%*	-	*30%*	-	*30%*	-
	Total	100 %		100 %		100 %		100 %		100 %	

CLA – 4 can be from any combination of these: Assignments, Seminars, Tech Talks, Mini-Projects, Case-Studies, Self-Study, MOOCs, Certifications, Conf. Paper etc.,

Course Designers		
Experts from Industry	Experts from Higher Technical Institutions	Internal Experts
Dr. Senthil, EID Parry, Chennai, parrynutraceuticals@parry.murugappa.com	*Prof .Usha Vijayraghavan. IISc, Bangalore, uvr@mcbl.iisc.ernet.in*	*Dr. R. Pachaiappan, SRMIST*
Dr. G. N. Ramchand, Saksin Life sciences Pvt Ltd, Chennai, ramchand@saksinlife.com	*Prof. Akhilesh. S. Raghubanshi, Banaras Hindu University, Varanasi, asr@bhu.ac.in*	*Dr. D.V.L. Sarada, SRMIST*

Course Code	18BTE310T	Course Name	PLANT HORMONES AND SIGNALING	Course Category	E	Professional Elective	L	T	P	C
							3	0	0	3

Pre-requisite Courses	Nil	Co-requisite Courses	Nil	Progressive Courses	Nil
Course Offering Department	Biotechnology	Data Book / Codes/Standards	Nil		

Course Learning Rationale (CLR):	*The purpose of learning this course is to:*
CLR-1 :	*Illustrate how plant hormones contribute to their growth, development, reproduction and stress responses*
CLR-2 :	*Understand the fundamental properties, tropic movement and mechanism of actions of auxin*
CLR-3 :	*Interpret the effects of Cytokinin, and its receptor perception & signaling*
CLR-4:	*Study the interaction between Gibberllins receptors and regulation of physiological functions*
CLR-5:	*Interpret the phenotypes of Arabidopsis seedlings mutated in ethylene perception, and reconstruct a genetic pathway from double mutant phenotypes*
CLR-6:	*Illustrate the interactions of the core signaling for controlling the functions of Abscisic acid in plants*

Course Learning Outcomes (CLO):	*At the end of this course, learners will be able to:*	Learning 1: Level of Thinking (Bloom)	Learning 2: Expected Proficiency (%)	Learning 3: Expected Attainment (%)	PLO 1: Engineering Knowledge	PLO 2: Problem Analysis	PLO 3: Design & Development	PLO 4: Analysis, Design, Research	PLO 5: Modern Tool Usage	PLO 6: Society & Culture	PLO 7: Environment & Sustainability	PLO 8: Ethics	PLO 9: Individual & Team Work	PLO 10: Communication	PLO 11: Project Mgt. & Finance	PLO 12: Life Long Learning	PLO 13: PSO - 1	PLO 14: PSO - 2	PLO 15: PSO – 3
CLO-1 :	*Gain knowledge on major plant hormones*	1	80	80	L	M	H	H	H	M	H	H	H	H	H	H	H	H	H
CLO-2 :	*Explain the history, synthesis, transport and functions of auxin in plant life*	2	85	75	M	M	H	H	H	H	M	H	H	M	H	H	H	H	H
CLO-3 :	*Describe the cytokinin biosynthetic pathway, two methods of analyzing and protein kinase cascade*	2	75	80	M	M	M	H	M	M	H	M	H	M	H	H	H	H	H
CLO-4 :	*Discuss the processes that control the accumulation of bioactive GAs, role of DELLAs and physiological responses*	2	85	80	M	M	H	H	H	M	M	M	H	M	H	H	H	H	H
CLO-5 :	*Gain knowledge the different physiological responses to ethylene*	3	85	75	L	H	M	H	M	M	H	M	H	L	H	H	H	H	H
CLO-6 :	*Explain the ways that ABA affects development of roots, fruits and seeds*	2	80	80	M	M	H	H	L	M	H	M	H	M	H	H	H	H	H

Duration (hour)		9	9	9	9	9
S-1	SLO-1	*What are phytohormones*	*Historical studies of auxin*	*Overview*	*History and overview*	*Abscisic acid*
	SLO-2	*Types*	*Classical studies*	*The discovery of cytokinins*	*Inhibitor of an inhibitor*	*Plant processes*
S-2	SLO-1	*Overview of hormone action*	*Auxin signaling pathway*	*Cytokinin homeostasis*	*GA synthesis and homeostasis*	*Biosynthesis and homeostasis*
	SLO-2	*Signaling*	*Biosynthesis and homeostasis*	*Structure of major CKs*	*GA deactivation & transport*	*Zeaxanthin epoxidase, NCED, VP14 & CYP707A*
S-3	SLO-1	*Hormones and vegetative developments*	*Tools in auxin research*	*The Agrobacterium tmr gene is a CK biosynthesis gene*	*GA perception and signaling*	*Transport*
	SLO-2	*Auxin & cytokinin*	*Experimental evidences*	*CYP735A*	*GID1 encodes a GA receptor*	*ABA movement*
S-4	SLO-1	*Vegetative development*	*Auxin transport*	*Formation of active CKs*	*GA-regulated growth repressors*	*Perception and signaling*
	SLO-2	*Strigolactones, Gibberellins & Brassinosteroids*	*Polar auxin transport*	*LONELY GUY, IPT over expression*	*DELLA proteins*	*PYR/ RCAR*
S-5	SLO-1	*Hormonal control of reproductive development*	*Chemiosmotic model*	*CK inactivation by conjugation or degradation*	*GA's roles in whole-plant physiology*	*ABI1 encodes a PP2C protein phosphatase*
	SLO-2	*Transition to flowering, development of flowers and fruits*	*Auxin moves through efflux and influx carrier proteins*	*Cytokinin oxidase*	*Response to salt stress, seed germination and Flowering*	*PP2C binds ABA + receptor & SnRK kinase similarly*
S-6	SLO-1	*Reproductive development*	*Types of carrier proteins*	*CK acts as a paracrine and a long-distance signal*	*Ethylene is a gaseous hormone*	*Calcium-dependent protein kinases*
	SLO-2	*Ethylene & Abscisic Acid*	*AUX1 / LAX, ABCB family & PIN family*	*PUP and ENT*	*Triple response*	*Transcription factors are major targets of SnRK2s and CDPKs*
S-7	SLO-1	*Hormonal responses to abiotic stress*	*Auxin perception - receptors*	*CK perception and signaling*	*Ethylene synthesis and homeostasis*	*ABA's roles in the control of guard cell turgor*
	SLO-2	*Abscisic Acid*	*ABP1, TIR1 and AFP protein family of F-box proteins*	*Two-component-like system*	*Burg and Thimann's studies, The Yang cycle*	*SnRK2s and PP2Cs contribute to guard cell responses*
S-8	SLO-1	*Hormonal responses to biotic stress*	*Auxin signaling*	*Downstream of the receptors*	*Ethylene response*	*ABA in whole-plant processes*

	SLO-2	*Jasmonates & Salicylates*	*Aux/IAA proteins, auxin-responsive transcription factors*	*Histidine phosphotransfer proteins (HPTs) and response regulators (RRs)*	*Receptors and downstream signaling*	*drought stress*
S-9	SLO-1	*Hormonal crosstalk*	*Auxin action*	*CK action in whole-plant processes*	*Ethylene's roles*	*surviving extreme desiccation*
	SLO-2	*Cross-talk in defense signaling*	*Whole-plant processes*	*Abiotic and biotic stress responses*	*Whole-plant processes*	*systemic stress responses*

Learning Resources	*1. Lincoln Taiz and Eduardo Zeiger, "Plant Physiology", Third edition. Panima Publishing corporation, 2003.* *2. Davies, P. J., "Plant Hormones -Biosynthesis, Signal Transduction, Action", Third Edition, Springer 2010.* *3. Teaching Tools in Plant Biology: Lecture Notes. The Plant Cell (online) http://www.plantcell.org/content/teaching-tools-plant-biology.*

Learning Assessment

	Bloom's Level of Thinking	Continuous Learning Assessment (50% weightage)								Final Examination (50% weightage)	
		CLA – 1 (10%)		CLA – 2 (15%)		CLA – 3 (15%)		CLA – 4 (10%)#			
		Theory	Practice	Theory	Practice	Theory	Practice	Theory	Practice	Theory	Practice
Level 1	Remember Understand	*40 %*	-	*30%*	-	*30%*	-	*30%*	-	*30%*	-
Level 2	Apply Analyze	*40 %*	-	*40%*	-	*40%*	-	*40%*	-	*40%*	-
Level 3	Evaluate Create	*20 %*	-	*30%*	-	*30%*	-	*30%*	-	*30%*	-
	Total	100 %		100 %		100 %		100 %		100 %	

CLA – 4 can be from any combination of these: Assignments, Seminars, Tech Talks, Mini-Projects, Case-Studies, Self-Study, MOOCs, Certifications, Conf. Paper etc.,

Course Designers

Experts from Industry	Experts from Higher Technical Institutions	Internal Experts
Dr. Senthil, EID Parry, Chennai, parrynutraceuticals@parry.murugappa.com	*Prof .Usha Vijayraghavan. IISc, Bangalore, uvr@mcbl.iisc.ernet.in*	*Dr. R. Pachaiappan, SRMIST*
Dr. Karthik Periyasamy, Scientist I, Aurozymes Unit, Aurobindo Pharma Limited, Hyderabad, karthikmpk@gmail.com	*Prof. Santa Ram Joshi., Department of Biotechnology & Bioinformatics North Eastern Hill University, Shillong-793022, Meghalaya, srjoshi2006@gmail.com*	*Dr. D.V.L. Sarada, SRMIST*

Course Code	18BTE311T	Course Name	PATHOGENESIS - RELATED PROTEINS IN PLANTS	Course Category	E	Professional Elective	L	T	P	C
							3	0	0	3

Pre-requisite Courses	Nil	Co-requisite Courses	Nil	Progressive Courses	Nil
Course Offering Department	Biotechnology	Data Book / Codes/Standards	Nil		

Course Learning Rationale (CLR):	*The purpose of learning this course is to:*
CLR-1 :	*Understand the six different types of pathogens by kingdom and by mode of pathogenicity*
CLR-2 :	*Analyze the role of plant defence proteins against pathogens*
CLR-3 :	*Understand the knowledge about the structural, catalytic mechanism and regulation of PR*
CLR-4:	*Compare and evaluate the plant – insect and other pathogen interactions*
CLR-5:	*Study the roles of PR-Proteins in physiological and developmental processes in plants*
CLR-6:	*Interpret the plant molecular responses to biotic factors*

Course Learning Outcomes (CLO):	*At the end of this course, learners will be able to:*	Learning 1: Level of Thinking (Bloom)	2: Expected Proficiency (%)	3: Expected Attainment (%)	PLO 1: Engineering Knowledge	2: Problem Analysis	3: Design & Development	4: Analysis, Design, Research	5: Modern Tool Usage	6: Society & Culture	7: Environment & Sustainability	8: Ethics	9: Individual & Team Work	10: Communication	11: Project Mgt. & Finance	12: Life Long Learning	13: PSO - 1	14: PSO - 2	15: PSO – 3
CLO-1 :	*Describe the three ways that plants defend themselves against pathogens*	1	80	80	M	H	H	H	-	H	H	M	H	H	H	H	H	H	H
CLO-2 :	*Explain the physiological functions of pathogenesis related proteins in plants*	2	85	75	M	-	H	H	-	M	H	H	H	H	H	H	H	H	H
CLO-3 :	*Comprehend the concept of cell wall degrading enzymes produced from plants as a defence*	2	75	80	H	M	-	H	H	H	H	M	H	H	H	H	H	H	H
CLO-4 :	*Discuss the different ways of resistance to pathogens at molecular level*	2	85	80	-	M	H	H	-	H	H	M	H	H	H	H	H	H	H
CLO-5 :	*Explain the importance of PR-Proteins in agriculture crop development*	3	85	75	H	H	H	H	H	H	H	-	H	M	H	H	H	H	H
CLO-6 :	*Gain knowledge about the signals, synthesis, binding to the receptor and role during plant – pathogen interactions*	2	80	80	H	M	H	H	-	H	H	M	H	M	H	H	H	H	H

Duration (hour)		9	9	9	9	9
S-1	SLO-1	*Pathogens make plants sick*	*Introduction*	*Plant chitinases*	*The PR-6 Family*	*PR gene expression*
	SLO-2	*Pathogens include viruses, bacteria, fungi, oomycetes and nematodes*	*PR- 1 Proteins*	*PR-3, 4, 8, 11*	*Proteinase Inhibitors in Plant-Microbe and Plant-Insect Interactions*	*Signals and Putative Receptors that Activate PR Gene Expression*
S-2	SLO-1	*Brief history*	*Characterization*	*Structure of the Proteins*	*Occurrence and Structure*	*Receptors*
	SLO-2	*Plant pathology*	*Acidic and basic proteins*	*PR-3, A Plant-Specific Chitinase Family (Family 19,), Family 18, The Ubiquitous*	*Plant Proteinase Inhibitors with Potential Defensive Capabilities*	*Leucine-rich repeat receptor kinases , LysM receptor proteins*
S-3	SLO-1	*The disease triangle concept*	*Occurrence*	*PR-8/Class III Chitinases, PR-11 Chitinases*	*Proteinases and Proteinase Inhibitors*	*Pathogens Activate PR Genes by Different Pathways*
	SLO-2	*Pathogen, Host, Environment*	*PR - proteins from other organisms & Functions*	*Other Related Proteins, The PR-4 Family*	*Plant–Microbe Interactions*	*Reactive oxygen species (ROS), salicylic acid (SA), ethylene, and jasmonates*
S-4	SLO-1	*Strategies of pathogenicity*	*Expression of PR-1*	*Catalytic Mechanisms and Specificities*	*Proteinases and Proteinase Inhibitors*	*Transcriptional Regulation of PR Gene Expression*
	SLO-2	*Pathogen lifestyles – biotropy, necrotrophy, and hemibiotrophy*	*Pathogens/wounds, salicylic acid, ethylene and other hormones, UV light and developmental stimuli*	*Family 18 & 19 Chitinases*	*Plant–Insect Interactions*	*W-box, GCC box, MRE-like sequence & G-box*
S-5	SLO-1	*Plant immune responses*	*PR-1 promoter analysis*	*Structure and Regulation of the Genes*	*Ribosome inactivating proteins (RIP)*	*GCC box-binding proteins*
	SLO-2	*Pathogen-triggered & Effector-triggered immunity*	*Acidic and basic proteins*	*Chib (PR-8) and Chic (PR-11) Genes*	*Structure*	*EREBP-1, EREBP-2, EREBP-3, and EREBP-4*
S-6	SLO-1	*Pathogen-recognition receptors*	*Introduction*	*Functions of Plant Chitinases*	*RIP*	*Genetic studies of PR gene expression*
	SLO-2	*PTI stimulates production of phytoalexins, reactive oxygen and callose*	*PR-2 – β-1,3-Glucanases*	*Antifungal and other physiological*	*Function, and Engineering*	*SA-inducible promoter-GUS,*
S-7	SLO-1	*Recognition and response to effectors through paired R proteins*	*Structural classes*	*PR-5 - Thaumatin-like proteins*	*Plant defensins*	*Transgenic plants*
	SLO-2	*ETI and biochemical response*	*PR-2 Nomenclature*	*Occurrence, Physico-Chemical properties*	*Introduction*	*Over expression of PR proteins*
S-8	SLO-1	*Induction*	*Biological functions of β-1,3-Glucanases*	*Biological properties*	*Protein Structure*	*PR Proteins*

	SLO-2	*Pathogenesis Related proteins (PR-Proteins)*	*Plant reproductive and defence*	*Taste, Antifungal Activity, TLPs as Anti-Freeze Proteins & TLPs as Inhibitors?*	*Disulfide-linked cysteine residues*	*Antifungal and insecticidal proteins*
S-9	SLO-1	*PRs, and PR like proteins*	*Regulation of β-1,3-Glucanases expression*	*Regulation of TLP Expression*	*Antimicrobial Activities*	*PR proteins in Rice*
	SLO-2	*Occurrence, properties and functions*	*Developmental and hormonal & pathogenic*	*Microbial Infection, Osmotic Stress, Abscisic Acid and Ethylene, Salicylate, Methyl Jasmonate, and Elicitors, Wounding.*	*Structure activity relationships, Mode of action*	*IR72 and IR64*

Learning Resources	1. *Agrios, G.N. (2005). Plant Pathology. (Burlington, MA: Elsevier Academic Press).* 2. *Schumann, G.L., andand D'Arcy, C.J. (2010). Essential Plant Pathology. (St. Paul, MN: The American Phytopathological Society).* 3. *Swapan K. Datta and Muthukrishnan, "Pathogenesis –Related Proteins in plants", CRC Press, 1999.*

Learning Assessment

	Bloom's Level of Thinking	Continuous Learning Assessment (50% weightage)								Final Examination (50% weightage)	
		CLA – 1 (10%)		CLA – 2 (15%)		CLA – 3 (15%)		CLA – 4 (10%)#			
		Theory	Practice	Theory	Practice	Theory	Practice	Theory	Practice	Theory	Practice
Level 1	Remember Understand	*40 %*	-	*30%*	-	*30%*	-	*30%*	-	*30%*	-
Level 2	Apply Analyze	*40 %*	-	*40%*	-	*40%*	-	*40%*	-	*40%*	-
Level 3	Evaluate Create	*20 %*	-	*30%*	-	*30%*	-	*30%*	-	*30%*	-
	Total	100 %		100 %		100 %		100 %		100 %	

CLA – 4 can be from any combination of these: Assignments, Seminars, Tech Talks, Mini-Projects, Case-Studies, Self-Study, MOOCs, Certifications, Conf. Paper etc.,

Course Designers		
Experts from Industry	Experts from Higher Technical Institutions	Internal Experts
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Course Code	18BTE312T	Course Name	FOOD SCIENCE AND NUTRITION	Course Category	E	Professional Elective	L	T	P	C
							3	0	0	3

Pre-requisite Courses	Nil	Co-requisite Courses	Nil	Progressive Courses	Nil
Course Offering Department	Biotechnology	Data Book / Codes/Standards	Nil		

Course Learning Rationale (CLR):	The purpose of learning this course is to:
CLR-1 :	*Identify the need for greater and more efficient utilization of the existing food sources*
CLR-2 :	*Demonstrate nutritional quality and nutritional requirement*
CLR-3 :	*Solve calculate energy requirements of the body*
CLR-4:	*Describe about new trends in nutrition*
CLR-5:	*Design balanced meal preparation*
CLR-6:	*Identify antinutritional factors in food*

Course Learning Outcomes (CLO):	At the end of this course, learners will be able to:	Learning 1: Level of Thinking (Bloom)	Learning 2: Expected Proficiency (%)	Learning 3: Expected Attainment (%)	1 Engineering Knowledge	2 Problem Analysis	3 Design & Development	4 Analysis, Design, Research	5 Modern Tool Usage	6 Society & Culture	7 Environment & Sustainability	8 Ethics	9 Individual & Team Work	10 Communication	11 Project Mgt. & Finance	12 Life Long Learning	13 PSO - 1	14 PSO - 2	15 PSO – 3
CLO-1 :	*Define basic concepts of Food and Nutrition*	2	80	70		H	H			H		H	H				H	H	H
CLO-2 :	*Formulate food with daily dietary allowances*	2	80	70		H	H				H						H	H	H
CLO-3 :	*Identify the scope and prospects of food science in food industries*	2	80	70	M	H	H	M	H		M		H		H		H	H	H
CLO-4 :	*Design diet according to energy requirements of the body*	2	80	70	H		H		H		M		H		H		H	H	H
CLO-5 :	*Design diet for different age group and for people under diseased condition*	3	80	70	H	H	H	H	H		M		H		H		H	H	H
CLO-6 :	*Evaluate food constituents and its importance*	2	80	70	H	H	H	H	H		H	H	H		H	H	H	H	H

Program Learning Outcomes (PLO): columns 1–15 above.

Duration (hour)		9	9	9	9	9
S-1	SLO-1	*Food as a source of energy*	*Functions of protein, fat and carbohydrates and their dietary requirements*	*Carbohydrates- dietary requirements and functions, deficiency in diet*	*Function and daily intake of water*	*New trends in nutrition-nutitional value of fast food and junk food*
	SLO-2	*Macro and micro nutrients*	*Sources of Carbohydrates*	*Nutritional significance of carbohydrates ,*	*Daily loss of body water and deficiency of water*	*Probiotics and prebiotics*
S-2	SLO-1	*Carbohydrate, Fat and Protein*	*Classification of Carbohydrates*	*Digestion, metabolism and absorption of carbohydrates*	*Sources of vitamins*	*Antioxidants*
	SLO-2	*Food requirement in human body*	*Polysaccharides –Starch and dietary fibers*	*Nutritional significance of proteins*	*Fat soluble vitamins –A,D,E, and K*	*Nutraceuticals*
S-3	SLO-1	*Planning balanced diets to meet the requirements of different age groups*	*Chemical composition of cereals*	*Animal sources of protein*	*Water soluble Vitamins-B-complex vitamins, Anemia –preventing vitamins and Vitamin-C*	*Fortification*
	SLO-2	*Solving Problems-*	*Nutritional value of cereals*	*Digestion, metabolism and absorption of protein*	*Effect of cooking on vitamins*	*Significance of nutritional labeling*
S-4	SLO-1	*Energy requirements of the body*	*Protein- dietary requirements, functions, and deficiency in diet*	*Nutritional significance of lipids*	*stability of vitamin during food processing*	*Trans fatty acids*
	SLO-2	*Calculations of energy value based on proximate principles*	*Sources of Protein*	*Classification of lipids*	*toxicity due to vitamins*	*Role of photochemical*
S-5	SLO-1	*BMR, Test for basal metabolism and Factors affecting BMR*	*Chemical composition of pulses (grams and dhal)*	*Plant Sources of fat/oil*	*bioavailability of vitamins*	*Naturally occurring food toxicants in foods*
	SLO-2	*Estimation of energy requirements*	*Nutritional value of pulses*	*Marine and animal sources of fat/oil*	*reasons for losses of vitamins in foods*	*protease inhibitors*
S-6	SLO-1	*Instrumental methods to calculate caloric value of food*	*Antinutritional factors in pulses*	*Digestion, metabolism and absorption of fat*	*Role of these constituents in food industry*	*hemagglutinins*
	SLO-2	*RDS's for specific nutrients*	*Chemical composition of oil seeds*	*The food pyramid*	*Mineral in food*	*goitrogens*
S-7	SLO-1	*Dietary allowances fixed by FAO*	*effect of processing on the nutritional value of food grains (cereals and pulses)*	*Therapeutic diets – A brief account.*	*Classification of minerals*	*lathyrogens*

	SLO-2	*Dietary allowances fixed by WHO*	*Chemical composition of cereals*	*Planning of balanced meal*	*Sources of minerals in food*	*toxic amino acids*
S-8	SLO-1	*Recommended dietary allowances for Indians fixed by ICMR*	*Nutritional value of cereals*	*Dietary requirement for different Age group*	*stability status of minerals in food*	*naturally occurring carcinogens in food*
	SLO-2	*comparison of Indian dietary allowances with that of FAO/WHO standards*	*Chemical composition of pulses (grams and dhal)*	*Dietary requirement for women at different stages of life*	*Nutritional value of fruits*	*Carcinogens produced during food processing and storage*
S-9	SLO-1	*Modifying energy content of meals*	*Nutritional value of pulses*	*Meal frequency pattern and variety in balanced diet*	*Nutritional value of vegetables*	*Acrylamide formation in food*
	SLO-2	*Under weight/,overweight/obesity*	*Antinutritional factors in pulses*	*Calculating nutritional value of a recipe*	*Nutritional value of biverages*	*furan formation in food*

Learning Resources	1. *Sunetra Roday. "Food science and nutrition". 2016, Oxford university Press..* 2. *Swaminathan, M. (5th Edition). "Hand Book of food and Nutrition", 2015. The Bangalore Printing and Publishing co. Ltd. Bangalore*	3. *Ahuja, K.J, Nath Prem and K.R.M Swamy Food and Nutrition, 2010. Studium Press Pvt. Ltd., New Delhi.,* 4. *Shakuntala Manay and Shadasharasamy "Foods; Facts and principles", 1997. New Age international Publishers, New Delhi. ,*

Learning Assessment

	Bloom's Level of Thinking	Continuous Learning Assessment (50% weightage)								Final Examination (50% weightage)	
		CLA – 1 (10%)		CLA – 2 (15%)		CLA – 3 (15%)		CLA – 4 (10%)#			
		Theory	Practice	Theory	Practice	Theory	Practice	Theory	Practice	Theory	Practice
Level 1	Remember Understand	*40 %*	-	*30%*	-	*30%*	-	*30%*	-	*30%*	-
Level 2	Apply Analyze	*40 %*	-	*40%*	-	*40%*	-	*40%*	-	*40%*	-
Level 3	Evaluate Create	*20 %*	-	*30%*	-	*30%*	-	*30%*	-	*30%*	-
	Total	100 %		100 %		100 %		100 %		100 %	

CLA – 4 can be from any combination of these: Assignments, Seminars, Tech Talks, Mini-Projects, Case-Studies, Self-Study, MOOCs, Certifications, Conf. Paper etc.,

Course Designers

Experts from Industry	Experts from Higher Technical Institutions	Internal Experts
1. Dr. S. Sam Gunasekar, Orchid Chemicals and Pharmaceuticals Ltd., sam@orchidpharma.com	*1. Dr. A. Gnanamani, CSIR-Central Leather Research Institute, agmani_2000@yahoomail.com*	*Dr. K.A.Athmaselvi, SRMIST*
2. Dr. D. Gunaseelan, BIOCON Ltd., guna.sachin@gmail.com	*2. Dr. Anbumani Sadasivam, CSIR-Indian Institute of Toxicology Research,anbumani@iitr.res.in*	*Dr. R.Preetha, SRMIST*

Course Code	18BTE405T	Course Name	THERAPEUTIC COMPOUNDS FROM PLANTS	Course Category	E	Professional Elective	L	T	P	C
							3	0	0	3

Pre-requisite Courses	Nil	Co-requisite Courses	Nil	Progressive Courses	Nil
Course Offering Department	Biotechnology	Data Book / Codes/Standards	Nil		

Course Learning Rationale (CLR):	*The purpose of learning this course is to:*
CLR-1 :	*Gain knowledge on historical uses of plants and plant parts as medicines and traditional knowledge*
CLR-2 :	*Understand the techniques involved in Bioprospecting*
CLR-3 :	*Understand the major secondary metabolic pathways that produce pharmaceutically important compounds*
CLR-4:	*understand the structures and roles of the major classes of photochemicals with medicinal properties*
CLR-5:	*Gain insight into engineering for enhanced production of pharmaceutically important metabolites in planta*
CLR-6:	*know the mechanism of action of major known pharmaceutically important compounds in therapeutics*

Course Learning Outcomes (CLO):	*At the end of this course, learners will be able to:*	Learning 1: Level of Thinking (Bloom)	Learning 2: Expected Proficiency (%)	Learning 3: Expected Attainment (%)	PLO 1: Engineering Knowledge	2: Problem Analysis	3: Design & Development	4: Analysis, Design, Research	5: Modern Tool Usage	6: Society & Culture	7: Environment & Sustainability	8: Ethics	9: Individual & Team Work	10: Communication	11: Project Mgt. & Finance	12: Life Long Learning	13: PSO - 1	14: PSO - 2	15: PSO – 3
CLO-1 :	*Identify plants and plant parts used as medicine traditionally*	1	80	80	L		M	H		H	H	H	H	H	H	H	H	H	H
CLO-2 :	*Apply techniques to screen plants for drugs and medicines*	2	85	75	H	H	H	H	H	H	H	H	H	H	H	H	H	H	H
CLO-3 :	*Analyze the secondary metabolic pathways that produce several medicinally important compounds*	2	75	80	H	H	M	H	H	M		M	H	H	H	H	H	H	H
CLO-4 :	*Deduce structure activity relationship*	3	85	80	H	H	H	H	H		L	L	H	H	H	H	H	H	H
CLO-5 :	*Predict the metabolic branch points that can be targeted for engineering*	3	85	75	H	H	H	H	H	H	H	L	H	L	H	H	H	H	H
CLO-6 :	*Explain the mechanism of action of major known pharmaceutically important compounds in therapeutics*	2	80	80	H	H	H	H	H	M	M	M	H	H	H	H	H	H	H

Duration (hour)		9	9	9	9	9
S-1	SLO-1	*Plants vs Medicinal Plants*	*Overview of extraction and purification of Phytoconstituents*	*Primary vs Secondary Metabolism*	*In vitro Synthesis – Advantages and dis advantages*	*Therapeutic Applications of Phytoconstituents*
	SLO-2	*Taxonomy and validation of Herbal Medicine*	*Extraction Techniques*	*Examples of Major Secondary Metabolic Pathways*	*Omics, Systems and Semi synthetic methods*	*Potential drugs available in the market*
S-2	SLO-1	*Traditional Indian Medicine*	*Different Types*	*The Mevalonate Pathway*	*Metabolic Engineering - Strategies*	*Mechanisms of Action*
	SLO-2	*Traditional Chinese Medicine*	*Advantages and Limitations of Extraction Techniques*	*Examples*	*Alteration, Silencing and augmentation of functions*	*Analgesic action of alkaloids (Morphine)*
S-3	SLO-1	*Traditional Knowledge*	*Analytical Techniques - Spectrometry*	*The Shikmate Pathway*	*Pioneering studies microbial synthesis of plant metabolites*	*Antihyperglycemic action of alkaloids (Piperene)*
	SLO-2	*Ethanobotany*	*Purification*	*Examples*	*Reconstitution of metabolic pathways in microbes*	*Anti cancer activity of alkaloids (Berberine)*
S-4	SLO-1	*Quality Assurance of Herbal Medicines*	*Analytical Techniques – Chromatography*	*The Phenyl Propanoid and the Polyketide Pathway*	*Host Selection and Pathway reconstitution*	*Anticancer activity of Vinca alkaloids*
	SLO-2	*Over the Counter Herbal Medicines*	*Bioassay Guided Fractionation*	*Examples*	*Optimization*	*Antibacterial action of alkaloids (ciproflaxicin)*
S-5	SLO-1	*Plant Extracts vs Purified Compounds*	*Identification*	*Biosynthesis of Alkaloids*	*Metabolic Engineering for alkaloid production in Yeast*	*Neurostimulatory effects of alkaloids*
	SLO-2	*Quest for Active Compounds*	*Analytical Techniques –Mass Spectrometry*	*Tissue Cultures for production of metabolites*	*Metabolic Engineering for terpenoid production in Yeast*	*Neuroprotective effects of alkaloids*
S-6	SLO-1	*Modern Approaches*	*Standardization*	*Examples*	*Metabolic Engineering for carotenoid production in Yeast*	*Antiinflammatory mechanism of action of flavanoids*
	SLO-2	*Screening plants for Drugs*	*Clinical Validation*	*Organ Cultures for production of metabolites*	*Metabolic Engineering for caffeine production in Yeast*	*Antimalarial action of Terpenoids (Quinine)*
S-7	SLO-1	*Plant Families associated with Drug Production*	*Example from TIM to clinical trials*	*Examples*	*Other Examples*	*Antimalarial action of Terpenoids (Artemesin)*

	SLO-2	*Drug discovery by relatedness*	*Example from TCM to clinical trials*	*Hairy Root Cultures as a means for enhanced metabolite production*	*Metabolic Engineering in Plants and Plant Cell Cultures*	*Terpenoids against Trypaonosomes*
S-8	SLO-1	*Phytoconstituents*	*Central Drugs Control Standard Organization*	*Manipulation of hairy roots for metabolite production*	*Metabolic Engineering of Terpenoids in Plants*	*Terpenoids against Leishmanias*
	SLO-2	*Alkaloids*	*Drugs Technical Advisory Board (DTAB) and Drugs Consultative Committee (DCC)*	*Production of Gingsenolides*	*Metabolic Engineering of Alkaloids in Plants*	*Ephedra- Use and Misuse*
S-9	SLO-1	*Flavanoids*	*Regulatory Approval*	*In vitro production – Role of Endophytes*	*Metabolic Engineering of Flavanoids in Plants*	*Ginseng – The Panacea*
	SLO-2	*Terpenoids*	*Pharmacovigilence*	*Production of Taxol*	*High throughput methods to identify genes intermediates and pathways*	*Traditional vs Western Medicine*

Learning Resources	1. *Trease and Evans Pharmacognosy, William Evans, Sixteenth Edition Elsivier 2009* 2. *Phytochemical Methods – A guide to Modern Techniques in Plant Analysis, Harborne Springer 1998* 3. *Text Book of Pharmacognasy and Phytochemistry, First Edition, Biren Shah, Elsevier 2009* 4. *Fundementals of Pharmacognosy and Phytotherapy Second Edition Michael Heinrich, Joanne Barnes, Simon Gibbons and Elizabeth M. Williamson, Elsivier 2012*

Learning Assessment

	Bloom's Level of Thinking	Continuous Learning Assessment (50% weightage)								Final Examination (50% weightage)	
		CLA – 1 (10%)		CLA – 2 (15%)		CLA – 3 (15%)		CLA – 4 (10%)#			
		Theory	Practice	Theory	Practice	Theory	Practice	Theory	Practice	Theory	Practice
Level 1	Remember Understand	*40 %*	-	*30%*	-	*30%*	-	*30%*	-	*30%*	-
Level 2	Apply Analyze	*40 %*	-	*40%*	-	*40%*	-	*40%*	-	*40%*	-
Level 3	Evaluate Create	*20 %*	-	*30%*	-	*30%*	-	*30%*	-	*30%*	-
	Total	100 %		100 %		100 %		100 %		100 %	

CLA – 4 can be from any combination of these: Assignments, Seminars, Tech Talks, Mini-Projects, Case-Studies, Self-Study, MOOCs, Certifications, Conf. Paper etc.,

Course Designers

Experts from Industry	Experts from Higher Technical Institutions	Internal Experts
Dr. G. N. Ramchand, Saksin Life sciences Pvt Ltd, Chennai, ramchand@saksinlife.com	*Prof.. K Subramaniam, IITM, Chennai, suubu@iitm.ac.in*	*Dr. R. Pachaiappan, SRMIST*
Dr. Karthik Periyasamy, Scientist I, Aurozymes Unit, Aurobindo Pharma Limited, Hyderabad, karthikmpk@gmail.com	*Prof. R. B. Narayanan, SVCE, Chennai, rbn@svce.ac.in*	*Dr. Sarada, DVL,SRMIST*

Course Code	18BTE406T	Course Name	FOOD SAFETY AND QUALITY MANAGEMENT	Course Category	E	Professional Elective	L	T	P	C
							3	0	0	3

Pre-requisite Courses	Nil	Co-requisite Courses	Nil	Progressive Courses	Nil
Course Offering Department	Biotechnology	Data Book / Codes/Standards	Nil		

Course Learning Rationale (CLR):	*The purpose of learning this course is to:*
CLR-1 :	*Describe safety limits of food additives and risk assessment*
CLR-2 :	*Memorize to prepare HACCP based SOP*
CLR-3 :	*Prepare HACCP program to any food industry*
CLR-4:	*Apply quality auditing in the food industries*
CLR-5:	*Describe ISO 9000, ISO 14000, ISO 22000*
CLR-6:	*Employ ISO 22000 in food industry*

Course Learning Outcomes (CLO):	*At the end of this course, learners will be able to:*	Learning 1: Level of Thinking (Bloom)	Learning 2: Expected Proficiency (%)	Learning 3: Expected Attainment (%)	PLO 1: Engineering Knowledge	2: Problem Analysis	3: Design & Development	4: Analysis, Design, Research	5: Modern Tool Usage	6: Society & Culture	7: Environment & Sustainability	8: Ethics	9: Individual & Team Work	10: Communication	11: Project Mgt. & Finance	12: Life Long Learning	13: PSO - 1	14: PSO - 2	15: PSO – 3
CLO-1 :	*Describe about the food safety terms*	2	80	70		H				H		H	H				H	H	H
CLO-2 :	*Identify the issues of food safety and quality*	2	80	70		H	H				H						H	H	H
CLO-3 :	*Explain the process of food safety analysis*	2	80	70	M	H	H	M	H		H		H		H		H	H	H
CLO-4 :	*Describe basic concepts of Food Safety and Quality Management*	2	80	70	H		H		H		M		H		H		H	H	H
CLO-5 :	*Set up and operate HACCP, SOP and ISO 22000 for food industries*	3	80	70	H	H	H	H	H		M		H		H		H	H	H
CLO-6 :	*Practice quality auditing methods in the food industries*	2	80	70	H	H	H	H	H		M		H		H	H	H	H	H

Duration (hour)		9	9	9	9	9
S-1	SLO-1	*Definition of Quality, Dimensions of Quality*	*Safety limits of Food additives*	*Sampling*	*Quality of Foods*	*Seven old and new Quality management tools*
	SLO-2	*Quality Planning, Quality costs*	*Risk assessment and risk benefit Indices of human exposure*	*concept, methods and importance of sampling*	*Quality Standards - mandatory and optional standards*	*Statistical process control*
S-2	SLO-1	*Basic concepts of Food Safety and Quality Management*	*acute toxicity*	*Statistical Process and Quality Control*	*Food Safety Systems*	*Mean & range chart, P chart and C chart*
	SLO-2	*Historical Review, Principles of FSQM*	*mutagenicity and carcinogenicity*	*concept, importance and tools*	*ISO 9000, ISO 14000, ISO 22000*	*Seven deadly wastages*
S-3	SLO-1	*Leadership Concepts*	*reproductive and developmental toxicity*	*Control charts*	*Mechanism of developing and fixing food standards*	*PDCA cycle*
	SLO-2	*Quality Council, Quality Statements*	*teratogenicity, neurotoxicity and behavioral effect, immunotoxicity*	*importance, types, design process control limits*	*Good Manufacturing Practice*	*Quality circle, Quality audit, Internal audit*
S 4-5	SLO-1	*Strategic Planning*	*Determination of the limit for addition*	*Errors in process control*	*HACCP Standards of Weights*	*Continuous improvement of productivity proficiency testing for product quality*
	SLO-2	*Barriers to Food Safety Implementation*	*NOEL – Method of determining toxicity*			
S-6	SLO-1	*Barriers to Food Safety Implementation*	*LD50, FSSAI regulations and GRAS additives.*	*Process Capability.*	*HACCP Standards of Measures*	*Six Sigma Concept*
	SLO-2	*Definition of Quality, Dimensions of Quality*	*Safety limits of Food additives*	*Sampling*	*Quality of Foods*	*Seven old and new Quality management tools*
S-7	SLO-1	*Quality Planning, Quality costs*	*Risk assessment and risk benefit Indices of human exposure*	*concept, methods and importance of sampling*	*Quality Standards - mandatory and optional standards*	*Statistical process control*
	SLO-2	*Basic concepts of Food Safety and Quality Management*	*acute toxicity*	*Statistical Process and Quality Control*	*Food Safety Systems*	*Mean & range chart, P chart and C chart*
S-8	SLO-1	*Historical Review, Principles of FSQM*	*mutagenicity and carcinogenicity*	*concept, importance and tools for quality control*	*ISO 9000, ISO 14000, ISO 22000*	*Seven deadly wastages*
	SLO-2	*Leadership Concepts*	*reproductive and developmental toxicity*	*quality control charts*	*Mechanism of developing and fixing food standards*	*PDCA cycle*

S-9	SLO-1	*Quality Council, Quality Statements*	*teratogenicity, neurotoxicity and behavioral effect, immunotoxicity*	*importance, types, design process*	*Good Manufacturing Practice*	*Quality circle, Quality audit, Internal audit*
	SLO-2					

Learning Resources	1. *Andres Vasconcellos J. 2 nd edition. Quality Assurance for the Food industry - A practical approach. 2005, CRC press.* 2. *Inteaz Alli. 1st edition, Food quality assurance - Principles & practices. 2004, CRC Press. New York.*	3. *Sara Mortimore and Carol Wallace. 3rd edition HACCP - A practical approach.2013, Chapman and Hall, London.* 4. *Roday, S. 2 nd edition Food Hygiene and Sanitation, 201,Tata McGraw-Hill Education.*

Learning Assessment											
	Bloom's Level of Thinking	Continuous Learning Assessment (50% weightage)								Final Examination (50% weightage)	
		CLA – 1 (10%)		CLA – 2 (15%)		CLA – 3 (15%)		CLA – 4 (10%)#			
		Theory	Practice	Theory	Practice	Theory	Practice	Theory	Practice	Theory	Practice
Level 1	Remember Understand	*40 %*	-	*30%*	-	*30%*	-	*30%*	-	*30%*	-
Level 2	Apply Analyze	*40 %*	-	*40%*	-	*40%*	-	*40%*	-	*40%*	-
Level 3	Evaluate Create	*20 %*	-	*30%*	-	*30%*	-	*30%*	-	*30%*	-
	Total	100 %		100 %		100 %		100 %		100 %	

CLA – 4 can be from any combination of these: Assignments, Seminars, Tech Talks, Mini-Projects, Case-Studies, Self-Study, MOOCs, Certifications, Conf. Paper etc.,

Course Designers		
Experts from Industry	Experts from Higher Technical Institutions	Internal Experts
Dr. S. Sam Gunasekar, Orchid Chemicals and Pharmaceuticals Ltd., sam@orchidpharma.com	*Dr. A. Gnanamani, CSIR-Central Leather Research Institute, agmani_2000@yahoomail.com*	*Dr. K.A.Athmaselvi, SRMIST*
Dr. D. Gunaseelan, BIOCON Ltd., guna.sachin@gmail.com	*Dr. Anbumani Sadasivam, CSIR-Indian Institute of Toxicology Research,anbumani@iitr.res.in*	*Dr. R.Preetha, SRMIST*

Course Code	18BTE313T	Course Name	ENZYME ENGINEERING AND TECHNOLOGY	Course Category	E	Professional Elective	L	T	P	C
							3	0	0	3

Pre-requisite Courses	Nil	Co-requisite Courses	Nil	Progressive Courses	Nil
Course Offering Department	Biotechnology	Data Book / Codes/Standards	Nil		

Course Learning Rationale (CLR):	*The purpose of learning this course is to:*
CLR-1 :	*Discuss the basics of enzyme mechanism, classification, and factors affecting enzyme activity*
CLR-2 :	*Analyze the kinetics of enzyme action, inhibition, and their regulation*
CLR-3 :	*Examine the sequential procedure of the enzyme purification process*
CLR-4:	*Apply the various methods of enzyme immobilization and evaluating their kinetic efficiency*
CLR-5:	*Discuss the applications of enzymes in various industries*
CLR-6:	*Demonstrates the importance of enzymes in engineering research and industries*

Course Learning Outcomes (CLO):	*At the end of this course, learners will be able to:*	Learning 1 Level of Thinking (Bloom)	2 Expected Proficiency (%)	3 Expected Attainment (%)	Program Learning Outcomes (PLO) 1 Engineering Knowledge	2 Problem Analysis	3 Design & Development	4 Analysis, Design, Research	5 Modern Tool Usage	6 Society & Culture	7 Environment & Sustainability	8 Ethics	9 Individual & Team Work	10 Communication	11 Project Mgt. & Finance	12 Life Long Learning	13 PSO - 1	14 PSO - 2	15 PSO – 3
CLO-1 :	*Recognize the basic nature of enzyme, classification and their mechanism of working*	*1*	*80*	*80*	*H*	*M*	*L*	*H*	*M*		*H*		*H*		*H*		*H*	*H*	*H*
CLO-2 :	*Describe the various kinetic mechanisms and regulation of enzyme actions*	*2*	*85*	*75*	*H*	*H*	*H*	*H*	*H*		*H*		*H*				*H*	*H*	*H*
CLO-3 :	*Formulate the succession of enzyme purification and their characterization*	*2*	*75*	*80*	*M*	*L*	*H*	*H*	*H*		*H*		*H*		*H*		*H*	*H*	*H*
CLO-4 :	*Illustrate the methods of enzyme immobilization and evaluating the effectiveness of immobilization*	*2*	*85*	*80*	*H*	*H*	*H*	*H*	*H*		*H*		*H*		*M*		*H*	*H*	*H*
CLO-5 :	*Assess the extent of enzyme applications in various industries*	*3*	*85*	*75*	*H*	*L*	*H*	*H*	*M*		*H*		*H*		*H*	*H*	*H*	*H*	*H*
CLO-6 :	*Interpret the mechanisms of enzyme action and evaluating their importance in various applications*	*2*	*80*	*80*	*H*	*H*	*H*	*H*	*H*		*H*		*H*		*H*	*H*	*H*	*H*	*H*

Duration (hour)		9	9	9	9	9
S-1	SLO-1	*Chemical nature of enzymes*	*Basics of enzyme kinetics*	*Production of enzymes on a commercial scale*	*Enzyme immobilization*	*Applications of enzymes - Food processing*
	SLO-2	*Characteristics of enzymes*	*Michaelis Menten Kinetic equation*	*Nature of the extraction medium*	*Advantages and disadvantages*	*Starch and sucrose industries*
S-2	SLO-1	*Enzymes and their actions*	*Significance of Michaelis-Menten Kinetics*	*Extraction of soluble enzymes*	*Physical methods of enzyme immobilization*	*Dairy industries*
	SLO-2	*Mechanism of enzyme action*	*Solving problems in enzyme kinetics*	*Extraction of membrane-bound enzymes*	*Chemical methods of enzyme immobilization*	*Brewing industries*
S-3	SLO-1	*Structural components of enzymes*	*Evaluation of Michaelis-Menten kinetic parameters*	*Technologies for enzyme production*	*Carrier-based immobilization*	*Beverage industries*
	SLO-2	*The active site of an enzyme*	*Line weaver Burk plot, Hanes Woolf plot and Eadie Hofstee plot*	*Recovery and purification methods for enzymes*	*Carrier free immobilization*	*Leather industries*
S-4	SLO-1	*Cofactors and coenzymes*	*Turn over number, Catalytic efficiency*	*Cell disruption*	*Immobilization by using porous support*	*Textile industries*
	SLO-2	*Role of cofactors and coenzymes*	*Enzyme Inhibitors*	*Solid-liquid separation*	*Mass transfer effects and diffusion limitations*	*Detergent industries*
S-5	SLO-1	*Classification of enzymes*	*Types of enzyme inhibition*	*Concentration*	*Immobilization by using non-porous support*	*Pulp and paper industries*
	SLO-2	*Enzyme commission classification of enzymes*	*Competitive inhibition*	*Precipitation*	*Mass transfer effects and diffusion limitations*	*Polymer industries*
S-6	SLO-1	*Oxidoreductase,Transferase, Hydrolase*	*Uncompetitive inhibition*	*Liquid- liquid extraction*	*Stabilization of immobilized enzymes in aqueous environment*	*Analytical applications of enzymes*
	SLO-2	*Lyase, Isomerase, Ligase*	*Noncompetitive inhibition*	*Ion exchange chromatography*	*Stabilization of immobilized enzymes in non-aqueous environment*	*Diagnostic applications of enzymes*
S-7	SLO-1	*Enzyme-substrate complex formation models*	*Substrate inhibition*	*Gel filtration, Affinity chromatography*	*Electrostatic and steric effects in immobilized enzyme systems*	*Role of enzymes - Pharmaceuticals*

	SLO-2	*Lock and Key and Induced fit models*	*Feedback inhibition*	*Criteria of purity – Electrophoresis*	*Analyzing the effectiveness factor of immobilized enzymes*	*Medicine*
S-8	SLO-1	*Mechanisms of enzyme catalysis*	*Enzyme deactivation model*	*Isoelectric focusing, Capillary electrophoresis*	*Applications of immobilized enzyme systems*	*Medical research*
	SLO-2	*Proximity and orientation effects, Conformational distortion*	*Allosteric activation and inhibition*	*Monitoring of purification of enzymes*	*Limitations of immobilized enzyme systems*	*Agriculture*
S-9	SLO-1	*Factors affecting enzyme activity*	*Solving problems in enzyme inhibition*	*Determination of molecular weight of enzymes- MALDI-TOF*	*Solving problems in enzyme immobilization and their kinetics*	*Environment protection*
	SLO-2	*Effect of substrate, enzyme and inhibitor concentration on enzyme activity*	*Solving problems in enzyme inhibition*	*Drying and packing*	*Solving problems in enzyme immobilization and their kinetics*	*Biofuels development*

Learning Resources	*1. Trevor Palmer and Philip L Bonner. "Enzymes: Biochemistry, Biotechnology, Clinical Chemistry," East-West Press, 2004.* *2. Syed Tanveer Ahmed Inamdar. "Biochemical Engineering: Principles and Concepts "Third Edition, PHI Learning Pvt. Ltd., 2012* *3. Kargi. F., Shuler. M.L., "Bioprocess Engineering: Basic Concepts," 3rd Edition. Prentice Hall, 2017.*

Learning Assessment

	Bloom's Level of Thinking	Continuous Learning Assessment (50% weightage)								Final Examination (50% weightage)	
		CLA – 1 (10%)		CLA – 2 (15%)		CLA – 3 (15%)		CLA – 4 (10%)#			
		Theory	Practice	Theory	Practice	Theory	Practice	Theory	Practice	Theory	Practice
Level 1	Remember Understand	*40 %*	-	*30%*	-	*30%*	-	*30%*	-	*30%*	-
Level 2	Apply Analyze	*40 %*	-	*40%*	-	*40%*	-	*40%*	-	*40%*	-
Level 3	Evaluate Create	*20 %*	-	*30%*	-	*30%*	-	*30%*	-	*30%*	-
	Total	100 %		100 %		100 %		100 %		100 %	

CLA – 4 can be from any combination of these: Assignments, Seminars, Tech Talks, Mini-Projects, Case-Studies, Self-Study, MOOCs, Certifications, Conf. Paper etc.,

Course Designers

Experts from Industry	Experts from Higher Technical Institutions	Internal Experts
Dr. G. N. Ramchand, Saksin Life sciences Pvt Ltd, Chennai, ramchand@saksinlife.com	*Prof. K Subramaniam, IITM, Chennai, subbu@iitm.ac.in*	*Dr. V.Vinothkumar, SRMIST, vinothkumar.v@ktr.srmuniv.ac.in*
Dr. Karthik Periyasamy, Scientist I, Aurozymes Unit, Aurobindo Pharma Limited, Hyderabad, karthikmpk@gmail.com	*Prof. R. B. Narayanan, SVCE, Chennai, rbn@svce.ac.in*	*Ms. P.Radha, SRMIST, radha.p@ktr.srmuniv.ac.in*

Course Code	18BTE314T	Course Name	MEMBRANE TECHNOLOGY	Course Category	E	Professional Elective	L	T	P	C
							3	0	0	3

Pre-requisite Courses	Nil	Co-requisite Courses	Nil	Progressive Courses	Nil
Course Offering Department	Biotechnology	Data Book / Codes/Standards	Nil		

Course Learning Rationale (CLR):	*The purpose of learning this course is to:*
CLR-1 :	*Acquire knowledge on membrane and its types cum application*
CLR-2 :	*Understand the casting and characterization of membrane*
CLR-3 :	*Analyse the functions of reverse osmosis, Micro and ultra-filtration membranes*
CLR-4:	*Discuss the functions of dialysis and electro dialysis membrane*
CLR-5:	*Discuss the membranes as reactor and distillation of alcohol*
CLR-6:	*Get acquaint on membranes for industrial application*

Course Learning Outcomes (CLO):	*At the end of this course, learners will be able to:*	Learning 1: Level of Thinking (Bloom)	2: Expected Proficiency (%)	3: Expected Attainment (%)	PLO 1: Engineering Knowledge	2: Problem Analysis	3: Design & Development	4: Analysis, Design, Research	5: Modern Tool Usage	6: Society & Culture	7: Environment & Sustainability	8: Ethics	9: Individual & Team Work	10: Communication	11: Project Mgt. & Finance	12: Life Long Learning	13: PSO - 1	14: PSO - 2	15: PSO – 3
CLO-1 :	*Apply membranes for bioprocess industries*	2	80	90	M	M	H	M	M						H	H	H	H	H
CLO-2 :	*Demonstrate methods of casting membrane*	2	85	90	M	M	H	M	M						H	H	H	H	H
CLO-3 :	*Utilize the selection of membranes for micro and Macro molecules separation*	2	75	80	M	M	H	M	L						H	H	H	H	H
CLO-4 :	*Apply membrane for dialysis*	2	90	85	M	M	H	M	M						H	H	H	H	H
CLO-5 :	*Demonstrate membrane for distillation and production*	2	80	80	M	M	H	M	M						H	H	H	H	H
CLO-6 :	*Explain membrane in upstream and downstream process economically*	2	80	80	M	M	H	M	H						H	H	H	H	H

Duration (hour)		9	9	9	9	9
S-1	SLO-1	*Overview of membrane separation process*	*Membrane Types, Materials, Preparation and Characterization*	*Reverse Osmosis, Nano filtration, Ultra filtration, and Microfiltration*	*Dialysis, pervaporation and electro dialysis*	*Membrane distillation, Membrane bioreactors and industrial membranes*
	SLO-2	*Equilibrium and rate controlled separation*	*Types of Synthetic Membranes- Micro porous Membranes*	*Concept of osmosis*	*Principles of Dialysis*	*Membrane contactors, Principles*
S-2	SLO-1	*What is membrane?*	*Asymmetric, thin film*	*Determination of osmotic pressure and thermodynamics of osmosis*	*Dialysis membranes*	*Advantages and Disadvantages*
	SLO-2	*Basic principles of Membrane Separation*	*Electrically Charged Inorganic Membrane*	*Phenomena of Reverse osmosis*	*Mass transfer in dialysis*	*Applications*
S-3	SLO-1	*Historical development of Membranes*	*Membrane Modules-Plate and frame, Tubular.*	*Models of Reverse osmosis*	*Design of Dialysis membranes*	*Membrane Distillation*
	SLO-2	*Golden age of Membranes*	*Spiral wound and Hollow fiber*	*Design and operating parameters*	*Applications and its advantages.*	*Mechanism*
S-4	SLO-1	*Classification of Membrane Processes*	*Typical Flow pattern*	*Design of Reverse Osmosis module*	*Principles*	*Membrane recycle bioreactors*
	SLO-2	*Pressure driven, Concentration gradient and Electrical Potential*	*Membrane Material*	*Principles , Transport Mechanism*	*Operation of Pervaporation*	*Plug flow bioreactors*
S-5	SLO-1	*Advantages of Membrane Processes*	*Pore Characterization*	*Mass transfer and Industrial Application of Nano filtration*	*Application of Pervaporation*	*Perstraction*
	SLO-2	*Disadvantages of Membrane Processes*	*General Methods of Membrane Manufacture*	*Process Limitation*	*Design of pervaporation modules*	*Flux and separation in Perstraction*
S-6	SLO-1	*Biotechnology Industry*	*Phase Inversion Method,*	*Basic principles of Ultra filtration Types of Ultra filtration*	*Factors affecting pervaporation*	*Membrane Chromatography*
	SLO-2	*Micro and Macromolecule Separation*	*Track–etching*	*Factors affecting Ultra filtration and membrane flux of ultra filtration*	*Applications*	*Design and application*
S-7	SLO-1	*Chemical and Pharmaceutical Industry*	*Sol-gel Peptisation Method*	*Principles of Microfiltration*	*Principles of Electro dialysis Ion Exchange Membranes*	*Membranes in Wastewater Treatment*
	SLO-2	*Recovery of salt, acid and Bases*	*Interfacial Polymerization*	*Microfiltration Membranes*	*Energy requirements*	*Design and Application*
S-8	SLO-1	*Food and Dairy Industry*	*Melt pressing*	*Mechanism of Transport*	*Current utilization and Efficiency*	*Membrane in Desalination*

	SLO-2	*Dairy, animal Products , Fruits and Vegetables etc.*	*Film Stretching*	*Flow characterization*	*Application*	*Membrane in in Fuel cells*
S-9	SLO-1	*Electrochemical Industry*	*Template Leaching*	*Fouling and applications in Microfiltration*	*Batch electro- dialysis*	*Biomedical application of membranes*
	SLO-2	*Effluent Treatment Plant*	*Ion Exchange Membrane Preparation*	*Energy Consideration and Application*	*Continuous electro- dialysis*	*Blood Oxygenator and Drug Delivery*

Learning Resources	1. *Kaushik Nath," Membrane Separation Processes", PHI, Publication, India, 2012.* 2. *William.K..Wang," Membrane Separations in Biotechnology", Marcel Dekker. INC, New York,2001* 3. *Scott .K, "Hand Book of Industrial Membranes "Elsevier Publication, 1995.*

Learning Assessment

	Bloom's Level of Thinking	Continuous Learning Assessment (50% weightage)								Final Examination (50% weightage)	
		CLA – 1 (10%)		CLA – 2 (15%)		CLA – 3 (15%)		CLA – 4 (10%)#			
		Theory	Practice	Theory	Practice	Theory	Practice	Theory	Practice	Theory	Practice
Level 1	Remember Understand	*40 %*	-	*30%*	-	*30%*	-	*30%*	-	*30%*	-
Level 2	Apply Analyze	*40 %*	-	*40%*	-	*40%*	-	*40%*	-	*40%*	-
Level 3	Evaluate Create	*20 %*	-	*30%*	-	*30%*	-	*30%*	-	*30%*	-
	Total	100 %		100 %		100 %		100 %		100 %	

CLA – 4 can be from any combination of these: Assignments, Seminars, Tech Talks, Mini-Projects, Case-Studies, Self-Study, MOOCs, Certifications, Conf. Paper etc.,

Course Designers

Experts from Industry	Experts from Higher Technical Institutions	Internal Experts
Dr. P. BalaKumaran, Proklean Technologies (P) Limited, Chennai, genbalu86@gmail.com	*Prof. K Subramaniam, IITM, Chennai, subbu@iitm.ac.in*	*1 .Dr.M.Venkatesh Prabhu SRM IST*
Dr. Karthik Periyasamy, Aurobindo Pharma Limited, Hyderabad, karthikmpk@gmail.com	*Prof. R. B. Narayanan, SVCE, Chennai, rbn@svce.ac.in*	*2 .Dr. Y.Ravichandran SRM IST*

Course Code	18BTE315T	Course Name	INDUSTRIAL FERMENTATION TECHNOLOGY	Course Category	E	Professional Elective		L	T	P	C
								3	0	0	3

Pre-requisite Courses	Nil	Co-requisite Courses	Nil	Progressive Courses	Nil
Course Offering Department	Biotechnology	Data Book / Codes/Standards	Nil		

Course Learning Rationale (CLR):	The purpose of learning this course is to:
CLR-1 :	*Analyze the fundamental behind the need of aseptic strain development.*
CLR-2 :	*Explore the importance of Isolation and Screening of Industrially Important Microorganisms*
CLR-3 :	*Decipher an understanding on the production of various primary metabolites from microbial fermentation*
CLR-4:	*Comprehend the importance and production of secondary metabolites with commercial significance*
CLR-5:	*Apprehend the biochemical transformation in the production of recombinant protein with medical importance*
CLR-6:	*Instigate knowledge on food fermentation, food flavourants, preservants and SCP*

Course Learning Outcomes (CLO):	At the end of this course, learners will be able to:	Learning 1: Level of Thinking (Bloom)	2: Expected Proficiency (%)	3: Expected Attainment (%)
CLO-1 :	*Accomplish knowledge on improvement of strain development for primary and secondary metabolites*	2	80	70
CLO-2 :	*Explain the upstream and Downstream fermentation process of organic acids and aminoacids*	2	85	75
CLO-3 :	*Describe the industrial scale methodologies for Antibiotic and microbial enzyme production*	3	75	80
CLO-4 :	*Understand enzyme biotransformation biostratergies and recombinant protein production with commercial and medical importance*	3	85	80
CLO-5 :	*Apprehend the food fermentation process and its preservants used for improving the shelf period*	3	85	80
CLO-6 :	*Decipher the availability and application of various food colourants, flavourants and SCP*	2	80	75

Program Learning Outcomes (PLO)

	1 Engineering Knowledge	2 Problem Analysis	3 Design & Development	4 Analysis, Design, Research	5 Modern Tool Usage	6 Society & Culture	7 Environment & Sustainability	8 Ethics	9 Individual & Team Work	10 Communication	11 Project Mgt. & Finance	12 Life Long Learning	13 PSO - 1	14 PSO - 2	15 PSO – 3
CLO-1	H	H	H	H			H		H		H	H	H	H	H
CLO-2	H	H	H	H			H		H		H	H	H	H	H
CLO-3	H	H	H	M	H		H		H		H	H	H	H	H
CLO-4	H	H	H	H	H		M		H		H	H	H	H	H
CLO-5	H	H	H	H	H		M		H		H	H	H	H	H
CLO-6	H	H	H	H	H		M		H		H	H	H	H	H

Duration (hour)		9	9	9	9	
S-1	SLO-1	*Introduction to industrial fermentations*	*Production of primary metabolites*	*Production of secondary metabolites*	*Recombinant protein production*	*Food fermentations*
	SLO-2	*Chronological Development of the Fermentation Industry*	*Organic acids fermentation*	*Antibiotic production*	*Insulin - Upstream process*	*Cheese and Yogurt fermentation*
S-2	SLO-1	*Isolation and Screening of Industrially Important Microorganisms*	*Citric acid – Upstream process*	*Carbohydrate containing antibiotic: Streptomycin - Upstream process*	*Insulin - Downstream process*	*Sauerkraut and Soy sauce fermentation*
	SLO-2	*Types of fermentation process*	*Citric acid – Downstream process*	*Streptomycin - Downstream process*	*Interferon - Upstream process*	*Food flavoring agents' fermentations*
S-3	SLO-1	*Microbial growth metabolism*	*Lactic acid – Upstream process*	*Macro cyclic lactones: Erythromycin - Upstream process*	*Interferon - Downstream process*	*Mono sodium glutamate fermentation*
	SLO-2	*Microbial metabolites*	*Lactic acid – Downstream process*	*Erythromycin - Downstream process*	*Production of nucleosides and nucleotides*	*γ-decalactone fermentation*
S-4	SLO-1	*Strain development*	*Acetic acid – Upstream process*	*Peptide antibiotic: Bacitracin - Upstream process*	*5' Inosine monophosphate*	*Food preservative fermentation*
	SLO-2	*Improvement of Strains Producing Primary metabolites*	*Acetic acid – Downstream process*	*Peptide antibiotic: Bacitracin - Downstream process*	*5' Guanosine monophosphate*	*Nisin fermentation*
S-5	SLO-1	*Improvement of Strains Producing Secondary metabolites*	*Amino acids fermentation*	*Industrial Enzyme production*	*Enzyme biotransformations*	*Food colorants fermentation*
	SLO-2	*Preservation of Industrially Important Cell Cultures and Microorganisms*	*L-glutamic acid - Upstream process*	*Protease - Upstream process*	*Steroid transformations*	*Monascus pigments fermentation*
S-6	SLO-1	*Inoculum Development*	*L-glutamic acid – Downstream process*	*Protease - Downstream process*	*Antibiotic transformations*	*Carotenoid production*
	SLO-2	*Aseptic Inoculation of Plant Fermenters*	*L-lysine – Upstream process*	*Lipase - Upstream process*	*Biopolymers fermentation*	*Astaxanthin Production*
S-7	SLO-1	*Measuring Process Variables*	*L-lysine – Downstream process*	*Lipase - Downstream process*	*Xanthan gum*	*Production of single cell protein*
	SLO-2	*Product development:*	*L-tryptophan - Upstream process*	*Vitamins production*	*Polyhydroxyalkanoates*	*Bel – symba – pekilo – pruteen processes*
S-8	SLO-1	*Regulation and safety*	*L-tryptophan - Downstream process*	*Cyanaocobalamin - Upstream process*	*Polyhydroxybutyrate*	*Beverages*
	SLO-2	*Use of Process flowcharts*	*Solvents fermentation*	*Cyanaocobalamin - Downstream process*	*Agrochemicals production*	*Brewing process*

S-9	SLO-1	*Use of Process block diagrams*	*Acetone - Butanol – Ethanol - Upstream process*	*Riboflavin - Upstream process*	*Bacillus thuringenesis*	*Wine production*
	SLO-2	*Examples*	*Acetone - Butanol – Ethanol - Downstream process*	*Riboflavin - Downstream process*	*Artemisinin*	*Cider production*

Learning Resources	1. *Cruger W., Cruger A., Aneja K.R., "Biotechnology: A Textbook of Industrial Microbiology", Medtech Publishing, 3rd edition, 2017.* 2. *Lee Y.K., "Microbial Biotechnology: Principles and Applications", World Scientific Publishing, 3rd edition, 2013.* 4. *Waites M. J., Morgan N.L., Rockey J.S., Higton G., "Industrial Microbiology: An Introduction", Blackwell Science, 2013.*	5. *Saran S., Babu V., Chuabey A., "High Value Fermentation Products: Human Health", Scrivener Publishing, 2019* 6. *Stanbury. P.F., Whitaker. A., Hall. S.J., "Principles of Fermentation Technology", 3rd Edition, Butterworth– Heinemann, 2016.*

Learning Assessment

	Bloom's Level of Thinking	Continuous Learning Assessment (50% weightage)								Final Examination (50% weightage)	
		CLA – 1 (10%)		CLA – 2 (15%)		CLA – 3 (15%)		CLA – 4 (10%)#			
		Theory	Practice	Theory	Practice	Theory	Practice	Theory	Practice	Theory	Practice
Level 1	Remember Understand	*40 %*	-	*30%*	-	*30%*	-	*30%*	-	*30%*	-
Level 2	Apply Analyze	*40 %*	-	*40%*	-	*40%*	-	*40%*	-	*40%*	-
Level 3	Evaluate Create	*20 %*	-	*30%*	-	*30%*	-	*30%*	-	*30%*	-
	Total	100 %		100 %		100 %		100 %		100 %	

CLA – 4 can be from any combination of these: Assignments, Seminars, Tech Talks, Mini-Projects, Case-Studies, Self-Study, MOOCs, Certifications, Conf. Paper etc.,

Course Designers		
Experts from Industry	Experts from Higher Technical Institutions	Internal Experts
Dr. P. BalaKumaran, Proklean Technologies (P) Limited, Chennai, genbalu86@gmail.com	*Prof. K Subramaniam, IITM, Chennai, subbu@iitm.ac.in*	*Dr. V. Vinoth Kumar, SRMIST*
Dr. Karthik Periyasamy, Aurobindo Pharma Limited, Hyderabad, karthikmpk@gmail.com	*Prof. R. B. Narayanan, SVCE, Chennai, rbn@svce.ac.in*	*Dr. M. Venkatesh Prabhu, SRMIST*

Course Code	18BTE316T	Course Name	BIOREACTOR DESIGN	Course Category	E	Professional Elective	L	T	P	C
							3	0	0	3

Pre-requisite Courses	18BTC107J	Co-requisite Courses	Nil	Progressive Courses	Nil
Course Offering Department	Biotechnology	Data Book / Codes/Standards	Nil		

Course Learning Rationale (CLR):	*The purpose of learning this course is to:*
CLR-1 :	*Understand the basic design and development of Bioreactors and its operation*
CLR-2 :	*Design the air driven reactors*
CLR-3 :	*Acquire knowledge on different types of Solid state bioreactors and its operation*
CLR-4:	*Learn about the sequential batch reactor and biofilm reactors*
CLR-5:	*Know about the modeling, simulation, Control and CFD analysis of bioraector*
CLR-6:	*Familiarized with concept of design and application of reactors*

Course Learning Outcomes (CLO):	*At the end of this course, learners will be able to:*	Learning 1: Level of Thinking (Bloom)	Learning 2: Expected Proficiency (%)	Learning 3: Expected Attainment (%)	PLO 1: Engineering Knowledge	PLO 2: Problem Analysis	PLO 3: Design & Development	PLO 4: Analysis, Design, Research	PLO 5: Modern Tool Usage	PLO 6: Society & Culture	PLO 7: Environment & Sustainability	PLO 8: Ethics	PLO 9: Individual & Team Work	PLO 10: Communication	PLO 11: Project Mgt. & Finance	PLO 12: Life Long Learning	PLO 13: PSO - 1	PLO 14: PSO - 2	PLO 15: PSO – 3
CLO-1 :	*Know the basic design of reactor*	*1*	*85*	*80*	*H*	*H*	*H*	*H*	*M*				*H*	*M*	*H*	*H*	*H*	*H*	*H*
CLO-2 :	*Acquire knowledge on air driven reactor*	*2*	*90*	*80*	*H*	*H*	*H*	*H*	*M*				*H*	*M*	*H*	*H*	*H*	*H*	*H*
CLO-3 :	*Know about reactors for solid state fermentation*	*2*	*80*	*80*	*H*	*H*	*H*	*M*	*L*				*H*	*M*	*H*	*H*	*H*	*H*	*H*
CLO-4 :	*Have knowledge on biofilm reactor*	*2*	*80*	*80*	*H*	*H*	*H*	*H*	*M*				*H*	*M*	*H*	*H*	*H*	*H*	*H*
CLO-5 :	*Know about modeling, simulation and control system used in reactor*	*2*	*85*	*80*	*H*	*H*	*H*	*H*	*M*				*H*	*M*	*H*	*H*	*H*	*H*	*H*
CLO-6 :	*Acquire the basic knowledge on design of SMF and SSF and its control*	*2*	*80*	*80*	*H*	*H*	*H*	*H*	*H*				*H*	*M*	*H*	*H*	*H*	*H*	*H*

Duration (hour)		9	9	9	9	9
S-1	SLO-1	*Understanding of Bioreactor Design*	*Air Driven Reactors*	*Solid State Fermentation Bioreactors*	*Sequential Batch ,Biofilm and Trickle flow reactors*	*Bioreactor Modeling, simulation , control and CFD analysis*
	SLO-2	*Basics and importance of bioreactors*	*General features of bubble column and airlift reactor*	*Solid-State Bioreactor Fundamentals: Selection and design of SSF reactors*	*Sequential Batch reactors*	*Modeling and Simulation*
S-2	SLO-1	*Guidelines for bioreactor design*	*Factors influencing mass transfer in bubble column*	*Heat transfer in SSF reactors*	*Bioreactors containing microbial films*	*Types of Modelling*
	SLO-2	*General requirement for Mechanical construction of Bioreactor*	*Flow patterns , liquid mixing and gas dispersion in bubble column, Mass and Heat transfer in bubble column*	*Mass transfer in SSF reactors*	*Completely mixed microbial reactor*	*Types of simulation*
S-3	SLO-1	*Design of thin walled , internal pressure, stirred tank reactor*	*Airlift bioreactors*	*Laboratory and pilot scale of solid state bioreactor*	*Microbial film Bioreactor*	*Steps involved in Modeling*
	SLO-2	*Solving Problems*	*Design and construction of the airlift loop reactor*	*Industrial scale of solid state bioreactor*	*Design and Construction*	*Steps*
S-4	SLO-1	*Development of bioreactors*	*Modeling in Air Lift Reactor*	*Classification of SSF Bioreactor*	*Trickle flow reactor*	*Methods and strategies for bioreactor control*
	SLO-2	*Instrumentations to control a bioreactor*	*Mass and Energy Balance*	*Mode of Operation*	*Design and Construction*	*Control loop*
S-5	SLO-1	*Sensors*	*Hydrodynamics in ALR*	*Un aerated and Unmixed Bioreactor*	*Theory of Trickle flow reactor*	*Analogue and digital control*
	SLO-2	*Probes in bioreactor*	*Three phase flow in ALR*	*Design and Construction*	*Physical model*	*Control algorithm*
S-6	SLO-1	*Common operations of bioreactor*	*Mixing*	*Forcefully – Aerated bioreactors without mixing*	*Mathematical model of Trickle flow reactor*	*Physical control of Bioreactor*
	SLO-2	*Types of Reactor*	*Oxygen transfer in ALR*	*Design and Construction*	*Solving Problems*	*Methods*
S-7	SLO-1	*Performance of Batch Reactor*	*Design of fluidized bed bioreactor*	*Rotating –Drum and Stirred –Drum bioreactors*	*Performance analysis of Trickle flow reactor*	*Computers in control of Bioreactor*
	SLO-2	*Solving Problems*	*Operation of fluidized bed bioreactor*	*Continuously mixed bioreactors*	*High substrate concentration and low substrate concentration*	*Solving Problems*

S-8	SLO-1	*Performance of Continuous reactor*	*Design and operation of inverse fluidized bed bioreactor*	*Mixed ,Forcefully – Aerated Bioreactors*	*Calculation of parameter estimation*	*Control Strategy for Bioreactor*
	SLO-2	*Performance of Continuous reactor with recycle*	*Models in Fluidized bed bioreactor*	*Design and Construction*	*Problems*	*Solving Problems*
S-9	SLO-1	*Fed Batch Reactor*	*Hydrodynamics of fluidized bed rector*	*Intermittently Mixed bioreactors*	*Design method*	*CFD analysis in Bioreactor design.*
	SLO-2	*Solving Problems*	*Solving Problems*	*Design and Construction*	*Calculation procedure and Evaluation of parameter estimation*	*Solving Problems*

Learning Resources	1. *Scragg. H., "Bioreactors in Biotechnology", Ellis Horwood series, 1991.* 2. *B.Atkinson.,"Biochemical Reactors",Pion limited,London,1974* 3. *Panda. T., "Bioreactors: Analysis and Design", McGraw Hill Education (India) Private Limited, 2011* 4. *Riet. K. V., Tramper. J., "Basic Bioreactor Design", 2nd ed., Marcel Dekker, Inc., New York, 1991.*

Learning Assessment

	Bloom's Level of Thinking	Continuous Learning Assessment (50% weightage)								Final Examination (50% weightage)	
		CLA – 1 (10%)		CLA – 2 (15%)		CLA – 3 (15%)		CLA – 4 (10%)#			
		Theory	Practice	Theory	Practice	Theory	Practice	Theory	Practice	Theory	Practice
Level 1	Remember Understand	*40 %*	-	*30%*	-	*30%*	-	*30%*	-	*30%*	-
Level 2	Apply Analyze	*40 %*	-	*40%*	-	*40%*	-	*40%*	-	*40%*	-
Level 3	Evaluate Create	*20 %*	-	*30%*	-	*30%*	-	*30%*	-	*30%*	-
	Total	100 %		100 %		100 %		100 %		100 %	

CLA – 4 can be from any combination of these: Assignments, Seminars, Tech Talks, Mini-Projects, Case-Studies, Self-Study, MOOCs, Certifications, Conf. Paper etc.,

Course Designers

Experts from Industry	Experts from Higher Technical Institutions	Internal Experts
Dr. P. BalaKumaran, Proklean Technologies (P) Limited, Chennai, genbalu86@gmail.com	*Prof. K Subramaniam, IITM, Chennai, subbu@iitm.ac.in*	*Dr.M.Venkatesh Prabhu, SRM IST*
Dr. Karthik Periyasamy, Aurobindo Pharma Limited, Hyderabad, karthikmpk@gmail.com	*Prof. R. B. Narayanan, SVCE, Chennai, rbn@svce.ac.in*	*Dr. Y.Ravichandran SRM IST*

Course Code	18BTE407T	Course Name	BIOPROCESS MODELLING AND SIMULATION	Course Category	E	Professional Elective	L	T	P	C
							3	0	0	3

Pre-requisite Courses	Nil	Co-requisite Courses	Nil	Progressive Courses	Nil
Course Offering Department	Biotechnology	Data Book / Codes/Standards	Nil		

Course Learning Rationale (CLR):	*The purpose of learning this course is to:*
CLR-1 :	*Illustrate the knowledge on various mathematical models of biological systems.*
CLR-2 :	*Explore the modelling of bioprocess with a view to engineering application.*
CLR-3 :	*Demonstrate the advanced software knowledge for the automation of bioprocess systems.*
CLR-4:	*Demonstrate the Use of Superpro software to design a bioprocess system for the production of bioproducts.*
CLR-5:	*Analyze the solutions of various mathematical problems using MATLAB.*
CLR-6:	*Familiarize the students with the various bioprocess models and softwares.*

Course Learning Outcomes (CLO):	*At the end of this course, learners will be able to:*	Learning 1: Level of Thinking (Bloom)	Learning 2: Expected Proficiency (%)	Learning 3: Expected Attainment (%)	PLO 1: Engineering Knowledge	PLO 2: Problem Analysis	PLO 3: Design & Development	PLO 4: Analysis, Design, Research	PLO 5: Modern Tool Usage	PLO 6: Society & Culture	PLO 7: Environment & Sustainability	PLO 8: Ethics	PLO 9: Individual & Team Work	PLO 10: Communication	PLO 11: Project Mgt. & Finance	PLO 12: Life Long Learning	PLO 13: PSO - 1	PLO 14: PSO - 2	PLO 15: PSO – 3
CLO-1 :	*Describe the fundamental laws and concepts about the mathematical modeling*	2	80	70	H	H	H	H			H		H		H	H	H	H	H
CLO-2 :	*Explain about the various mathematical models in biochemical engineering systems*	2	85	75	H	H	H	H			H		H		H	H	H	H	H
CLO-3 :	*Discuss the application of SuperPro Design for analysis of material and energy balance of biochemical reaction*	3	75	80	H	H	H	M	H		H		H		H	H	H	H	H
CLO-4 :	*Explain the basic concepts of MATLAB, data analysis and interpretation of data*	3	85	80	H	H	H	H	H		M		H		H	H	H	H	H
CLO-5 :	*Explain the basic concepts of SIMULINK, data analysis and interpretation of data*	3	85	80	H	H	H	H	H		M		H		H	H	H	H	H
CLO-6 :	*Accomplish knowledge about the fundamentals of modeling and simulations of bioprocess*	2	80	75	H	H	H	H	H		M		H		H	H	H	H	H

Duration (hour)		9	9	9	9	9
S-1	SLO-1	*Models - Introduction*	*Basic Mathematical Models*	*Introduction to Superpro*	*MATLAB - Introduction*	*Modeling of Batch Culture Using MATLAB – basics*
	SLO-2	*Basic modeling principles*	*Setting up a model*	*Developing a Process Model*	*MATLAB - basics*	*Batch Culture – programme*
S-2	SLO-1	*Introduction of mathematical modeling*	*Continuous flow tanks - enclosed vessel*	*Process design*	*MATLAB - Data analysis*	*Batch Culture – expected outputs*
	SLO-2	*Uses of mathematical modeling*	*Continuous flow tanks - mixing vessel*	*Process Modeling and Simulation*	*Curve fitting - Introduction*	*Modeling of Fed-batch Culture Using MATLAB – basics*
S-3	SLO-1	*Classification of modeling techniques*	*Steam jacketed vessel*	*Process flow diagrams*	*Curve fitting using MATLAB - Theory*	*Fed-batch Culture – programme*
	SLO-2	*Grouping of models into opposite pairs*	*Steam jacketed vessel - open and closed*	*Process flow diagram to produce human insulin*	*Curve fitting using MATLAB – examples*	*Fed-batch Culture – expected outputs*
S-4	SLO-1	*Classification based on Mathematical complexity*	*Batch distillation – basics*	*The β-Galactosidase Process*	*Numerical Integration*	*Modeling of Continuous Culture Using MATLAB – basics*
	SLO-2	*Classification of models according to scale*	*Batch distillation model*	*The Industrial Wastewater Treatment Process*	*Numerical Integration Techniques*	*Continuous Culture – programme*
S-5	SLO-1	*Fundamental laws – Expression and examples*	*Bioprocess modeling*	*Procedures & Operations*	*Trapezoidal Rule*	*Continuous Culture – expected outputs*
	SLO-2	*Energy equations*	*Modelling approaches for biomanufacturing operations*	*Resources*	*Trapezoidal Rule - Problems*	*Process Simulation*
S-6	SLO-1	*Energy equations - expression and examples*	*Types of bioprocess model*	*Scheduling*	*Simpson's Rule*	*Simulink - Introduction*
	SLO-2	*Continuity equations*	*Mathematical models of microbial process*	*Process Properties & Simulation*	*Simpson's Rule - Problems*	*Simulink - basics*
S-7	SLO-1	*Continuity equations – expression and examples*	*Applying mechanistic models in bioprocess development*	*Economics*	*Euler's Method*	*Simulation of gravity flow tank*
	SLO-2	*Transport equations*	*Model formulation for aerobic cultivation of budding yeast*	*Reports*	*Euler's Method - Problems*	*Simulation of three isothermal CSTR*

S-8	SLO-1	*Transport equations expression and examples*	*Parameter identifiable analysis*	*Material-Balance Calculations*	*Runge-Kutta 4th Order Method*	*Simulation by Simulink in Batch Culture*
	SLO-2	*Equations of motion*	*Uncertainty analysis*	*Material-Balance Problems*	*Runge-Kutta 4th Order Method - Problems*	*Simulation by Simulink in fed-batch Culture*
S-9	SLO-1	*Chemical kinetics*	*Metabolic flux modelling (MFM)*	*Energy-Balance Calculations*	*Programming with MATLAB*	*Simulation by Simulink in continuous Culture*
	SLO-2	*Examples*	*MFM as a tool to analyze the behavior of genetically modified yeast strain*	*Energy-Balance Problems*	*Program design and development*	*Expected outputs of Batch, Continuous and Fed-batch fermentation process*

Learning Resources	1. *Mandenius C., Titchener-Hooker N. J., "Measurement, Monitoring, Modelling and Control of Bioprocesses", Springer Publishers, 2013.* 2. *Burstein L., "Matlab® in Bioscience and Biotechnology, Woodhead Publishing, 2011.* 3. *Luben. W.L., "Process Modelling Simulation and Control for Chemical Engineers", McGrawHill, 1990.* 5. *Franks. R.G.E., "Mathematical Modeling in Chemical Engineering", John Wiley and Sons, Inc., 2004.*	6. *Biquette. W.B., "Process Dynamics- Modeling analysis with simulation", Prentice Hall; 1 edition, 1998.* 7. *Beers. K.J., "Numerical Methods for Chemical Engineering Applications in MATLAB®", Massachusetts Institute of Technology, Cambridge University press. 2007.* *www.intelligen.com/ SuperPro Designer user guide.*

Learning Assessment											
	Bloom's Level of Thinking	Continuous Learning Assessment (50% weightage)								Final Examination (50% weightage)	
		CLA – 1 (10%)		CLA – 2 (15%)		CLA – 3 (15%)		CLA – 4 (10%)#			
		Theory	Practice	Theory	Practice	Theory	Practice	Theory	Practice	Theory	Practice
Level 1	Remember Understand	*40 %*	-	*30%*	-	*30%*	-	*30%*	-	*30%*	-
Level 2	Apply Analyze	*40 %*	-	*40%*	-	*40%*	-	*40%*	-	*40%*	-
Level 3	Evaluate Create	*20 %*	-	*30%*	-	*30%*	-	*30%*	-	*30%*	-
	Total	100 %		100 %		100 %		100 %		100 %	

CLA – 4 can be from any combination of these: Assignments, Seminars, Tech Talks, Mini-Projects, Case-Studies, Self-Study, MOOCs, Certifications, Conf. Paper etc.,

Course Designers		
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Dr. Karthik Periyasamy, Aurobindo Pharma Limited, Hyderabad, karthikmpk@gmail.com	*Prof. R. B. Narayanan, SVCE, Chennai, rbn@svce.ac.in*	*Dr. M. Venkatesh Prabhu, SRMIST*

Course Code	18BTE408T	Course Name	BIOPROCESS PLANT DESIGN	Course Category	E	Professional Elective	L	T	P	C
							3	0	0	3

Pre-requisite Courses	Nil	Co-requisite Courses	Nil	Progressive Courses	Nil
Course Offering Department	Biotechnology	Data Book / Codes/Standards	Nil		

Course Learning Rationale (CLR):	*The purpose of learning this course is to:*
CLR-1 :	*Equip the students with designing aspects for industrial scale fermenter*
CLR-2 :	*Infer various scale up and scale down parameters for good optimization process*
CLR-3 :	*Understand the factors involved in heat and mass transfer studies for controlling process parameters*
CLR-4:	*Envisage the guidelines for plant operation and its risk assessment*
CLR-5:	*Decipher process economics involved in industrial operations*
CLR-6:	*Instigate the production strategies in protein and other metabolites with commercial importance*

Course Learning Outcomes (CLO):	*At the end of this course, learners will be able to:*	Learning 1 Level of Thinking (Bloom)	Learning 2 Expected Proficiency (%)	Learning 3 Expected Attainment (%)	PLO 1 Engineering Knowledge	2 Problem Analysis	3 Design & Development	4 Analysis, Design, Research	5 Modern Tool Usage	6 Society & Culture	7 Environment & Sustainability	8 Ethics	9 Individual & Team Work	10 Communication	11 Project Mgt. & Finance	12 Life Long Learning	13 PSO - 1	14 PSO - 2	15 PSO – 3
CLO-1 :	*Manage Inoculum development and nutritional balance for product conversion.*	2	80	70	H	H	H	H			H		H		H	H	H	H	H
CLO-2 :	*learn about the mass and energy balance of bioprocess*	2	85	75	H	H	H	H			H		H		H	H	H	H	H
CLO-3 :	*develop and optimize the process parameters for the industries*	3	75	80	H	H	H	M	H		H		H		H	H	H	H	H
CLO-4 :	*apply design factors for scale up in the industry*	3	85	80	H	H	H	H	H		M		H		H	H	H	H	H
CLO-5 :	*evaluate the process plant design for regulatory compliance*	3	85	80	H	H	H	H	H		M		H		H	H	H	H	H
CLO-6 :	*design a plant layout for processing of biological materials*	2	80	75	H	H	H	H	H		M		H		H	H	H	H	H

Duration (hour)		9	9	9	9	9
S-1	SLO-1	*Design-Project Procedure*	*Heat and Mass Transfer studies*	*Selection of bioprocess equipment - upstream*	*Plant location and site selection*	*Cash Flow for Industrial Operations*
	SLO-2	*Types of Designs*	*Effect of scale on oxygenation*	*Selection of bioprocess equipment - downstream*	*Plant Layout*	*Cumulative Cash Position*
S-2	SLO-1	*Feasibility Survey*	*mixing and sterilization*	*Specifications of bioprocess equipment*	*Plant operation and control*	*Factors affecting investment and production costs*
	SLO-2	*Flow Diagrams*	*Inoculum development and nutrient availability*	*Mechanical design of reactors*	*Techniques Used in Site and Plant Layout*	*Capital Investments*
S-3	SLO-1	*Process Flow sheeting*	*Bioreactor scale-up*	*Heat transfer equipment*	*Utility supply aspects*	*Estimation of Capital Investment*
	SLO-2	*Equipment Design*	*Scale-up - constant power consumption per volume*	*Heat exchangers and Evaporators*	*Environmental Considerations*	*Cost Indexes*
S-4	SLO-1	*Equipment Selection*	*Scale-up - mixing time*	*Mass transfer equipment*	*Equipment cleaning aspects*	*Cost Factors in Capital Investment*
	SLO-2	*Comparison of Different Design-Projects*	*Scale-up - impeller tip speed (shear)*	*Finite-Stage Contactors*	*Culture cell banks*	*Estimating Equipment Costs by Scaling*
S-5	SLO-1	*Material balance*	*Scale-up - mass transfer coefficients*	*Continuous contactors - Packed towers*	*cGMP guidelines*	*Purchased-Equipment Installation*
	SLO-2	*Material balance calculations*	*Problems*	*Pressure Drop*	*Global Regulatory Environment*	*Methods for estimating capital investment*
S-6	SLO-1	*Examples*	*Scale up of downstream processes*	*Factors Influencing Plate and Column Efficiencies*	*Key Pharmaceutical Regulations Related to Design and Engineering*	*Estimation of Total Product Cost*
	SLO-2	*Problems*	*Adsorption*	*Piping and instrumentation*	*Implications for Performance and Compliance*	*Fixed Charges*
S-7	SLO-1	*Energy balance*	*Adsorption (LUB method)*	*HAZOPS Study*	*Risk Assessments*	*Case study – Commodity chemicals*
	SLO-2	*Energy balance calculations*	*Chromatography*	*Safety checklist for identifying process hazards*	*Validation*	*Cost analysis of enzyme production*
S-8	SLO-1	Examples	Chromatography (constant resolution etc.)	Materials of construction for bioprocess plants	Project Plans	Bioethanol from Corn Stover

	SLO-2	*Problems*	*Filtration (constant resistance etc.) -*	*Classification of stainless steels by alloy content and microstructure*	*Detailed Design Phase*	*Furfural and lignin from Corn Stover*
S-9	SLO-1	*Scale-Up in Design*	*Centrifugation (equivalent times etc.)*	*Low- and high-temperature Materials*	*Process Safety Management*	*Insulin production*
	SLO-2	*Factors in equipment scale-up and design*	*Scale-down related aspects*	*Economics in Selection of Materials*	*Safety Indices*	*Monoclonal Antibody Production*

Learning Resources	1. *Jacobs T., Signore A. A., "Good Design Practices for GMP Pharmaceutical Facilities", 2nd edition, Taylor and Francis, 2017.* 2. *Peters M. S., Timmerhaus. K. D., "Plant Design and Economics for Chemical Engineers", 5th Edition, McGrawHill Book Co., 2003* 3. *Perry R. H., Green D. W., "Perry's Chemical Engineers' Handbook", 9th Edition, McGraw Hill Book Co., 2018.* 4. *Towler G., Sinnott R., "Chemical Engineering Design - Principles, Practice and Economics of Plant and Process Design, Elsevier, 2007.*

Learning Assessment

	Bloom's Level of Thinking	Continuous Learning Assessment (50% weightage)								Final Examination (50% weightage)	
		CLA – 1 (10%)		CLA – 2 (15%)		CLA – 3 (15%)		CLA – 4 (10%)#			
		Theory	Practice	Theory	Practice	Theory	Practice	Theory	Practice	Theory	Practice
Level 1	Remember Understand	*40 %*	-	*30%*	-	*30%*	-	*30%*	-	*30%*	-
Level 2	Apply Analyze	*40 %*	-	*40%*	-	*40%*	-	*40%*	-	*40%*	-
Level 3	Evaluate Create	*20 %*	-	*30%*	-	*30%*	-	*30%*	-	*30%*	-
	Total	100 %		100 %		100 %		100 %		100 %	

CLA – 4 can be from any combination of these: Assignments, Seminars, Tech Talks, Mini-Projects, Case-Studies, Self-Study, MOOCs, Certifications, Conf. Paper etc.,

Course Designers

Experts from Industry	Experts from Higher Technical Institutions	Internal Experts
Dr. P. BalaKumaran, Proklean Technologies (P) Limited, Chennai, genbalu86@gmail.com	*Prof. K Subramaniam, IITM, Chennai, subbu@iitm.ac.in*	*Dr. V. Vinoth Kumar, SRMIST*
Dr. Karthik Periyasamy, Aurobindo Pharma Limited, Hyderabad, karthikmpk@gmail.com	*Prof. R. B. Narayanan, SVCE, Chennai, rbn@svce.ac.in*	*Dr. M. Venkatesh Prabhu, SRMIST*

Course Code	18BTE317T	Course Name	ENVIRONMENTAL BIOTECHNOLOGY	Course Category	E	Professional Elective	L	T	P	C
							3	0	0	3

Pre-requisite Courses	Nil	Co-requisite Courses	Nil	Progressive Courses	Nil
Course Offering Department	Biotechnology	Data Book / Codes/Standards			

Course Learning Rationale (CLR):	*The purpose of learning this course is to:*	Learning			Program Learning Outcomes (PLO)														
		1	2	3	1	2	3	4	5	6	7	8	9	10	11	12	13	14	15
CLR-1 :	*Create awareness on environmental pollution and the need for advanced technologies for their mitigation*	Level of Thinking (Bloom)	Expected Proficiency (%)	Expected Attainment (%)	Engineering Knowledge	Problem Analysis	Design & Development	Analysis, Design, Research	Modern Tool Usage	Society & Culture	Environment & Sustainability	Ethics	Individual & Team Work	Communication	Project Mgt. & Finance	Life Long Learning	PSO - 1	PSO - 2	PSO – 3
CLR-2 :	*Provide overview of biological approach for the conversion of various environmental pollutants*																		
CLR-3 :	*Understand the importance of biotechnology in the environmental management*																		
CLR-4:	*Understand various biotechnological contributions to the industries to reduce the environmental pollution*																		
CLR-5:	*Educate the relevant information about recovery of bioproducts from industrial wastes*																		
CLR-6:	*Identify the novel technology for the environmental pollution abatement*																		
Course Learning Outcomes (CLO):	*At the end of this course, learners will be able to:*																		
CLO-1 :	*Understand the biotechnological solutions for the treatment of industrial liquid and solid wastes*	*1*	*80*	*80*	*H*	*H*	*H*	*H*	*M*	*M*	*L*	*H*	*H*	*H*	*H*	*H*	*H*	*H*	*H*
CLO-2 :	*Acquire knowledge in aerobic and anaerobic biological treatment technologies*	*2*	*85*	*75*	*H*	*H*	*H*	*H*	*H*	*H*	*M*	*H*	*H*	*H*	*H*	*H*	*H*	*H*	*H*
CLO-3 :	*Understand the importance of biotechnology in the environmental pollution management*	*2*	*75*	*80*	*M*	*H*	*M*	*H*	*M*	*M*	*M*	*M*	*H*	*H*	*H*	*H*	*H*	*H*	*H*
CLO-4 :	*Understand the bioconversion pathways for the degradation of various xenobiotic compounds*	*2*	*85*	*80*	*H*	*H*	*H*	*H*	*H*	*M*	*H*	*L*	*H*	*H*	*H*	*H*	*H*	*H*	*H*
CLO-5 :	*Gain knowledge on the recovery of high value-added bioproducts from industrial wastes*	*3*	*85*	*75*	*H*	*H*	*H*	*H*	*M*	*M*	*H*	*H*	*H*	*L*	*H*	*H*	*H*	*H*	*H*
CLO-6 :	*Choose from an array of options to turn waste into economic goods*	*2*	*80*	*80*	*H*	*H*	*H*	*H*	*L*	*M*	*M*	*M*	*H*	*H*	*H*	*H*	*H*	*H*	*H*

Duration (hour)		9	9	9	9	9
S-1	SLO-1	*Introduction to Environmental pollution-water, air, soil*	*Recent trends in Biological wastewater treatment*	*Xenobiotics and recalcitrants*	*Recent trends in Biodegradation of industrial wastes*	*Waste to Wealth*
	SLO-2	*Perspectives of liquid and solid wastes*	*Aerobic biological treatment technologies*	*Environmental effects of Xenobiotics and recalcitrants*	*Contributions of Biotechnology for the environmental managements and industrial applications*	*Value-added bioproducts from Industrial wastes*
S-2	SLO-1	*Overview of stages of wastewater treatment*	*Anaerobic digestion process*	*Biodegradation of xenobiotics*	*Microbial enzymes for environmental applications*	*Slaughterhouse industry wastes*
	SLO-2	*primary, secondary and tertiary treatment*	*Stages of anaerobic digestion process*	*Mechanisms of Biodegradation of xenobiotics -Reductive/Oxidative/Hydrolytic*	*Advantages of immobile cells or enzymes over free cells and enzymes*	*Recovery of enzymes from slaughterhouse industry waste for industrial applications*
S-3	SLO-1	*Physicochemical technologies for the liquid waste disposal*	*Anaerobic Biological treatment technologies*	*Aliphatic and Hydrocarbons*	*Role of Biocatalysts in pollutant removal*	*Recovery of secondary metabolites from slaughterhouse industry waste for industrial applications*
	SLO-2	*Coagulation, Flocculation, Sedimentation*	*Advantages of anaerobic digestion processes over aerobic digestion processes*	*Biotransformation of Aliphatic and Hydrocarbons*	*Application of Immobilized cells in pollutants removal*	*Leather industry wastes*
S-4	SLO-1	*Chemical precipitation*	*Microbiology of anaerobic digester*	*Aromatic Hydrocarbons*	*Role of Biocatalysts in pollutant removal – Immobilized Enzymes*	*Types of solid wastes generated from leather industry*
	SLO-2	*Pros and Cons of chemical precipitation*	*Factors affecting anaerobic digestion process*	*Biotransformation of Aromatic Hydrocarbons*	*Application of Immobilized enzymes in pollutants removal*	*Recovery of enzymes from leather industry wastes for industrial applications*
S-5	SLO-1	*Filtration processes-mechanisms*	*Attached growth system-Biofilm*	*Polyaromatic hydrocarbons*	*Classification of dyes and their effects on the environment*	*Recovery of secondary metabolites from leather industry wastes for industrial applications*
	SLO-2	*Types of filtration processes*	*Biofilm development process*	*Biotransformation of Polyaromatic hydrocarbons*	*Microbial dye decolourization*	*Plastic wastes*
S-7	SLO-1	*Adsorption processes-Activated carbon technology-applications*	*Biofilm Technologies in environmental pollution management*	*Polycyclic aromatic Hydrocarbons*	*Enzyme based dye decolourization*	*Environmental impacts*

	SLO-2	*Ion Exchange processes-applications*	*Advantages of attached growth system over suspended system*	*Biotransformation of Polycyclic aromatic Hydrocarbons*	*Biodegradation of textile dyes*	*Recycling of plastic wastes*
S-8	SLO-1	*Solid waste disposal-Effects*	*Nutrients removal-Eutrophication*	*Halogenated hydrocarbons*	*Laccases and their role in Bioremediation of Industrial wastes*	*Bioplastics*
	SLO-2	*Secured Landfill, Bacterial and Vermi composting, incineration/pyrolysis*	*Recent advances in Nitrogen removal*	*Biotransformation of halogenated hydrocarbons*	*Heavy metal toxicity to the environment*	*Renewable resources for energy generation*
S-9	SLO-1	*Advanced oxidation processes for recalcitrants treatment*	*Biological Phosphorous Removal*	*Oil pollution and its effect on the environment*	*Microbial heavy metal removal-mechanisms*	*Alternate technologies for Energy recovery*
	SLO-2	*Electrolysis-Cu removal*	*EBPR process-mechanisms*	*Microbial treatment of oil pollution*	*Role of biosurfactants, Extracellular polysaccharides and siderophores in the heavy metal removal*	*Biomass residue as a fertilizer*

Learning Resources	1. *Bruce E.Rittmann and Perry L.McCarty, Environmental Biotechnology: Principles and Applications, McGraw Hill.2001.* 2. *Bimal C Bhattacharyya, Environmental Biotechnology, Oxford University press, 2007.* 3. *Milton Wainwright, an Introduction to Environmental Biotechnology, Springer, 1999.* 4. *P.Rajendran, P.Gunasekaran, Microbial Bioremediation, MJP Publishers, India, 2006.*	5. *Ram Chandra, Advances in biodegradation and bioremediation of industrial wastes, CRC Press, Taylor&Francis, 2015.* 6. *Hanes Joachim Joardening, Environmental Biotechnology, Concepts and Applications, 2017.* 7. *Chatterjee A.K, Introduction to Environmental Biotechnology, Prentice Hall of India, 2011.*

SLO – Session Learning Outcome

Learning Assessment

	Bloom's Level of Thinking	Continuous Learning Assessment (50% weightage)								Final Examination (50% weightage)	
		CLA – 1 (10%)		CLA – 2 (15%)		CLA – 3 (15%)		CLA – 4 (10%)#			
		Theory	Practice	Theory	Practice	Theory	Practice	Theory	Practice	Theory	Practice
Level 1	Remember Understand	*40 %*	-	*30%*	-	*30%*	-	*30%*	-	*30%*	-
Level 2	Apply Analyze	*40 %*	-	*40%*	-	*40%*	-	*40%*	-	*40%*	-
Level 3	Evaluate Create	*20 %*	-	*30%*	-	*30%*	-	*30%*	-	*30%*	-
	Total	100 %		100 %		100 %		100 %		100 %	

CLA – 4 can be from any combination of these: Assignments, Seminars, Tech Talks, Mini-Projects, Case-Studies, Self-Study, MOOCs, Certifications, Conf. Paper etc.,

Course Designers		
Experts from Industry	Experts from Higher Technical Institutions	Internal Experts
1. Dr. S. Sam Gunasekar, Orchid Chemicals and Pharmaceuticals Ltd., sam@orchidpharma.com	*1. Dr. A. Gnanamani, CSIR-Central Leather Research Institute, agmani_2000@yahoomail.com*	*1 Dr. K.Ramani SRM Inst. of Science & Technology, ramani.k@ktr.srmuniv.ac.in*
2. Dr. D. Gunaseelan, BIOCON Ltd., guna.sachin@gmail.com	*2. Dr. Anbumani Sadasivam, CSIR-Indian Institute of Toxicology Research,anbumani@iitr.res.in*	*2 Dr. B.Samuel Jacob SRM Inst. of Science & Technology, Samueljacob.b@ ktr.srmuniv.ac.in*

Course Code	18BTE318T	Course Name	INDUSTRIAL WASTE MANAGEMENT	Course Category	E	Professional Elective	L	T	P	C
							3	0	0	3

Pre-requisite Courses	Nil	Co-requisite Courses	Nil	Progressive Courses	Nil
Course Offering Department	Biotechnology	Data Book / Codes/Standards	Nil		

Course Learning Rationale (CLR):	*The purpose of learning this course is to:*
CLR-1 :	*Identify the relevant information about industrial solid waste reduction and hazardous waste management*
CLR-2 :	*Identify the applications of energy conversion technology*
CLR-3 :	*Demonstrate the state of the art in technology, organizational and legislative developments and practices*
CLR-4:	*Create insights to the waste characterization aspects*
CLR-5:	*Analyze the mass balance and carbon foot print for a given industrial process*
CLR-6:	*Utilize the concepts environmental regulation and inculcate in newly developed treatment technologies*

Course Learning Outcomes (CLO):	*At the end of this course, learners will be able to:*	Learning 1 Level of Thinking (Bloom)	2 Expected Proficiency (%)	3 Expected Attainment (%)	PLO 1 Engineering Knowledge	2 Problem Analysis	3 Design & Development	4 Analysis, Design, Research	5 Modern Tool Usage	6 Society & Culture	7 Environment & Sustainability	8 Ethics	9 Individual & Team Work	10 Communication	11 Project Mgt. & Finance	12 Life Long Learning	13 PSO - 1	14 PSO - 2	15 PSO – 3
CLO-1 :	*Formulate an insight into the pollution from major industries including the sources and characteristics of pollutants*	*1*	*80*	*70*	*H*	*H*	*M*	*M*	*M*	*H*	*H*	*H*	*M*	*H*	*M*	*H*	*M*	*H*	*H*
CLO-2 :	*Analyze the mode of treatment based on waste characteristics*	*2*	*85*	*75*	*H*	*M*	*M*	*M*	*M*	*H*	*H*	*H*	*M*	*L*	*H*	*H*	*M*	*H*	*H*
CLO-3 :	*Design of wastewater treatment plants to attain standard limits*	*2*	*75*	*70*	*H*	*H*	*M*	*M*	*M*	*H*	*H*	*H*	*H*	*M*	*H*	*H*	*H*	*M*	*H*
CLO-4 :	*Assess the impact of industrial wastes on the environmental compartments (land, water and air)*	*2*	*85*	*80*	*H*	*H*	*M*	*M*	*M*	*H*	*H*	*H*	*H*	*M*	*H*	*H*	*H*	*H*	*H*
CLO-5 :	*Analyze and choose approportate strategy to convert waste to economic goods*	*2*	*85*	*75*	*H*	*H*	*M*	*M*	*M*	*H*	*H*	*H*	*M*	*H*	*M*	*H*	*H*	*H*	*H*
CLO-6 :	*Develop knowledge on environmental regulations and legal aspects*	*1*	*80*	*70*	*H*	*M*	*M*	*M*	*M*	*H*	*H*	*H*	*M*	*H*	*M*	*H*	*H*	*M*	*H*

Duration (hour)		9	9	9	9	9
S-1	SLO-1	*Introduction to industrial wastes and their impacts-Industrial wastes - Sources*	*Standards for waste disposal & methods of waste reduction –*	*Treatment and disposal of industrial effluents*	*Biodegradation/ Recycling Of Industrial Wastes*	*Environmental Concerns, Legislations And Environmental Impact Assessment*
	SLO-2	*Classification of industrial wastes*	*Standards for disposal of treated effluents, solid wastes and gaseous emissions from different industries*	*Stages of effluent treatment- primary, secondary and tertiary*	*Immobilized cell and enzyme technologies for the effluent treatment*	*Environmental Assessment and Management Systems*
S-2	SLO-1	*Industrial waste generation scenario in India*	*Characteristics of industrial wastewater- COD, BOD and TOC*	*Physicochemical treatment-Coagulation, flocculation and their mechanisms*	*Energy recovery from hybrid treatment technology*	*Applicable federal and provincial environmental regulations*
	SLO-2	*Industrial waste generation scenario in Global context*	*Solids analysis – TDS, TSS and VSS*	*Precipitation –heavy metal removal-Merits and Demerits*	*Case study f sustainable technologies from European Union*	*Environmental impact assessment (EIA) legislation and regulatory framework*
S-3	SLO-1	*Environmental impacts*	*Characteristics of industrial wastewater-, TKN, Ammonia, Chloride, Sulfide and Sulfate*	*Secondary Biological treatment: Aerobic- activated sludge process,*	*Algal based technologies for nutrient and pollutant removal*	*EIA applied to solid and liquid waste management*
	SLO-2	*Threat to biodiversity*	*Metal analysis using AAS and ICP-MS*	*Sequential batch process. fluidized bed reactor*	*Bioreactor designs for algal based wastewater*	*Environmental toxicology assessment and regulations*
S-4	SLO-1	*Toxicity of industrial effluents*	*Removal of heavy metals by physico- chemical process*	*Secondary Biological treatment: Anaerobic-UASB, MBR –Merits and Demerits*	*Bioelectricity production through MFC with leachate and wastewater*	*Management of toxic chemicals*
	SLO-2	*Case studies of industrial toxicity (Bhopal gas leak, Chernobyl etc.)*	*Biological process for heavy metal removal*	*High rate bioreactors*	*Water splitting technologies*	*Nuclear waste management*
S-5	SLO-1	*Functions of Regulatory bodies-State and Central Pollution Control Board*	*Individual and Common Effluent Treatment Plants*	*Reprocessing of bio-sludge for value addition*	*Bioplastic synthesis from the compounds derived from wastewater*	*Effluent control, air pollution control and urban development*
	SLO-2	*Common effluent treatment plants for textile and tannery industry wastewater treatment*	*Case study of Indian industries waste treatment through common effluent treatment process*	*Energy recovery from sludge*	*Polymer synthesis from the compounds derived from wastewater*	*Pollution abatement in national river bodies: Case studies*

S-6	SLO-1	*Selection of candidate technologies for waste treatment based on characteristics*	*Volume and strength reduction*	*Removal of refractory organics-strategies*	*Plastics degrading bacteria*	*Environmental auditing*
	SLO-2	*Rationale for biological treatment over convetional methods*	*Material and process modifications*	*Advanced oxidation processes*	*Phytoremediation for removal of heavy metals*	*ISO 14001:2015 And its implication in environmental assessment*
S-7	SLO-1	*The solid waste landfill*	*4R principles– Recycle, reuse and by-product recovery*	*Photo-oxidation process*	*Bioremediation of hydrocarbon contaminated wastewater of refinery plants through super bugs (GM Pseudomonas putida)*	*Carbon foot print for an industry*
	SLO-2	*Leachate management*	*Waste treatment flow sheets for selected industries such as Textiles, Tanneries, Pharmaceuticals, Electroplating industries,*	*Volatile organic compound (VOC) removal by Evaporation*	*Ocean cleaning for oil spill using super bugs*	*Carbon credit*
S-8	SLO-1	*The process of composting Industrial wastes*	*Dairy, Sugar, Paper, distilleries, Steel plants, Refineries, fertilizer, thermal power plants*	*Air and steam stripping*	*Biosurfactants for bioremediation and biodegradation of various pollutants discharged from industrial waste*	*Occupational Safety and Health Assessment*
	SLO-2	*Vermi-composting and its advantages*	*Hazardous waste management– Physico chemical treatment*	*Adsorption processes (Activated carbon)*	*Mechanism of biosurfactant based technologies for solids reduction in wastewater*	*Waste Hazard identification and problem formulation*
S-9	SLO-1	*Hierarchy of Potential Implementation waste management Strategies*	*Solidification and incineration – Zero discharge*	*Colour removal from wastewater from textile industries*	*Application of nanotechnology for waste degradation*	*Life cycle assessment of industrial wastes*
	SLO-2	*Waste management pyramid*	*Secure land fills*	*Role of microorganisms and enzymes for dye removal*	*Nano-enzymes for pollutant removal*	*Implications of biological agents on environment for pollutant removal*

Learning Resources	1. *Eckenfelder, W.W., (1999) "Industrial Water Pollution Control ", Mc-Graw Hill.* 2. *Clair N. Sawyer, Perry L. McCarty, "Chemistry for Environmental Engineering and Science" McGraw-Hill, 1978* 3. *Metcalf & Eddy Inc.Wastewater Engineering: Treatment and reuse 2016*

Learning Assessment

	Bloom's Level of Thinking	Continuous Learning Assessment (50% weightage)								Final Examination (50% weightage)	
		CLA – 1 (10%)		CLA – 2 (15%)		CLA – 3 (15%)		CLA – 4 (10%)#			
		Theory	Practice	Theory	Practice	Theory	Practice	Theory	Practice	Theory	Practice
Level 1	Remember Understand	*40 %*	-	*30%*	-	*30%*	-	*30%*	-	*30%*	-
Level 2	Apply Analyze	*40 %*	-	*40%*	-	*40%*	-	*40%*	-	*40%*	-
Level 3	Evaluate Create	*20 %*	-	*30%*	-	*30%*	-	*30%*	-	*30%*	-
	Total	100 %		100 %		100 %		100 %		100 %	

CLA – 4 can be from any combination of these: Assignments, Seminars, Tech Talks, Mini-Projects, Case-Studies, Self-Study, MOOCs, Certifications, Conf. Paper etc.,

Course Designers

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2.Dr. D. Gunaseelan, BIOCON Ltd., guna.sachin@gmail.com	*2. Dr. Anbumani Sadasivam, CSIR-Indian Institute of Toxicology Research,anbumani@iitr.res.in*	*Dr. B.Samuel Jacob SRM Inst. of Science & Technology, ssamueljacob.b@ ktr.srmuniv.ac.in*

Course Code	18BTE319T	Course Name	BIOENERGY	Course Category	E	Professional Elective	L	T	P	C
							3	0	0	3

Pre-requisite Courses	Nil	Co-requisite Courses	Nil	Progressive Courses	Nil
Course Offering Department	Biotechnology	Data Book / Codes/Standards	Nil		

Course Learning Rationale (CLR):	*The purpose of learning this course is to:*
CLR-1 :	*Identify the potent biomass resources for energy production*
CLR-2 :	*Identify the applications of energy conversion technology*
CLR-3 :	*Demonstrate the significance of environmental benefits of bioenergy*
CLR-4:	*Create insights to the concepts of sustainable and green technologies*
CLR-5:	*Analyze the important wastes to energy conversion*
CLR-6:	*Utilize the concepts scale up strategies for biomass based energy production*

Course Learning Outcomes (CLO):	*At the end of this course, learners will be able to:*	Learning			Program Learning Outcomes (PLO)														
		1	2	3	1	2	3	4	5	6	7	8	9	10	11	12	13	14	15
		Level of Thinking (Bloom)	Expected Proficiency (%)	Expected Attainment (%)	Engineering Knowledge	Problem Analysis	Design & Development	Analysis, Design, Research	Modern Tool Usage	Society & Culture	Environment & Sustainability	Ethics	Individual & Team Work	Communication	Project Mgt. & Finance	Life Long Learning	PSO - 1	PSO - 2	PSO – 3
CLO-1 :	*Formulate the appropriate biofuel production based on available feedstocks*	*1*	*80*	*70*	*H*	*H*	*M*	*M*	*M*	*H*	*H*	*H*	*M*	*H*	*M*	*H*	*M*	*H*	*H*
CLO-2 :	*Analyze cell wall components of biomass*	*2*	*85*	*75*	*H*	*M*	*M*	*M*	*M*	*H*	*H*	*H*	*M*	*L*	*H*	*H*	*M*	*H*	*H*
CLO-3 :	*Apply thermo-chemical conversion process for biomass conversion to produce biofuel*	*2*	*75*	*70*	*H*	*H*	*M*	*M*	*M*	*H*	*H*	*H*	*H*	*M*	*H*	*H*	*H*	*M*	*H*
CLO-4 :	*Apply enzymatic process to convert biomass t fuel and value added chemicals*	*2*	*85*	*80*	*H*	*H*	*M*	*M*	*M*	*H*	*H*	*H*	*H*	*M*	*H*	*H*	*H*	*H*	*H*
CLO-5 :	*Employ synthetic routes for ease and fast biofuel prouction*	*2*	*85*	*75*	*H*	*H*	*M*	*M*	*M*	*H*	*H*	*H*	*M*	*H*	*M*	*H*	*H*	*H*	*H*
CLO-6 :	*Describe the National policy towards biofuel production and Energy security*	*1*	*80*	*70*	*H*	*M*	*M*	*M*	*M*	*H*	*H*	*H*	*M*	*H*	*M*	*H*	*H*	*M*	*H*

		Introduction to Sources of energy	First Generation Bioenergy	Second & Third Generation Bioenergy	Fourth generation bioenergy and next generation bio-molecules	Policies and future R&D of biofuels & Bioenergy
Duration (hour)		9	9	9	9	9
S-1	SLO-1	*Non-renewable Resources (Fossil fuel)*	*Sugar and Starch based bioenergy*	*2nd generation (Non-edible lignocellulosics)*	*CO_2 biosequestration and biofuel production strategies*	*Policies and Future R&D of Biofuels & Bioenergy*
	SLO-2	*Alternate and renewable resources (Solar, wind and biomass based)*	*Corn, sugarcane, sugar beets, soybeans, canola oil, fryer grease, and coconut oil*	*Wood bioenergy*	*Use of plants and microalgae for CO_2 sequestration*	*National biofuel policy framework*
S-2	SLO-1	*Bioenergy – Classification (Liquid and gaseous biofuel)*	*Fuel from food crops*	*Pretreatment strategies for biofuel production*	*Synthetic (bio)fuels*	*Evaluation of current and future R&D needs*
	SLO-2	*An overview of bioenergy in Global and national context*	*Consequences for food crops as fuel source*	*Green chemicals for biomass pretreatment*	*Sustainability aspects of synthetic biofuels*	*Focus area such as Mission Innovations India and Horizon 2020*
S-3	SLO-1	*Rationale of biomass power sustainable environment*	*Role of cell wall components (Lignin, cellulose and hemicelluloses) in different plants for ethanol production*	*Rationale for biological pretreatment over physical and chemical modes.*	*Pyrolysis bio-oil/bio-char*	*Legal framework to support sustainable development and increased use of biofuels*
	SLO-2	*Treatment technologies for biomass to useful energy*	*Bottlenecks in biomass conversion to fuels*	*Bioethanol plant design and its components*	*Hydrogenated biodiesels*	*Need for International cooperation and intervention in biofuel sectior in India*
S-3	SLO-1	*Circular & Biobased Economy*	*Recalcitrant lignin and its biochemistry*	*Bio refinery demonstration projects of Bioethanol*	*Pyrolysis diesel*	*Government policies and programs with regard to biofuels*
	SLO-2	*Environment impact over biofuel usage*	*Importance of cellulose and hemicelluloses*	*Sustainable Solid and liquid waste management*	*Comparative analysis of different grades of diesel based on ASTM*	*R and D focus area for biofuel in India*
S-4	SLO-1	*Feedstocks – Food Vs Feed Vs Fuel*	*Conversions Process: Physico-chemical*	*Biomethanation process*	*Dimethyl ether (DME)*	*Investment opportunities on biofuels worldwide*
	SLO-2	*Characteristics for feedstock for bioenergy*	*Constraints of conventional processing technologies*	*Microbiology of anaerobic digestion*	*Bio-synthetic natural gas (SNG)*	*Industrial opportunities of biofuels in India – at a glance*

S-5	SLO-1	*Waste resources – Industrial (solid and liquid) and MSW*	*Biological route and Enzymatic Conversion*	*Biological Processes for Hydrogen Production*	*Comparative analysis of CNG/SNG/bio-gas based on ASTM*	*Economic, Social and Ecological Impacts of Bioenergy*
	SLO-2	*Agro waste resources – Crop residues and by-products*	*Enzymology for conversion of biomass to biofuels – Ligninolytic enzymes (MnP, LiP and laccase)*	*Dark fermentation and algal based technologies*	*Bio-butanol production*	*Comparative analysis of National and Global Levels*
S-6	SLO-1	*Energy crops – Terrestrial*	*Mechanism of depolymerization of lignin by enzymes and whole cells*	*3rd generation biofuel*	*ABE biosynthesis (Acetone Butanol and Ethanol)*	*Current and Emerging Challenges to Bioenergy Development*
	SLO-2	*Energy crops – Aquatic*	*Hexose sugar conversion to ethanol*	*Need for 3rd generation biofuels*	*Bottlenecks in ABE fermentation; Types of feedstocks preferred*	*Impact of solar and wind energy over biomass energy*
S-7	SLO 1	*Potential Benefits of Replacing Fossil Fuels with Biofuel, Biomass and Biogas*	*Pentose sugar conversion to ethanol*	*Genetically modified organisms for improved fuel production*	*Metabolic pathway engineering for ABE biosynthesis*	*Community Participation in Renewable Energy Development*
	SLO 2	*Cradle to grave approach of waste raw materials for bioenergy development*	*By-products of ethanol production and its*	*Case study of insect ruminant biology for biofuel production*	*Case study of GM microbes on ABE fermentation*	*Techno-economic feasibility for biofuel production*
S-8	SLO 1	*Political Drivers for Biofuel Development*	*Inhibitory products of bioethanol production*	*GM plants for enhanced biomass for ethanol production*	*Bio-alkanes and alkenes from waste biomass*	*Combined industrial waste treatment for energy recovery*
	SLO 2	*Consequences of Burning Fossil Fuel*	*Plausible contaminants from bioethanol production and its re-utilization*	*GM based oil crops for biodiesel production*	*Economic advantage of chemicals production from biomass*	*Zero-discharge concept for wastewater from industries and energy recovery process*
S-9	SLO 1	*Mitigation of Global Warming*	*Biodiesel from vegetable oils*	*Hybrid energy system through biomass*	*New energy research Projects in Global context*	*Urban and rural integration system for sustainable waste utilization*
	SLO 2	*Carbon dioxide sequestration Approaches*	*Transesterification process*	*Algal based technologies for biofuel and value added chemical preparation*	*New energy research Projects in Indian context*	*Life-cycle Analysis of Biofuels*

Learning Resources	1. *David M. Mousdale, "Biofuels: Biotechnology, Chemistry, and Sustainable Development, "CRC Press, 2008.* 2. *Roland A. Jansen, "Second Generation Biofuels and Biomass", Wiley – VCH Verlag GmbH Co., 2013.*	3. *A.H.Scragg, "Biofuels, Production, Application and Development", CAB Internaional, 2009* 4. *Robert C. Brown and Tristan R.Brown, "Biorenewable Resources: Engineering New Products from Agriculture," Wiley-Blackwell Publishing, 2nd Edition, 2014.*

Learning Assessment											
	Bloom's Level of Thinking	Continuous Learning Assessment (50% weightage)								Final Examination (50% weightage)	
		CLA – 1 (10%)		CLA – 2 (15%)		CLA – 3 (15%)		CLA – 4 (10%)#			
		Theory	Practice	Theory	Practice	Theory	Practice	Theory	Practice	Theory	Practice
Level 1	Remember Understand	*40 %*	-	*30%*	-	*30%*	-	*30%*	-	*30%*	-
Level 2	Apply Analyze	*40 %*	-	*40%*	-	*40%*	-	*40%*	-	*40%*	-
Level 3	Evaluate Create	*20 %*	-	*30%*	-	*30%*	-	*30%*	-	*30%*	-
	Total	100 %		100 %		100 %		100 %		100 %	

CLA – 4 can be from any combination of these: Assignments, Seminars, Tech Talks, Mini-Projects, Case-Studies, Self-Study, MOOCs, Certifications, Conf. Paper etc.,

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Dr. S. Sam Gunasekar Orchid Pharma Ltd., Chennai	*Dr. Subhabrata Ray IIT Kharagpur, sray@che.iitkgp.ernet.in*	*Dr. K.Ramani Department of Biotechnology SRM Inst. of Science & Technology, ramani.k@ktr.srmuniv.ac.in*

Course Code	18BTE320T	Course Name	ENVIRONMENTAL MICROBIOLOGY. & METAGENOMICS	Course Category	E	Professional Elective Course	L	T	P	C
							3	0	0	3

Pre-requisite Courses	Nil	Co-requisite Courses	Nil	Progressive Courses	Nil
Course Offering Department	Biotechnology	Data Book / Codes/Standards	Nil		

Course Learning Rationale (CLR):	*The purpose of learning this course is to:*
CLR-1 :	*Provide the awareness on the microbial applications in the environmental pollution abatement*
CLR-2 :	*Give an overview of indigenous microbes on environmental bioremediation*
CLR-3 :	*Educate the molecular insights on conservation of biodiversity*
CLR-4:	*Understand the environmental metagenomics for novel species identification*
CLR-5:	*Apply the metaproteomic concepts for environmental samples*
CLR-6:	*Educate the soil microbiome and biofilm organisms in the environment*

Course Learning Outcomes (CLO):	*At the end of this course, learners will be able to:*	Learning 1 Level of Thinking (Bloom)	2 Expected Proficiency (%)	3 Expected Attainment (%)	PLO 1 Engineering Knowledge	2 Problem Analysis	3 Design & Development	4 Analysis, Design, Research	5 Modern Tool Usage	6 Society & Culture	7 Environment & Sustainability	8 Ethics	9 Individual & Team Work	10 Communication	11 Project Mgt. & Finance	12 Life Long Learning	13 PSO - 1	14 PSO - 2	15 PSO – 3
CLO-1 :	*Apply the concepts of microbial diversity and its taxonomic make up.*	1	80	80	H	H	H	H	M	M	L	H	H	H	H	H	H	H	H
CLO-2 :	*Understand the extremophiles and its uses in Biotechnology.*	2	85	75	H	H	H	H	M	H	M	H	H	H	H	H	H	H	H
CLO-3 :	*Apply Metagenomics data to describe taxonomic make-up and ecological processes of microbial communities from a range of environments*	2	75	80	M	H	M	H	M	M	H	M	H	H	H	H	H	H	H
CLO-4 :	*Assemble and annotate genomes by identifying genes*	2	85	80	H	H	H	H	H	H	H	L	H	H	H	H	H	H	H
CLO-5 :	*Apply next generation sequencing technology.*	3	85	75	H	H	H	H	H	M	H	H	H	L	H	H	H	H	H
CLO-6 :	*Understand the soil microbiome and biofilm organisms in the environmental cleanup*	2	80	80	H	H	H	H	M	M	M	M	H	H	H	H	H	H	H

Duration (hour)		9	9	9	9	9
S-1	SLO-1	*Microbial diversity*	*Extremophiles*	*Environmental Metagenomics*	*Environmental meta proteomics*	*Soil microbiome and biofilms*
	SLO-2	*Microbial existence in the environment*	*Extremophiles-various types*	*Importance of metagenomics in microbial ecology*	*Importance of metaproteomics in microbial ecology*	*The soil microbiome — from metagenomics to metaphenomics*
S-2	SLO-1	*Biodiversity and its relationship with Environment*	*Extremophiles in the environmental management*	*Metagenomics-types, steps*	*Gel-based proteomics: 2-DE*	*Influence of soil structure and connectivity on the soil metaphenome*
	SLO-2	*Classification of microorganisms*	*Role of Acidophilic microorganisms and their biomolecules in Environmental remediation*	*Molecular Diversity and Metagenomics*	*Gel-based proteomics: DIGE*	*Influence of physiological status on the soil metaphenome*
S-3	SLO-1	*Role of microorganisms in the sustainability of biosphere*	*Role of alkalophilic microorganisms and their biomolecules in Environmental remediation*	*Concept of e-DNA (environmental DNA)*	*Gel-based proteomics: BN-PAGE*	*Influence of microbial community interactions on the soil metaphenome*
	SLO-2	*Culturability/unculturability and microbial ecology principles*	*Role of psychrophilic microorganisms in Environmental remediation*	*Diversity of Microbes in different environments*	*Merits and demerits of gel-based proteomic techniques*	*Role of soil microbiome for improving soil health under changing climate*
S-4	SLO-1	*Classification of microorganisms-Bacteria, Yeasts, Moulds, Viruses, Protozoans*	*Role of mesophilic microorganisms and in Environmental remediation*	*Conventional methods to study diversity; Cultured and Uncultured Methods*	*Gel-free proteomics: Isotope-Coded Affinity Tag (ICAT)*	*Biofilm mediated decontamination of pollutants from the environment*
	SLO-2	*Lichens and their role in the biosphere.*	*Role of thermophilic microorganisms in Environmental remediation*	*16S-rDNA sequencing of microbial communities*	*Isobaric Tagging for Relative and Absolute Quantitation (iTRAQ)*	*Role of Biofilms in Bioremediation*
S-5	SLO-1	*Mycorrhiza-types*	*Role of barophilic microorganisms in Environmental remediation*	*Partial community analysis methods - Genetic fingerprinting techniques - T-RFLP*	*Multidimensional Protein Identification Technology -MudPIT)*	*Strategies for Use of Biofilms in Remediation*
	SLO-2	*Mycorrhiza-Environmental applications*	*Role of osmophilic microorganisms in Environmental remediation*	*Partial community analysis methods - Genetic fingerprinting techniques - DGGE*	*Merits and demerits of gel-free proteomic techniques*	*Biofilm Survival Strategies in Polluted Environments*
S-6	SLO-1	*Photosynthetic organisms and their environmental applications*	*Halophiles- types*	*Partial community analysis methods - Genetic fingerprinting techniques RISA*	*Application of gel-free techniques in biological systems*	*Molecular Methods for the Assessment of Microbial Biofilms in Bioremediation*

	SLO-2	*Anoxygenic photosynthetic microbes*	*Halophiles- their biomolecules in Environmental remediation*	*Partial community analysis methods - Genetic fingerprinting techniques LH-PCR microarrays*	*Protein microarrays*	*Detoxification of Hexavalent Chromium from Industrial Wastewater using a Bacterial Biofilm System*
S-7	SLO-1	*General characteristics of purple and green sulphur bacteria.*	*Molecular aspects of extremophiles- Genes, Protein s and Enzymes.*	*Partial community analysis methods - Genetic fingerprinting techniques RAPD*	*Isotope-Coded Protein Label (ICPL)*	*Biofilm-mediated Degradation of PAHs and Pesticides*
	SLO-2	*Oxygenic photosynthetic microbes*	*Perspectives of Archaebacteria in Environment- distinguishing features*	*Partial community analysis methods - Genetic fingerprinting techniques DNA microarrays*	*Combined FRActional DIagonal Chromatography (COFRADIC)*	*Metagenome Analyses of Multispecies Microbial Biofilms*
S-8	SLO-1	*General characteristics of Cyanobacteria and Prochlorales*	*Phylogenetic groups of Archaebacteria, Ecology and habitats of Archaebacteria,*	*Whole community analysis methods: DNA-DNA reassociation,*	*Application of gel-free techniques in biological systems*	*Metagenomic approach for the biofilm community analysis*
	SLO-2	*Methanogens*	*Physiology of Archaebacteria-their role in environmental sustainability*	*Whole community analysis methods: G+C fractionation*	*Mass Spectrometry; Matrix Assisted Laser Desorption and Ionization (MALDI)*	*Metagenomic Approaches for Understanding New Concepts in Microbial Science*
S-9	SLO-1	*Methanogenic-General characteristics and properties*	*Role of Archaebacteria in the environmental pollution management*	*Whole genome sequencing; DNA Microarray Technology*	*Electronspray Ionization (ESI)*	*Accessing the Soil Metagenome for Studies of Microbial Diversity*
	SLO-2	*Methanogens –Environmental applications*	*Magneto tactic bacteria.*	*Next Generation Technology*	*Mass spectrometry data analysis – computational tools.*	*Recent Advances and Perspectives in Metagenomic Studies of Soil Microbial Communities*

Learning Resources	1. *Joanne M Willey, Joanne Willey, "Prescott's Microbiology," McGraw-Hill Education; 9th edition, 2013.* 2. *Stephen P. Hunt and Frederick J. Livesey, "Functional Genomics"Oxford University Press, 2000.* 3. *R. M. Twyman, "Principles of Proteomics", Taylor & Francis, 2nd edition, 2008.*	4. *Diana Marco Universidad Nacional de Cordoba, Argentina "Metagenomics: Current Innovations and Future Trends", Caister Academic Press, 2011.* 5. *Maier, R.M. Pepper, I.L and Gerba, "Environmental Microbiology," C.P. Academic press, 2000.* 6. *Gavin Lear, "Biofilms in Bioremediation: Current Research and Emerging Technologies", Caister Academic Press, 2016.*

Learning Assessment

	Bloom's Level of Thinking	Continuous Learning Assessment (50% weightage)								Final Examination (50% weightage)	
		CLA – 1 (10%)		CLA – 2 (15%)		CLA – 3 (15%)		CLA – 4 (10%)#			
		Theory	Practice	Theory	Practice	Theory	Practice	Theory	Practice	Theory	Practice
Level 1	Remember Understand	*40 %*	-	*30%*	-	*30%*	-	*30%*	-	*30%*	-
Level 2	Apply Analyze	*40 %*	-	*40%*	-	*40%*	-	*40%*	-	*40%*	-
Level 3	Evaluate Create	*20 %*	-	*30%*	-	*30%*	-	*30%*	-	*30%*	-
	Total	100 %		100 %		100 %		100 %		100 %	

CLA – 4 can be from any combination of these: Assignments, Seminars, Tech Talks, Mini-Projects, Case-Studies, Self-Study, MOOCs, Certifications, Conf. Paper etc.,

Course Designers

Experts from Industry	Experts from Higher Technical Institutions	Internal Experts
1. Dr. S. Sam Gunasekar, Orchid Chemicals and Pharmaceuticals Ltd., sam@orchidpharma.com	*1. Dr. A. Gnanamani, CSIR-Central Leather Research Institute, agmani_2000@yahoomail.com*	*Dr. Ramani, SRMIST*
2.Dr. D. Gunaseelan, BIOCON Ltd., guna.sachin@gmail.com	*2. Dr. Anbumani Sadasivam, CSIR-Indian Institute of Toxicology Research,anbumani@iitr.res.in*	*Dr.W.Richard Thilagaraj*

Course Code	18BTE409T	Course Name	BIOREMEDIATION TECHNOLOGY	Course Category	E	Professional Elective	L	T	P	C
							3	0	0	3

Pre-requisite Courses	Nil	Co-requisite Courses	Nil	Progressive Courses	Nil
Course Offering Department	Biotechnology	Data Book / Codes/Standards	Nil		

Course Learning Rationale (CLR):	*The purpose of learning this course is to:*
CLR-1 :	*Create the awareness on the microbial applications in the environmental pollution abatement*
CLR-2 :	*Give an overview of indigenous microbes on environmental bioremediation*
CLR-3 :	*Educate the molecular insights on conservation of biodiversity*
CLR-4:	*Apply the metagenomic approach for the environmental microbial analysis*
CLR-5:	*Apply the metaproteomic approach for the environmental applications*
CLR-6:	*Demonstrate the application of biofilm communities in environmental applications and their metagenomic approach*

Course Learning Outcomes (CLO):	*At the end of this course, learners will be able to:*	Learning 1 Level of Thinking (Bloom)	Learning 2 Expected Proficiency (%)	Learning 3 Expected Attainment (%)	PLO 1 Engineering Knowledge	PLO 2 Problem Analysis	PLO 3 Design & Development	PLO 4 Analysis, Design, Research	PLO 5 Modern Tool Usage	PLO 6 Society & Culture	PLO 7 Environment & Sustainability	PLO 8 Ethics	PLO 9 Individual & Team Work	PLO 10 Communication	PLO 11 Project Mgt. & Finance	PLO 12 Life Long Learning	PLO 13 PSO - 1	PLO 14 PSO - 2	PLO 15 PSO – 3
CLO-1 :	*Apply the concepts of biodiversity and their importance.*	*1*	*80*	*80*	*H*	*H*	*H*	*H*		*M*	*L*	*H*	*H*	*H*	*H*	*H*	*H*	*H*	*H*
CLO-2 :	*Understand the extremophiles and its applications in environmental remediation.*	*2*	*85*	*75*	*H*	*H*	*H*	*H*			*M*	*H*	*H*	*H*	*H*	*H*	*H*	*H*	*H*
CLO-3 :	*Use metagenomics data to describe the taxonomic make-up and ecological processes of microbial communities from a range of environments.*	*2*	*75*	*80*	*M*	*H*	*M*	*H*	*M*	*M*		*M*	*H*	*H*	*H*	*H*	*H*	*H*	*H*
CLO-4 :	*Assemble and annotate genomes by identifying genes.*	*2*	*85*	*80*	*H*	*H*	*H*	*H*			*H*	*L*	*H*	*H*	*H*	*H*	*H*	*H*	*H*
CLO-5 :	*Apply next generation sequencing technology.*	*3*	*85*	*75*	*H*	*H*	*H*	*H*		*M*	*H*	*H*	*H*	*L*	*H*	*H*	*H*	*H*	*H*
CLO-6 :	*Analyze the biofilm communities in the soil microbiome and their metagenomic strategies.*	*2*	*80*	*80*	*H*	*H*	*H*	*H*	*L*	*M*	*M*	*M*	*H*	*H*	*H*	*H*	*H*	*H*	*H*

Duration (hour)		9	9	9	9	9
S-1	SLO-1	*Principles of bioremediation*	*Bioremediation technologies*	*Bioremediation project management*	*Microbial oxidation of heavy metals*	*Nuclear waste bioremediation*
	SLO-2	*Introduction to Bioremediation: Types of Bioremediation*	*Bioremediation Techniques: bio stimulation & bio augmentation*	*Defining the project and goals*	*Bioleaching*	*Microbes in pollution Remediation*
S-2	SLO-1	*Bioremediation Mechanisms*	*In situ and ex situ remediation technologies : (Bio) venting*	*Site characterization*	*Biomining*	*Heavy metal toxicity in the environment*
	SLO-2	*Microbes for Bioremediation*	*In situ and ex situ remediation technologies : (Bio)sparging*	*Screening and selecting remediation alternatives*	*Microbial sources for the oxidation of minerals from ores*	*Heavy metal bioremediation*
S-3	SLO-1	*Metabolic process involved in bioremediation*	*In situ and ex situ remediation technologies : (Bio)stripping*	*Process design*	*Bio-oxidation mechanisms*	*Various reactors for heavy metal removal*
	SLO-2	*Factors affecting bioremediation*	*In situ and ex situ remediation technologies : (Bio)sorption barriers*	*Remediation field activities- Aerobic Bioremediation*	*Enzymes for heavy metal detoxification*	*Actinides pollutant removal strategeis*
S-4	SLO-1	*Metabolic process involved in bioremediation*	*In situ and ex situ remediation technologies : Biofilters*	*Bioremediation of Surface Soils*	*Bacterial oxidation of pyrite*	*Nuclear waste disposal methods*
	SLO-2	*Limitations of Bioremediations*	*In situ and ex situ remediation technologies : Bioreactors*	*Fate and transport of contaminants in the Vadose zone*	*Siderophores*	*Case studies of nuclear accidents and its further remediation stratgies*
S-5	SLO-1	*Mycoremediation,*	*Use of bioreactors for bioremediation*	*Anoxic/Anaerobic Bioremediation: Anoxic/Anaerobic Environment*	*Bacterial oxidation of chalcopyrite*	*Types of nuclear wastcs and environmental effects*
	SLO-2	*Phytoremediation technologies.*	*Molecular techniques in bioremediation*	*Potential anaerobic Bioremediation*	*Metallothinenis and Biosurfactants from microbial sources and their role in heavy metal removal*	*Natural nuclear wastes*
S-6	SLO-1	*Xenobiotics and recalcitrant Man-made pollution*	*Application, specific advantages and disadvantages of bioremediation technologies,*	*Anoxic/Anaerobic Processes – Fermentation*	*Bacterial oxidation Sphalerite*	*Man-made nuclear wastes*
	SLO-2	*Dyes and Detergents*	*Use of bioreactors for bioremediation.*	*Bioremediation in fresh water and marine systems*	*Heavy metal bioremediation by filamentous fungi*	*In situ disposal strategies*

S-7	SLO-1	*PAH and Aliphatic hydrocarbons*	*Soil bioreactors: Dry and slurry bioreactors*	*Bioremediation in marine systems*	*Microbial Desulfurization of coal*	*Bioremediation of oil/hydrocarbon contaminated sites*
	SLO-2	*Ocean oil spills and its consequences*	*Anaerobic and aerobic bioreactors for ex situ remediation*	*Natural Attenuation process*	*Biosorption by live and dead cells*	*Pathways for hydrocarbon degradation*
S-8	SLO-1	*Heavy metals leach in ground water*	*Composting of recalcitrant wastes*	*Ground water bioremediation*	*Extraction of metals from ores and metal recovery*	*Nuclear waste management by microbial intervention*
	SLO-2	*Antibiotics in wastewater*	*Land farm bioremediation for in situ wastes*	*Water desalination*	*Nano-sponges*	*e-waste management by microbial intervention*
S-9	SLO-1	*Volatile organic compounds (VOCs)*	*Fungal bioremediation*	*Reverse osmosis for toxic pollutant removal*	*Microbial enhanced oil recovery (MEOR)*	*Case studies of e-waste industries*
	SLO-2	*Radioactive compounds*	*Functionality of fungal enzymes*	*Membrane technology for pollutant removal*	*Nano material for metal recovery and treatment*	*Emerging contaminants*

Learning Resources	1. *Principles and Applications" McGraw-Hill, 2001.* 2. *Agarwal S. K., "Environmental Biotechnology", APH Publishing, 2000* 3. *Martin Alexander, "Biodegradation & Bioremediation", Academic press, 1999.*

Learning Assessment

	Bloom's Level of Thinking	Continuous Learning Assessment (50% weightage)								Final Examination (50% weightage)	
		CLA – 1 (10%)		CLA – 2 (15%)		CLA – 3 (15%)		CLA – 4 (10%)#			
		Theory	Practice	Theory	Practice	Theory	Practice	Theory	Practice	Theory	Practice
Level 1	Remember Understand	*40 %*	-	*30%*	-	*30%*	-	*30%*	-	*30%*	-
Level 2	Apply Analyze	*40 %*	-	*40%*	-	*40%*	-	*40%*	-	*40%*	-
Level 3	Evaluate Create	*20 %*	-	*30%*	-	*30%*	-	*30%*	-	*30%*	-
	Total	100 %		100 %		100 %		100 %		100 %	

CLA – 4 can be from any combination of these: Assignments, Seminars, Tech Talks, Mini-Projects, Case-Studies, Self-Study, MOOCs, Certifications, Conf. Paper etc.,

Course Designers		
Experts from Industry	Experts from Higher Technical Institutions	Internal Experts
1. Dr. S. Sam Gunasekar, Orchid Chemicals and Pharmaceuticals Ltd., sam@orchidpharma.com	*1. Dr. A. Gnanamani, CSIR-Central Leather Research Institute, agmani_2000@yahoomail.com*	*Dr. K.Ramani, SRMIST*
2.Dr. D. Gunaseelan, BIOCON Ltd., guna.sachin@gmail.com	*2. Dr. Anbumani Sadasivam, CSIR-Indian Institute of Toxicology Research,anbumani@iitr.res.in*	*Dr.W.Richard Thilagaraj, SRMIST*

Course Code	18BTE410T	Course Name	ENVIRONMENT BIOSENSORS	Course Category	E	Professional Elective	L	T	P	C
							3	0	0	3

Pre-requisite Courses	Nil	Co-requisite Courses	Nil	Progressive Courses	Nil
Course Offering Department	Biotechnology	Data Book / Codes/Standards	Nil		

Course Learning Rationale (CLR):	*The purpose of learning this course is to:*
CLR-1 :	*Understand the fundamentals of biosensors*
CLR-2 :	*Educate the various types of biosensors*
CLR-3 :	*Identify and choose the biosensor for the environmental monitoring*
CLR-4:	*Apply various types of biosensors for the environmental applications*
CLR-5:	*Design the biosensor based on the pollutant parameters*
CLR-6:	*Apply the biomolecules in the development of biosensors*

Course Learning Outcomes (CLO):	*At the end of this course, learners will be able to:*	Learning 1: Level of Thinking (Bloom)	Learning 2: Expected Proficiency (%)	Learning 3: Expected Attainment (%)	PLO 1: Engineering Knowledge	PLO 2: Problem Analysis	PLO 3: Design & Development	PLO 4: Analysis, Design, Research	PLO 5: Modern Tool Usage	PLO 6: Society & Culture	PLO 7: Environment & Sustainability	PLO 8: Ethics	PLO 9: Individual & Team Work	PLO 10: Communication	PLO 11: Project Mgt. & Finance	PLO 12: Life Long Learning	PLO 13: PSO - 1	PLO 14: PSO - 2	PLO 15: PSO – 3
CLO-1 :	*Describe the fundamental principles of biosensors*	*1*	*80*	*80*	*H*	*H*	*H*	*H*	*H*	*H*	*H*	*H*	*H*	*H*	*H*	*H*	*H*	*H*	*H*
CLO-2 :	*Explain the biosensor concepts for pollutant monitoring*	*2*	*85*	*75*	*H*	*H*	*H*	*H*	*H*	*H*	*M*	*H*	*H*	*H*	*H*	*H*	*H*	*H*	*H*
CLO-3 :	*Design the biosensors for the detection of emerging contaminants*	*2*	*75*	*80*	*M*	*H*	*M*	*H*	*M*	*M*	*H*	*M*	*H*	*H*	*H*	*H*	*H*	*H*	*H*
CLO-4 :	*Apply the specific biomolecules for the sensor development for the pollutants monitoring*	*2*	*85*	*80*	*H*	*H*	*H*	*H*	*M*	*H*	*H*	*H*	*H*	*H*	*H*	*H*	*H*	*H*	*H*
CLO-5 :	*Apply the nanomaterial for the development of environmental biosensors*	*3*	*85*	*75*	*H*	*H*	*H*	*H*	*H*	*M*	*H*	*H*	*H*	*M*	*H*	*H*	*H*	*H*	*H*
CLO-6 :	*Understand the importance of novel biosensor development for the environmental applications*	*2*	*80*	*80*	*H*	*H*	*H*	*H*	*H*	*M*	*M*	*M*	*H*	*H*	*H*	*H*	*H*	*H*	*H*

Duration (hour)		9	9	9	9	9
S-1	SLO-1	*Short Biosensor History*	*Biotransducers*	*Application of biosensors for Environmental Monitoring- Detection of Organic Compounds*	*DNA, Biological Recognition & Receptor based Sensors*	*Nanotechnology-based Biosensor*
	SLO-2	*Fundamentals of Biosensors*	*Classification of Biosensors*	*Polychlorinated biphenyls (PCB)*	*A Fiber Optic DNA Sensor for Rapid Detection of Environmental E.coli*	*Multi-analyte determination*
S-2	SLO-1	*Components of Biosensor*	*Electrochemical Biosensors*	*Endocrine-disrupting chemicals*	*Application of electrochemical DNA-Biosensor to Environmental problems*	*Miniaturisation*
	SLO-2	*Types of Biosensors*	*Electrochemical Immunosensors*	*Antibiotics*	*Application of nucleic acid based optical bioprobe for environmental and pharmaceutical analysis*	*Mass Production*
S-3	SLO-1	*Characteristics of Biosensor*	*Optical Biosensors*	*Pesticides*	*Lipid-based enzyme electrodes for environmental pollution control- Lipid based sensors for continuous monitoring or rapid screening of environmental pollutants in the field.*	*Network Systems*
	SLO-2	*Biosensor Technologies*	*Electronic Biosensors*	*Hormones*	*Immunochemical assays for pesticides and PCBs*	*Validation*
S-4	SLO-1	*Types of Bioreceptors*	*FET- based Electronic Biosensors*	*Application of Biosensors for Environmental Monitoring- Detection of Inorganic Compounds*	*Direct piezoelectric immunosensor for pesticides*	*Bioengineering (GMO)*
	SLO-2	*Sensing Techniques of Biosensors*	*Piezoelectric Biosensors*	*Heavy Metals*	*Enzyme sensors for detection of pesticides families*	*Biosensors for environmental monitoring- An EPA perspective*
S-5	SLO-1	*Biosensors Development for Environmental Monitoring*	*Gravimetric Biosensors*	*Inorganic phosphate and nitrate*	*Biosensors for water quality and exposure assessment issues*	*Microsystem Technology in Biosensors*
	SLO-2	*Architectural Design*	*Pyroelectric Biosensors*	*Application of Biosensors for Environmental Monitoring- Detection of Biological Compounds*	*Nanomaterials- based biosensor for detection of environmental pollutants*	*Recent biosensors for the detection of pathogens*
S-6	SLO-1	*Bio element and Sensor Element Coupling*	*Impedimetric Biosensors*	*Biosides*	*Recent progress in biosensors for environmental monitoring*	*Recent biosensors for the detection of potentially toxic elements*

	SLO-2	*Various Coupling Mechanisms*	*Amperometric Biosensors*	*Whole cell bacteria detection*	*Application of nucleic acid hybridization for the detection of organisms*	*Recent biosensors for the detection of Toxins*
S-7	SLO-1	*Covalent Fabrication*	*Ion Channel Switch*	*Estimation of Biological Oxygen Demand (BOD)*	*Enzyme-based electrochemical biosensors to detect pharmaceuticals residues in waste water*	*Recent biosensors for the detection of Endocrine disrupting chemicals*
	SLO-2	*Matrix Immobilization*	*Optical Biosensors*	*Microbial Detection*	*Biosensor for the detection of antibiotics residues in milk*	*Recent biosensors for the detection and monitoring of air pollutants*
S-8	SLO-1	*Membrane Encapsulation*	*Microarrays*	*Antibiotic resistant organisms*	*Lipid membranes based biosensor for the rapid detection of toxins*	*Recent biosensors for the detection and monitoring of water pollutants*
	SLO-2	*Physical Adsorption Fabrication*	*Surface Plasmon Resonance*	*Application of Biosensors for Environmental Monitoring- Detection of Air Pollutants*	*Nucleic acid based biosensors for environmental pollution monitoring*	*Future sensing system based on conjugation of biosensor and drones for monitoring remote areas*
S-9	SLO-1	*Nano Biosensors*	*Reagentless Fluorescent (RF) Biosensors*	*Biosensors for direct monitoring and indoor air quality and exposure assessment issues*	*Reporter genes based biosensors for chemical contamination sensing*	*Recent biosensors for the detection of pollutants in effluents*
	SLO-2	*Advantages of nanotechnological approaches to biosensor development*	*Glucose Biosensors*	*Application in Biodefense Biosensing*	*Biosensor for the detection of antibiotics in Poultry effluent*	*Recent biosensor for the detection of contaminants in effluent treatment plant*

Learning Resources	1. *Biosensors for Direct Monitoring of Environmental Pollutants in Field edited by D.P. Nikolelis, Ulrich J. Krull, Joseph Wang, Marco Mascini..* 2. *Chemical Sensors and Biosensors: Fundamentals and Applications edited by F.G. Bănică, Wiley, 2012 W. Strickberger, "Genetics," 3 rd edition – Phi Learning, 2008*

Learning Assessment

	Bloom's Level of Thinking	Continuous Learning Assessment (50% weightage)								Final Examination (50% weightage)	
		CLA – 1 (10%)		CLA – 2 (15%)		CLA – 3 (15%)		CLA – 4 (10%)#			
		Theory	Practice	Theory	Practice	Theory	Practice	Theory	Practice	Theory	Practice
Level 1	Remember Understand	*40 %*	-	*30%*	-	*30%*	-	*30%*	-	*30%*	-
Level 2	Apply Analyze	*40 %*	-	*40%*	-	*40%*	-	*40%*	-	*40%*	-
Level 3	Evaluate Create	*20 %*	-	*30%*	-	*30%*	-	*30%*	-	*30%*	-
	Total	100 %		100 %		100 %		100 %		100 %	

CLA – 4 can be from any combination of these: Assignments, Seminars, Tech Talks, Mini-Projects, Case-Studies, Self-Study, MOOCs, Certifications, Conf. Paper etc.,

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2 .Dr. D. Gunaseelan, BIOCON Ltd., guna.sachin@gmail.com	*2. Dr. Anbumani Sadasivam, CSIR-Indian Institute of Toxicology Research,anbumani@iitr.res.in*	*Dr.W.Richard Thilagaraj, SRMIST*

Course Code	18BTE411T	Course Name	MOLECULAR CELL BIOLOGY	Course Category	E	Professional Elective	L	T	P	C
							3	0	0	3

Pre-requisite Courses	Nil	Co-requisite Courses	Nil	Progressive Courses	Nil
Course Offering Department	Biotechnology	Data Book / Codes/Standards			

Course Learning Rationale (CLR):	*The purpose of learning this course is to:*
CLR-1 :	*Provide basic knowledge of stem cell specific gene expression in lineage based tissues from the perspective of engineers.*
CLR-2 :	*Identify the role of epigenetic regulation in stem cell proliferation and differentiation*
CLR-3 :	*Deliver the knowledge on signaling molecules and molecular mechanisms that regulate the stem cell proliferation and differentiation.*
CLR-4:	*Analyze transcriptomics and its applications in tissue engineering*
CLR-5:	*Create insights on genome reprogramming.*
CLR-6:	*Utilize the strategies for novel gene editing techniques for tissue engineering*

Course Learning Outcomes (CLO):	*At the end of this course, learners will be able to:*	Learning 1: Level of Thinking (Bloom)	Learning 2: Expected Proficiency (%)	Learning 3: Expected Attainment (%)
CLO-1 :	*Identify gene regulation in stem cells.*	*2*	*85*	*80*
CLO-2 :	*Analyze gene expression in stem cells and artificial generation of pluripotency.*	*2*	*80*	*75*
CLO-3 :	*Identify the applications of growth factor signaling and their receptor molecules.*	*2*	*80*	*75*
CLO-4 :	*Analyze the regulation of molecules involved in self-renewal of stem cells.*	*2*	*85*	*80*
CLO-5 :	*Discuss stem cell death mechanisms.*	*2*	*85*	*80*
CLO-6 :	*Explain nerve cell regeneration, cell survival and cell death.*	*2*	*80*	*75*

Program Learning Outcomes (PLO)

	1 Engineering Knowledge	2 Problem Analysis	3 Design & Development	4 Analysis, Design, Research	5 Modern Tool Usage	6 Society & Culture	7 Environment & Sustainability	8 Ethics	9 Individual & Team Work	10 Communication	11 Project Mgt. & Finance	12 Life Long Learning	13 PSO - 1	14 PSO - 2	15 PSO – 3
CLO-1	*H*	-	*M*	*H*	-	-	-	*H*	-	-	-	*H*	*H*	*H*	*H*
CLO-2	*M*	-	*M*	*H*	-	-	-	*M*	-	-	-	*M*	*H*	*H*	*H*
CLO-3	*M*	-	*M*	*H*	-	-	-	*H*	-	-	-	*H*	*H*	*H*	*H*
CLO-4	*M*	-	*M*	*H*	-	-	-	*H*	-	-	-	*M*	*H*	*H*	*H*
CLO-5	*H*	-	*M*	*H*	-	-	-	*M*	-	-	-	*H*	*H*	*H*	*H*
CLO-6	*H*	-	*M*	*H*	-	-	-	*H*	-	-	-	*M*	*H*	*H*	*H*

Duration (hour)		9	9	9	9	9
S-1	SLO-1	*Introduction to nucleic acids - genetic material,*	*Overview of Central dogma.*	*Principles of membrane organization membrane proteins*	*Differentiation in Early Development*	*Newborn screening: Neonatal PKU*
	SLO-2	*Structure and physicochemical properties of elements.*	*Characteristics promoter and enhancer sequences.*	*cytoskeletal proteins Extra cellular matrix*	*Potency, Commitment,*	*Cystic fibrosis and sweat tests.*
S-2	SLO-1	*Primary and secondary structure of DNA*	*Transcriptional bubble - prokaryotic and eukaryotic RNA polymerase*	*cell-cell junctions, various types of transport across cell membrane.*	*Polarity and the specification of asymmetric divisions.*	*Prenatal diagnosis of diseases, amniotic fluid*
	SLO-2	*Watson & Crick model*	*RNA synthesis- Fidelity of RNA synthesis. Inhibitors of transcription.*	*Protein sorting and trafficking, cargo proteins.*	*Cellular differentiation of the Nervous system*	*Fetal blood examination.*
S-3	SLO-1	*Hogsteen base pairing, Triple helix, Quadruple helix.*	*Differences in prokaryotic and eukaryotic transcription.*	*Growth factor signaling, cell-cell communication*	*Neuronal and Glial Progenitors in Adult Brain,*	*Karyotyping, Chromosomal abnormalities by cytogenetics.*
	SLO-2	*DNA super-coiling*	*Regulatory elements*	*Mechanism of action of different class of hormones.*	*Epithelial Stem Cells; Adult Progenitor Cells,*	*Restriction fragment length polymorphism (RFLP)*
S-4	SLO-1	*Linking number- satellite*	*Mechanism of transcription regulation.*	*Cell cycle –Molecules controlling cell cycle*	*Mesenchymal Stem Cells, Plasticity*	*Polymerase chain reaction (PCR)*
	SLO-2	*DNA replication*	*Transcription termination.*	*Cancer, role of Ras and Raf Oncogenesis and apoptosis.*	*De-differentiation and redifferentiation*	*Nuclear injection*
S-5	SLO-1	*Meselson & Stahl experiment bi–directional DNA replication*	*Splicing - nuclear export of mRNA - mRNA stability.*	*Cell culture and immortalization of cells and its applications.*	*Cancer cells and cancer stem Cells.*	*stem cell transplantations for sickle-cell anemia, hemophilia,*
	SLO-2	*Proteomics of DNA replication*	*Role of gene expression in microRNA*	*Molecular Basis of Pluripotency*	*Hematopoietic Stem Cells.*	*Stem cell transplantation for cancer (leukemia and myeloma).*
S-6	SLO-1	*Overview of differences in prokaryotic and eukaryotic DNA replication*	*LncRNA, snoRNA, piRNA*	*Induced pluripotency.*	*Stem Cells and tissue engineerings.*	*Muscular dystrophy and stem cell therapy*
	SLO-2	*Role of telomerase in aging and cancer*	*srRNA, siRNA and shRNA.*	*Cell cycle regulators in Stem Cells*	*Embryonic Stem Cells in Tissue Engineering.*	*Stem cell therapy*
S-7	SLO-1	*Mutagens, DNA mutations and their mechanism*	*Genetic code: Elucidation of genetic code*	*Stem Cell Niches,*	*Organ culture*	*Neurodegenerative disease*

	SLO-2	*Telomere replication in eukaryotes DNA Repair.*	*Codon degeneracy, Wobble hypothesis and its importance*	*Change of Phenotype and Differentiation,*	*Characterization and maintenance of murine and human embryonic stem cells,*	*Stem cell transplantation*
S-8	SLO-1	*DNA mismatch, Base-excision*	*Prokaryotic and eukaryotic ribosomes.*	*Aging and stem cell renewal, Quiescent Stem Cells.*	*Differentiation of embryonic Stem Cells*	*Dementia*
	SLO-2	*Nucleotide-excision and direct repair DNA recombination*	*Prokaryotic and eukaryotic translation and post-translational modification*	*Lineage tracing experiments in stem cells*	*Embryonic stem cell cloning*	*Neurodegenerative disease*
S-9	SLO-1	*Homologous, site-specific and DNA transposition*	*Regulation of gene expression with reference to λ phage life cycle.*	*Techniques used to study cells: flow cytometry and Confocal Microscopy.*	*Therapeutic cloning of stem cells*	*CRIPSR/Cas9 system-gene editing*
	SLO-2	*Operon concept - Lac and Trp operon*	*Eukaryotic gene regulation*	*Antibody labeling and Immunohistochemistry*	*Genomic Reprogramming*	*Applications of CRISPR/CAS-9 techniques in regenerative medicine.*

Learning Resources	1. *Fundamentals of Biochemistry. Life at the molecular level by Donald Voet, Judith G. Voet and Charlotte W. Pratt. Willey 2016.* 2. *Tietz Fundamentals of Clinical Chemistry and Molecular Diagnostics, Carl A. Burtis, David E. Bruns. 7th ed. Elsevier, 2014.* 3. *Practical Clinical Biochemistry, Harold Varley, Interscience Publishers Inc, 2005*	4. *Lecture Notes Clinical Biochemistry (8th Edition). Simon Walker, S., Ashby, P. , Rae, P., and Beckett, G., Blackwell, 2010.* 5. *Textbook of Biochemistry With Clinical Correlations. Devlin, D.M., (Ed). Wiley-Liss, 2010.*

SLO – Session Learning Outcome

Learning Assessment

	Bloom's Level of Thinking	Continuous Learning Assessment (50% weightage)								Final Examination (50% weightage)	
		CLA – 1 (10%)		CLA – 2 (15%)		CLA – 3 (15%)		CLA – 4 (10%)#			
		Theory	Practice	Theory	Practice	Theory	Practice	Theory	Practice	Theory	Practice
Level 1	Remember Understand	*40 %*	-	*30%*	-	*30%*	-	*30%*	-	*30%*	-
Level 2	Apply Analyze	*40 %*	-	*40%*	-	*40%*	-	*40%*	-	*40%*	-
Level 3	Evaluate Create	*20 %*	-	*30%*	-	*30%*	-	*30%*	-	*30%*	-
	Total	100 %		100 %		100 %		100 %		100 %	

CLA – 4 can be from any combination of these: Assignments, Seminars, Tech Talks, Mini-Projects, Case-Studies, Self-Study, MOOCs, Certifications, Conf. Paper etc.,

Course Designers		
Experts from Industry	Experts from Higher Technical Institutions	Internal Experts
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Course Code	18BTE412T	Course Name	CELL COMMUNICATION AND SIGNALING	Course Category	E	Professional Elective	L	T	P	C
							3	0	0	3

Pre-requisite Courses	Nil	Co-requisite Courses	Nil	Progressive Courses	Nil
Course Offering Department	Biotechnology	Data Book / Codes/Standards			

Course Learning Rationale (CLR):	*The purpose of learning this course is to:*
CLR-1 :	*Provide basic concepts of gene expression patterns from the perspective of engineers*
CLR-2 :	*Identify the role of epigenetic regulation in adult stem cells*
CLR-3 :	*Identify the external and internal signaling molecules that regulate the stem cell proliferation and differentiation*
CLR-4:	*Analyze the self-renewal and cell death mechanisms in stem cells*
CLR-5:	*Encourage engineering students to think solving neural degenerative diseases with stem cells*
CLR-6:	*Analyze the molecular mechanism of stemness- signaling pathways and transcription factors*

Course Learning Outcomes (CLO):	*At the end of this course, learners will be able to:*	Learning 1: Level of Thinking (Bloom)	Learning 2: Expected Proficiency (%)	Learning 3: Expected Attainment (%)	PLO 1: Engineering Knowledge	PLO 2: Problem Analysis	PLO 3: Design & Development	PLO 4: Analysis, Design, Research	PLO 5: Modern Tool Usage	PLO 6: Society & Culture	PLO 7: Environment & Sustainability	PLO 8: Ethics	PLO 9: Individual & Team Work	PLO 10: Communication	PLO 11: Project Mgt. & Finance	PLO 12: Life Long Learning	PLO 13: PSO - 1	PLO 14: PSO - 2	PLO 15: PSO – 3
CLO-1 :	*Apply the basic understanding of gene regulation in stem cells*	2	85	80	H	H	-	H	-	-	-	M	-	H	-	H	H	H	H
CLO-2 :	*Manipulate the gene expression in stem cells and artificial generation of pluripotency*	2	80	75	M	M	-	M	-	-	-	M	-	H	-	H	H	H	H
CLO-3 :	*Identify the applications of growth factor signaling and their receptor molecules*	2	80	80	H	M	-	M	-	-	-	M	-	H	-	H	H	H	H
CLO-4 :	*Apply the regulation of molecules involved in self-renewal of stem cells*	2	85	80	H	H	-	M	-	-	-	M	-	H	-	H	H	H	H
CLO-5 :	*Discuss the stem cell death mechanisms*	2	80	85	M	M	-	H	-	-	-	M	-	H	-	H	H	H	H
CLO-6 :	*Analyze nerve cell regeneration, cell survival and cell death.*	2	80	80	H	M	-	H	-	-	-	M	-	H	-	H	H	H	H

Duration (hour)		9	9	9	9	9
S-1	SLO-1	*Germ line stem cells*	*cell surface receptor mediated signal transduction*	*Stem cell aging and apoptosis*	*Neural stem cells*	*Regeneration, Stem Cells, and the Evolution of Tumor Suppression*
	SLO-2	*Embryonic fate cell decision*	*Growth factor and receptors*	*Regulation and significance apoptosis in stem cells*	*Neural progenitors*	*Smads - Polycomb genes*
S-2	SLO-1	*Interaction between stem cells and their niche*	*tyrosine kinases Mediated signaling (Ras-Raf-MAP-MEK)*	*Stem cell necrosis*	*The heterogeneity of adult neural stem cells*	*Cellular signaling of Akt/PKB - β-catenin*
	SLO-2	*Transcriptional regulatory circuitry in embryonic stem cells*	*Wnt -signaling*	*Intrinsic - extrinsic pathways of apoptosis*	*Emerging complexity of neural niche*	*Induced pluripotency (iPSc)*
S-3	SLO-1	*Gene expression during development*	*Notch signaling pathways*	*Death ligands, cytokines and tumor necrosis factor*	*Neural stem cell signaling*	*Epithelial-mesenchymal transition (EMT)*
	SLO-2	*Maintenance of totipotency and its factors*	*Hedgehog singling*	*Role of apoptosis in hematopoiesis*	*Neural stem cell homeostasis*	*EMT markers*
S-4	SLO-1	*Pluripotency associated transcription factors*	*Hippo signaling*	*Apoptosis resistance in stem cells*	*Galecitin-1 in neural stem cells*	*Growth factor induced differentiation of stem cells*
	SLO-2	*Tissue specific multipotency*	*Insulin-like growth factor signaling*	*Anti-apoptotic molecules expression in stem cells*	*Human ESC-derived Neural Rosettes and neural stem cell progression*	*Pancreatic stem cells*
S-5	SLO-1	*Stem cells with no tissue specificity*	*NfκB signaling pathways*	*Caspase mediated apoptosis*	*CNS fluids and neuronal differentiation*	*Beta cell differentiation factors and transplantation*
	SLO-2	*Transcriptional network controlling pluripotency in ES cells*	*TGFβ -activing/nodal BMP-signaling*	*Apoptosis transcription factors and regulators*	*Neurotransmitter-induced stem cell differentiation*	*Stem cell therapy for obesity*
S-6	SLO-1	*Alternative splicing in embryonic stem cells*	*FGF signaling pathways*	*Heat shock proteins*	*cholinergic-dopaminergic signals*	*Leukemia, lymphoma and Myeloma*
	SLO-2	*Niche required for inducing stem cell control*	*Hemotopoiesis and signaling molecules*	*Apoptosis intracellular kinases*	*Nerve cell growth factor*	*Bone marrow transplantation*
S-7	SLO-1	*Homeostasis and Feed-back regulation in niche*	*Progenitor cell differentiation factors*	*Apoptosis adaptor proteins*	*Induced regeneration of neuronal cells*	*Cytokine and chemokine therapies*
	SLO-2	*Cytokines and growth factors maintenance of stemness*	*Colony stimulating factor and its receptor signaling pathways*	*Small molecules-induced apoptosis*	*Neurosphere culture*	*Cancer stem cell - cell survival and tumor maintenance*

S-8	SLO-1	*Modeling for stem cell asymmetry*	*Platelet-derived growth factor signaling pathways*	*Inhibitors of apoptosis in cancer stem cells*	*Astrocyte, oligodendrocyte differentiation*	Mechanism of cancer stem cell resistance
	SLO-2	*Pluripotency genes, expression and regulation*	*Role of oncogenes in embryonic stem cells*	*Cellular senescence pathways*	*Glial cell differentiation*	Targeting cancer stem cells
S-9	SLO-1	*Epigenetic changes in DNA*	*Steroid hormone receptor signaling pathways*	*Telomerase in adult and pluripotent stem cells and Telomerase shortening*	*Pathophysiology of neuronal stem cell signaling*	Selective killing of cancer stem cells
	SLO-2	*Epigenetic changes in histones*	*Effects of melatonin and seratonin in stem cells*	*Autoimmune destruction of stem cells*	*Multiple sclerosis, Parkinson's and Alzhimer's*	Nanocarrier mediated drug delivery

Learning Resources	1. *The science of stem cells - Jonathan M.W Slack - Wiley Blackwell - 2018.* 2. *Transcriptional and Translational regulation of stem cells - (Advances in experimental medicine and biology - Gary Hime and Helen Abud, 2013.* 3. *Stem cell regulators (Vitamins and Hormones Book 87) - Gerald Litwack - Academic Press – 2011* 4. *Control and regulation of stem cells- Bruce Stillman, David Stewart, Terri Grodzicker - Cold Spring Harbor Laboratory -2008*

SLO – Session Learning Outcome

Learning Assessment

	Bloom's Level of Thinking	Continuous Learning Assessment (50% weightage)								Final Examination (50% weightage)	
		CLA – 1 (10%)		CLA – 2 (15%)		CLA – 3 (15%)		CLA – 4 (10%)#			
		Theory	Practice	Theory	Practice	Theory	Practice	Theory	Practice	Theory	Practice
Level 1	Remember Understand	*40 %*	-	*30%*	-	*30%*	-	*30%*	-	*30%*	-
Level 2	Apply Analyze	*40 %*	-	*40%*	-	*40%*	-	*40%*	-	*40%*	-
Level 3	Evaluate Create	*20 %*	-	*30%*	-	*30%*	-	*30%*	-	*30%*	-
	Total	100 %		100 %		100 %		100 %		100 %	

CLA – 4 can be from any combination of these: Assignments, Seminars, Tech Talks, Mini-Projects, Case-Studies, Self-Study, MOOCs, Certifications, Conf. Paper etc.,

Course Designers

Experts from Industry	Experts from Higher Technical Institutions	Internal Experts
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Course Code	18BTE413T	Course Name	STEM CELL TECHNOLOGY	Course Category	E	Professional Elective	L	T	P	C
							3	0	0	3

Pre-requisite Courses	Nil	Co-requisite Courses	Nil	Progressive Courses	Nil
Course Offering Department	Biotechnology	Data Book / Codes/Standards	Nil		

Course Learning Rationale (CLR):	*The purpose of learning this course is to:*
CLR-1 :	*Provide basic knowledge on embryogenesis from the perspective of engineers.*
CLR-2 :	*Create an interest to know about the different types of stem cells, its isolation, differentiation and transdifferentiation.*
CLR-3 :	*Develop awareness about cancer stem cells, iPSCs and importance of stem cell niches.*
CLR-4:	*Initiate interest on signaling pathways, epigenetics and latest techniques on gene editing.*
CLR-5:	*Generate interest on applications and uses of stem cells and create awareness on ethics and regulations of stem cell research.*
CLR-6:	*Encourage engineering students to develop the strategies for ex vivo for tissue development and disease*

Course Learning Outcomes (CLO):	*At the end of this course, learners will be able to:*	Learning 1: Level of Thinking (Bloom)	2: Expected Proficiency (%)	3: Expected Attainment (%)	PLO 1: Engineering Knowledge	2: Problem Analysis	3: Design & Development	4: Analysis, Design, Research	5: Modern Tool Usage	6: Society & Culture	7: Environment & Sustainability	8: Ethics	9: Individual & Team Work	10: Communication	11: Project Mgt. & Finance	12: Life Long Learning	13: PSO - 1	14: PSO - 2	15: PSO – 3
CLO-1 :	*Apply knowledge about embryogenesis, stem cells and its characteristics.*	2	80	70	-	-	H	M	-	-	M	H	-	H	-	H	H	H	H
CLO-2 :	*Gain knowledge on different types of stem cells isolation of ESCs, its specialized functions and transdifferentiation.*	3	85	70	-	-	H	M	-	-	M	H	-	H	-	H	H	H	H
CLO-3 :	*Discuss about cancer stem cells, iPSCs and stem cell niches.*	2	80	75	-	-	H	M	-	-	M	H	-	H	-	H	H	H	H
CLO-4 :	*Identify the role of signaling pathways, epigenetics and genome editing in engineering of stem cells.*	2	80	70	-	-	H	M	-	-	M	H	-	H	-	H	H	H	H
CLO-5 :	*Utilize application of stem cells in tissue engineering, treatment of different diseases & ethics and regulations of stem cell research.*	3	80	70	-	-	H	M	-	-	M	H	-	H	-	H	H	H	H
CLO-6 :	*Apply knowledge on CRISPR/Cas9 gene editing system.*	3	80	70	-	-	H	M	-	-	M	H	-	H	-	H	H	H	H

Duration (hour)		9	9	9	9	9
S-1	SLO-1	*Overview of Stem cells*	*ESCs –IVF, Primate and Mouse ES cells, Markerss*	*Adult stem cells (ASC)-advantages and disadvantages*	*ESC pluripotency and signaling- JAK-STAT pathway*	*Stem Cells in Tissue Engineering*
	SLO-2	*Early development of embryos*	*Nuclear transfer technology in ES cells*	*Sources of ASCs and its properties and its role as specialised cells in differentiation*	*Activin/Nodal/TGFβ Signaling Pathway*	*Therapeutic Applications*
S-2	SLO-1	*Stem Cells in research*	*Human ESCs*	*Transdifferentiation-Definition*	*FGF Signaling Pathway*	*Parkinson's disease*
	SLO-2	*Totipotent, multipotent, oligopotent*	*Isolation and culturing of hESC's*	*Fusion experiments*	*Wnt signaling and Insulin-like growth factors*	*Factors for a Successful Cell Therapy in PD- Problems*
S-3	SLO-1	*"Stemness": Definitions, Criteria*	*Differentiation of stem cells*	*Experiments on transdifferentiation*	*HSC signaling pathways- Notch*	*Autograft, allograft and xenograft-stem cells*
	SLO-2	*Criteria and Standard of stemness*	*Stem Cell Niche in Regenerative Medicine-Stem cells and their niches*	*Intestine-oseophagus cell transition, lens regeneration, liver to pancreas and vice versa*	*Wnt signaling*	*Bone defects-biomaterials- stem cells-osteoprogenitors-osteoblasts*
S-4	SLO-1	*Formation of stem cells*	*Stem Cells derived from early mouse embryos-ES cells*	*Induced pluripotent stem cells (iPSCs)-Methodology*	*TGF signaling*	*Stem Cells for Spinal Cord Injury-Introduction*
	SLO-2	*Embryonic and adult stem cells*	*EC cells*	*Induced pluripotent stem cells (iPSCs)-Applications*	*SMAD signalling*	*Common strategies toward regeneration of the damaged spinal cord.*
S-5	SLO-1	*Potency of Stem Cells*	*EG cells*	*SCNT*	*Epigenetic control of stem cells-experimental background*	*Stem Cell treatment for diabetes-Types of diabetes*
	SLO-2	*Types and classification of stem cells based on potency*	*TS cells*	*Cell fusion, treatment*	*Effects of global histone modifications*	*Development of cell-based therapies for diabetes*
S-6	SLO-1	*Types of stem cells –Embryonic stem cells (ESCs)*	*Systems/models for ES differentiation*	*Cancer stem cells- Isolation*	*DNA methylation in differentiated versus undifferentiated cells*	*Cardiac tissue engineering using stem cells-Methodology*
	SLO-2	*Types of stem cells-Adult stem cells (ASCs)*	*3D bioprinting using stem cells*	*Cancer stem cells -Characterization*	*Effect of TSA on stem cell differentiation*	*Cardiac tissue engineering using stem cells - Applications*
S-7	SLO-1	*Differences between ESCs and ASCs*	*Formation of early extraembryonic lineages*	*Cancer Stem Cells - properties, origin*	*Transcriptional factors network*	*Stem cell treatment for burns*

	SLO-2	*Similarities between ESCs and ASCs*	*Pluripotent cell development*	*Cancer Stem Cells - Theories*	*Effects of histone demethylases*	*Transplantable matrices*
S-8	SLO-1	*Identification and characterization of ESCs at cellular level*	*Formation of somatic lineages—Haematopoietic Lineages*	*CSCs and Metastasis: The Primary TME*	*Epigenetics in somatic cells*	*Ethics of Stem Cell Research- The Ethics of Destroying Human Embryos for Research*
	SLO-2	*Identification and characterization of ESCs at molecular level*	*Formation of somatic lineages—Neuronal Lineages*	*CSCs and Metastasis: Metastatic Niche*	*Epigenetics in iPSCs*	*The Ethics of Using Human Embryonic Stem Cells in Research*
S-9	SLO-1	*Identification and characterization of ASCs at cellular level*	*Therapeutic cloning using ESCs-Disease cell model development*	*Breast cancer metastasis*	*Genome Editing in Stem Cells- ZFN, TALENS*	*Regulations governing Stem Cell research-ICMR, Drugs and Cosmetic Act*
	SLO-2	*Identification and characterization of ASCs at molecular level*	*Reproductive cloning using ESCs*	*Tumor suppressor and Proto-oncogenes*	*CRISPR/CAs9 strategies, Design of DNA donor templates for gene knock-ins*	*Stem Cell as the investigational new drug*

Learning Resources	*1. Robert Lanza, Edited by: Robert Lanza and Anthony Atala, "Essentials of Stem Cell Biology"3rd Edition, Academic Press, Copyright © 2014 Elsevier Inc. 4.* *2. Huang G, Ye S, Zhou X, Liu D, Ying QL. Molecular basis of embryonic stem cell self-renewal: from signaling pathways to pluripotency network. Cell Mol Life Sci. 2015, May; 72 (9):1741-57.*

Learning Assessment

	Bloom's Level of Thinking	Continuous Learning Assessment (50% weightage)								Final Examination (50% weightage)	
		CLA – 1 (10%)		CLA – 2 (15%)		CLA – 3 (15%)		CLA – 4 (10%)#			
		Theory	Practice	Theory	Practice	Theory	Practice	Theory	Practice	Theory	Practice
Level 1	Remember Understand	*40 %*	-	*30%*	-	*30%*	-	*30%*	-	*30%*	-
Level 2	Apply Analyze	*40 %*	-	*40%*	-	*40%*	-	*40%*	-	*40%*	-
Level 3	Evaluate Create	*20 %*	-	*30%*	-	*30%*	-	*30%*	-	*30%*	-
	Total	100 %		100 %		100 %		100 %		100 %	

CLA – 4 can be from any combination of these: Assignments, Seminars, Tech Talks, Mini-Projects, Case-Studies, Self-Study, MOOCs, Certifications, Conf. Paper etc.,

Course Designers

Experts from Industry	Experts from Higher Technical Institutions	Internal Experts
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Course Code	18BTE414T	Course Name	BIOMATERIALS IN TISSUE ENGINEERING	Course Category	E	Professional Elective	L	T	P	C
							3	0	0	3

Pre-requisite Courses	Nil	Co-requisite Courses	Nil	Progressive Courses	Nil
Course Offering Department	Biotechonolgy	Data Book / Codes/Standards			

Course Learning Rationale (CLR):	*The purpose of learning this course is to:*	Learning			Program Learning Outcomes (PLO)														
		1	2	3	1	2	3	4	5	6	7	8	9	10	11	12	13	14	15
CLR-1 :	*Demonstrate the basic knowledge on biomaterials from the perspective of engineers.*																		
CLR-2 :	*Analyze biological tissue engineering problems with biomaterials.*																		
CLR-3 :	*Demonstrate basic concepts regarding design and mechanical properties of selected biomaterials.*																		
CLR-4:	*Analyze the design and mechanical properties of selected biomaterials for specific medical applications.*																		
CLR-5:	*Demonstrate good manufacturing of biomaterials*																		
CLR-6:	*Analyze the strategies for global marketing of biomaterials*																		
Course Learning Outcomes (CLO):	*At the end of this course, learners will be able to:*	Level of Thinking (Bloom)	Expected Proficiency (%)	Expected Attainment (%)	Engineering Knowledge	Problem Analysis	Design & Development	Analysis, Design, Research	Modern Tool Usage	Society & Culture	Environment & Sustainability	Ethics	Individual & Team Work	Communication	Project Mgt. & Finance	Life Long Learning	PSO - 1	PSO - 2	PSO – 3
CLO-1 :	*Explain the basic techniques to manufacture scaffolds from raw biomaterials and explain the different prerequisites for the biomaterials.*	*2*	*80*	*70*			*M*	*M*				*H*		*H*		*H*	*H*	*H*	*H*
CLO-2 :	*Illustrate the types of biomaterials for biomedical applications.*	*2*	*75*	*80*			*M*	*M*				*H*		*H*		*H*	*H*	*H*	*H*
CLO-3 :	*Explain the biological problems in tissue engineering that require engineering expertise to solve them.*	*2*	*80*	*70*			*M*	*M*				*H*		*H*		*H*	*H*	*H*	*H*
CLO-4 :	*Explain the applications of biomaterials for various biomedical applications.*	*2*	*80*	*75*			*M*	*M*				*H*		*H*		*H*	*H*	*H*	*H*
CLO-5 :	*Explain good manufacturing of biomaterials related their applications.*	*3*	*80*	*70*			*M*	*M*				*H*		*H*		*H*	*H*	*H*	*H*
CLO-6 :	*Illustrate global marketing of biomaterials for commercialization*	*2*	*85*	*75*			*M*	*M*				*H*		*H*		*H*	*H*	*H*	*H*

Duration (hour)		9	9	9	9	9
S-1	SLO-1	*Introduction to biomaterials*	*Introduction to tissue engineering*	*Bioactive molecules*	*Applications of biomaterials*	*Biomaterials and their applications in medicine*
	SLO-2	*Properties and salient features of biomaterials*	*Basic concepts in tissue engineering*	*Classification and role of bioactive molecules in tissue engineering*	*Healthcare*	*Biomedical applications*
S-2	SLO-1	*Elements of Biomaterials*	*Fundamentals of tissue engineering*	*Stimuli responsive in biomaterials*	*Biomaterials in biomedical applications*	*Technical considerations of biomaterials*
	SLO-2	*Metals, implants*	*Complexity of tissue engineering*	*Stimuli responsive in polymers*	*Tissue engineering*	*Commercialization of biomaterials*
S-3	SLO-1	*Biomaterials preparation*	*Tissues*	*Biomimetics*	*wound care und suture materials,*	*Regulatory strategies for biomaterials*
	SLO-2	*Biomaterials characterization*	*Organization of tissues in vertebrate body*	*Dental and bone*	*vascular implants and bio-inspired materials*	*Monitoring of regulatory strategies for biomaterials*
S-4	SLO-1	*Processing of different bioceramic and*	*Cell sources*	*Drug deliveries*	*Biomimetic devices*	*Clinical development with biomaterials*
	SLO-2	*Properties of bioceramics*	*Stem cells*	*Nanoparticles in drug delivery*	*Organ transplant*	*Endpoint strategies for biomaterials*
S-5	SLO-1	*Processing of different polymeric materials*	*Cell lineages*	*Designing of nanoparticles for drug delivery*	*Tissue Construction*	*Clinical evaluation of biomaterials*
	SLO-2	*Properties of polymeric materials*	*Osteoblasts*	*Targeted delivery*	*Bioartificial tissues*	*Approval threshold of biomaterials*
S-6	SLO-1	*biocomposites materials*	*Cell-material interactions*	*Peptides in drug delivery*	*Connective tissues*	*Supply chain of biomaterials*
	SLO-2	*Polymers-ceramics*	*Cell-material response*	*Proteins in drug delivery*	*Regeneration of connective tissues*	*Biomaterials control*
S-7	SLO-1	*Physical properties of biomaterials*	*Assessment of biocompatibility of biomaterials*	*DNAs in drug delivery*	*Targeting ligands in drug delivery*	*Strategies of global marketing*
	SLO-2	*Chemical properties of biomaterials*	*MTT and cytotoxicity assays*	*RNAs, oligos in drug delivery*	*Targeting ligands in cancer treatment*	*Regulatory controls in global marketing*
S-8	SLO-1	*Mechanical properties of biomaterials*	*Cell viability assays*	*Surface modifications*	*Tissue regeneration and growth and repair*	*Global authorization of biomaterials*
	SLO-2	*Thermal properties off biomaterials*	*Antibacterial assessment of biomaterials-*	*Applications in drug delivery*	*Cell growth and repair*	*Global marketing of biomaterials*
S-9	SLO-1	*Evaluation of biomaterials*	*In vitro evaluation of biomaterials-*	*Advantages and limitations of biomaterials in drug delivery*	*Drug discovery*	*Post-market surveillance approaches for biomaterials*
	SLO-2	*Biological response*	*In vivo evaluation of biomaterials*	*Limitations of biomaterials in drug delivery*	*Impact of drug discovery and development*	*Good manufacturing practice for biomaterials*

Learning Resources	1. *Hench L. Larry, and Jones J., (Editors), Biomaterials, Artificial organs and Tissue Engineering, Woodhead Publishing Limited, 2005* 2. *Nanocomposite science and technology, Pulickel M. Ajayan, Linda S. Schadler and Paul V. Braun, Wiley-VCH, 2005* 3. *Ulrich Meyer, Thomas Meyer, Jörg Handschel, Hans Peter Wiesmann (2009): Fundamentals of Tissue Engineering and Regenerative Medicine, Springer* 4. *Regenerative Medicine and Tissue Engineering, Edited by Jose A. Andrades, ISBN 978-953-51-1108-5, Publisher: InTech,2013* 5. *S. Amato and B. Ezzell, (Editors), Regulatory Affairs for Biomaterials and Medical Devices, Woodhead Publisher, 2015*

Learning Assessment

	Bloom's Level of Thinking	Continuous Learning Assessment (50% weightage)								Final Examination (50% weightage)	
		CLA – 1 (10%)		CLA – 2 (15%)		CLA – 3 (15%)		CLA – 4 (10%)#			
		Theory	Practice	Theory	Practice	Theory	Practice	Theory	Practice	Theory	Practice
Level 1	Remember Understand	*40 %*	-	*30%*	-	*30%*	-	*30%*	-	*30%*	-
Level 2	Apply Analyze	*40 %*	-	*40%*	-	*40%*	-	*40%*	-	*40%*	-
Level 3	Evaluate Create	*20 %*	-	*30%*	-	*30%*	-	*30%*	-	*30%*	-
	Total	100 %		100 %		100 %		100 %		100 %	

CLA – 4 can be from any combination of these: Assignments, Seminars, Tech Talks, Mini-Projects, Case-Studies, Self-Study, MOOCs, Certifications, Conf. Paper etc.,

Course Designers

Experts from Industry	Experts from Higher Technical Institutions	Internal Expert
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2. Dr. Gokuladhas Krishnan , Director, Laboratory, *World Stem Cell Clinic, Chennai, care@worldstemcellclinic.com*	*2. N. Srinivasan, Ph. D., Chettinad Health City, Chennai* *srinivasanibms@gmail.com*	*2. Dr. M. Pandima Devi, SRMIST* *pandimam@srmist.edu.in*

Course Code	18BTE415T	Course Name	NANOTECHNOLOGY IN REGENERATIVE MEDICINE	Course Category	E	Professional Elective	L	T	P	C
							3	0	0	3

Pre-requisite Courses	Nil	Co-requisite Courses	Nil	Progressive Courses	Nil
Course Offering Department	Biotechonolgy	Data Book / Codes/Standards			

Course Learning Rationale (CLR):	*The purpose of learning this course is to:*	Learning 1	Learning 2	Learning 3	PLO 1	2	3	4	5	6	7	8	9	10	11	12	13	14	15
CLR-1 :	*Provide an overview of the distinctive features of nanotechnology and their application to bio-medical problems from the perspective of engineers.*	Level of Thinking (Bloom)	Expected Proficiency (%)	Expected Attainment (%)	Engineering Knowledge	Problem Analysis	Design & Development	Analysis, Design, Research	Modern Tool Usage	Society & Culture	Environment & Sustainability	Ethics	Individual & Team Work	Communication	Project Mgt. & Finance	Life Long Learning	PSO - 1	PSO - 2	PSO – 3
CLR-2 :	*Obtain knowledge on cutting-edge nanomedicine technologies for sensing and imaging, drug delivery, and other therapeutic applications.*																		
CLR-3 :	*Develop the strategies for drug delivery.*																		
CLR-4:	*Initiate interest for utilizing nanotechnology in environmental applications.*																		
CLR-5:	*Generate interest on applications related to therapeutic applications.*																		
CLR-6:	*Encourage engineering students to develop nanomaterials in intellectual property perspective.*																		

Course Learning Outcomes (CLO):	*At the end of this course, learners will be able to:*	1	2	3	1	2	3	4	5	6	7	8	9	10	11	12	13	14	15
CLO-1 :	*Explain the basics of nanobiotechnology in relation to nanomedicine*	*1*	*75*	*70*			*H*	*M*	*M*				*M*	*H*		*H*	*H*	*H*	*H*
CLO-2 :	*Learn about the role of nanomaterials as vehicles for drug delivery*	*3*	*80*	*70*			*H*	*M*	*M*				*M*	*H*		*H*	*H*	*H*	*H*
CLO-3 :	*Obtain the knowledge on nanomedical devices and their applications*	*2*	*80*	*70*			*H*	*M*	*M*				*M*	*H*		*H*	*H*	*H*	*H*
CLO-4 :	*Learn about various types of nanobiosensors and their applications*	*2*	*85*	*75*			*H*	*M*	*M*				*M*	*H*		*H*	*H*	*H*	*H*
CLO-5 :	*Discuss about toxicity of nanomaterials and its remediation*	*2*	*80*	*70*			*H*	*M*	*M*				*M*	*H*		*H*	*H*	*H*	*H*
CLO-6 :	*Gain knowledge on nanomaterials in therapeutic applications.*	*2*	*80*	*70*			*H*	*M*	*M*				*M*	*H*		*H*	*H*	*H*	*H*

Duration (hour)		9	9	9	9	9
S-1	SLO-1	*Basics of nanobiotechnology in relation to nanomedicine*	*Nanomaterials as vehicles for drug delivery*	*nanorobots in medicine*	*Introduction- nanobiosensors*	*Nanomaterials exhibiting toxicity*
	SLO-2	*Scientific principles of nanomedicine*	*Types of Nanomaterials*	*nanorobots in nanosurgery*	*Biosensing Techniques*	*Physico-chemical characteristics dependent toxicity*
S-2	SLO-1	*Nanotools – types*	*criteria and selection of Nanomaterials*	*nanocameras*	*unique properties of nanobiosensors*	*Toxicity – carbon nanotubes,*
	SLO-2	*Nanotools – various techniques of detection*	*Sources of Nanomaterials*	*Application of nanocameras*	*nanobiosensors*	*quantam dots toxicity*
S-3	SLO-1	*Scanning Tunneling microscope*	*Drug loading and release*	*nanochips*	*Preparation of nanobiosensors- immobilsation stratergies*	*Toxicity – Gold nanomaterials,*
	SLO-2	*Atomic Force Microscope*	*biodegradation*	*nanoimplants*	*covalent conjugation technique*	*silver nanoparticles toxicity*
S-4	SLO-1	*Functional biological nanomaterials nanoengines*	*Nanomaterial clearance*	*nanomaterials for bone and cartilage applications*	*Preparation of nanobiosensors- Self assembled monolayer nanomaterial*	*Handling, storage and disposal of nanomaterials*
	SLO-2	*Functional biological nanomaterials nanoengines*	*Types of nanomaterials for clearance*	*nanomaterials for vascular applications and skin disorders*	*Nano biosensors for protein and DNA detection*	*Remediation in case of nanomaterials spills*
S-5	SLO-1	*Nanomaterials and their Production*	*nanopolymers*	*Nanogenetics*	*Detection methods – optical detection*	*In vitro and in vivo toxicity assessment of nanoparticles*
	SLO-2	*Nanomaterials and their Production*	*Classification of biopolymers*	*nanoparticle-based therapy for genetic diseases*	*Detection methods- electronic detection*	*Embryonic Toxicity of Nanoparticles*
S-6	SLO-1	*Nanodevices-Quantum Computing*	*magnetic nanoparticles – preparation and properties*	*Cell Delivery of Therapeutic Nanoparticles*	*In vivo Biosensors*	*quantitative nanostructure-toxicity relationship*
	SLO-2	*Spintronics, Photonic and fluidic devices*	*magnetic nanoparticles - applications*	*nanomaterials for delivery in cells- nerve cell repair*	*Nanowire Biosensors*	*Modelling the Toxicity of Nanoparticles*
S-7	SLO-1	*Impact of nanotechnology - Scientific and technical Impacts*	*nanotubes, dendrimers*	*Applications of Nanofibers in Tissue Engineering*	*Cantilever Biosensors*	*Green Synthesis of Nanoparticles – mechanism*

	SLO-2	*Environmental Impacts*	*Nano immunotherapy*	*Applications of Nanofibers in Tissue Engineering*	*Applications – DNA nanobiosensor*	*Green Synthesis of Nanoparticles – Applications*
S-8	SLO-1	*Grand challenges of nanomedicine*	*Nanomaterials for vaccine delivery*	*nanomaterials for stem cells growth*	*Applications – Protein biosensor*	*Nanoparticles: Environmental Problems*
	SLO-2	*Ethical issues*	*Types of nanomaterials as vaccine adjuvants*	*Stem Cell Tracking with Nanoparticles*	*whole cell biosensor applications*	*nanotoxicity regulations*
S-9	SLO-1	*Government Promotion of Advancements in Nanomedicine*	*Nanotechnology and Diagnostic Imaging*	*Nanomaterials for Stem Cell Imaging*	*Nanobiosensor in diagnostics*	*nanomaterials intellectual property perspective*
	SLO-2	*Government Evaluation, Policy and Regulation of Nanotechnology*	*Nanomaterials as contrast agents in clinical use*	*Nanotechnology in the regulation of stem cell behavior*	*Biosensors in forensic sciences*	*nanomaterials intellectual property perspective*

Learning Resources	1. *Zoraida P. Aguilar. Nanomaterials for Medical Applications (2012), Elsevier Publications* 2. *Harry F. Tibbals, Medical Nanotechnology and Nanomedicine Perspectives in Nanotechnology (2017), CRC Press*

Learning Assessment

	Bloom's Level of Thinking	Continuous Learning Assessment (50% weightage)								Final Examination (50% weightage)	
		CLA – 1 (10%)		CLA – 2 (15%)		CLA – 3 (15%)		CLA – 4 (10%)#			
		Theory	Practice	Theory	Practice	Theory	Practice	Theory	Practice	Theory	Practice
Level 1	Remember Understand	*40 %*	-	*30%*	-	*30%*	-	*30%*	-	*30%*	-
Level 2	Apply Analyze	*40 %*	-	*40%*	-	*40%*	-	*40%*	-	*40%*	-
Level 3	Evaluate Create	*20 %*	-	*30%*	-	*30%*	-	*30%*	-	*30%*	-
	Total	100 %		100 %		100 %		100 %		100 %	

CLA – 4 can be from any combination of these: Assignments, Seminars, Tech Talks, Mini-Projects, Case-Studies, Self-Study, MOOCs, Certifications, Conf. Paper etc.,

Course Designers		
Experts from Industry	Experts from Higher Technical Institutions	Internal Experts
1.Dr. S Natarajan *Advisor / Sr. Vice President - R & D; Sami Labs Limited* *Bangalore. mail@samilabs.com*	*1.Prof. Sundara Ramaprabhu, Department of Physics* *IIT-Madras. ramp@iitm.ac.in; ramp@physics.iitm.ac.in*	*1 Dr. Ramkumar K M, SRMIST* *ramkumar.km@res.srmuniv.ac.in.*
2. Dr. Gokuladhas Krishnan, Director, Laboratory, *World Stem Cell Clinic, Chennai, care@worldstemcellclinic.com*	*2. Prof. Ashok M. Raichur, Department of Materials Engineering* *IISc, Bangalore. amr@materials.iisc.ernet.in*	*2. Dr. N. Selvamururgan, SRMIST* *selvamun@srmist.edu.in*

Course Code	18BTE416T	Course Name	TISSUE ENGINEERING FOR REGENERATIVE MEDICINE	Course Category	E	Professional Elective	L	T	P	C
							3	0	0	3

Pre-requisite Courses	Nil	Co-requisite Courses	Nil	Progressive Courses	Nil
Course Offering Department	Biotechonolgy	Data Book / Codes/Standards	Nil		

Course Learning Rationale (CLR):	*The purpose of learning this course is to:*
CLR-1 :	*Describe the fundamentals of tissue engineering and tissue repairing from the perspective of engineers*
CLR-2 :	*Express knowledge on clinical applications of tissue engineering*
CLR-3 :	*Identify the basic concept behind tissue engineering*
CLR-4:	*State engineering students to think more on artificially generated tissues for their tissue engineering applications*
CLR-5:	*Discuss the knowledge on 3D-bioprinting*
CLR-6:	*Explain the strategies for innovative bioactive research on tissue engineering*

Course Learning Outcomes (CLO):	*At the end of this course, learners will be able to:*	Learning 1: Level of Thinking (Bloom)	2: Expected Proficiency (%)	3: Expected Attainment (%)	PLO 1: Engineering Knowledge	2: Problem Analysis	3: Design & Development	4: Analysis, Design, Research	5: Modern Tool Usage	6: Society & Culture	7: Environment & Sustainability	8: Ethics	9: Individual & Team Work	10: Communication	11: Project Mgt. & Finance	12: Life Long Learning	13: PSO - 1	14: PSO - 2	15: PSO – 3
CLO-1 :	*Apply the components of the tissue architecture*	*1*	*80*	*70*	*H*	*H*	*H*	*M*		*M*	*M*	*H*	*H*	*H*	*H*	*H*	*H*	*H*	*H*
CLO-2 :	*Illustrate the characteristics of stem cells and their relevance in medicine*	*3*	*85*	*75*	*H*	*H*	*H*	*M*			*M*	*H*	*H*	*H*	*H*	*H*	*H*	*H*	*H*
CLO-3 :	*Employ an awareness about the properties and broad applications of biomaterials*	*2*	*80*	*70*	*M*	*H*	*H*	*M*	*M*	*M*	*M*	*H*	*H*	*H*	*H*	*H*	*H*	*H*	*H*
CLO-4 :	*Demonstrate the role of tissue engineering and stem cell therapy in organogenesis*	*2*	*80*	*70*	*H*	*H*	*H*	*M*			*M*	*H*	*H*	*H*	*H*	*H*	*H*	*H*	*H*
CLO-5 :	*Illustrate the developing methods and new biomaterials for the construction of functional tissue and organ substitute\s*	*2*	*75*	*80*	*H*	*H*	*H*	*M*		*M*	*M*	*H*	*H*	*H*	*H*	*H*	*H*	*H*	*H*
CLO-6 :	*Analyze the testing of biomaterials in vitro and in vivo*	*2*	*80*	*70*	*H*	*H*	*H*	*M*	*M*	*M*	*M*	*H*	*H*	*H*	*H*	*H*	*H*	*H*	*H*

Duration (hour)		9	9	9	9	9
S-1	SLO-1	*Cellular Basis of Regeneration*	*Tissue types*	*Fundamentals of biomaterials science*	*Introduction to Stem Cells*	*Discussion on Stem cell therapy*
	SLO-2	*Molecular Basis of Regeneration*	*Tissue components*	*Concept of biocompatibility*	*Different types of Stem cells*	*Discussion on Molecular therapy*
S-2	SLO-1	*Introduction to tissue engineering*	*Tissue repair*	*Classes of biomaterials*	*Hematopoietic differentiation pathway of stem cells*	*Therapies for spinal cord injury, muscular dystrophy*
	SLO-2	*Basic definitions used tissue engineering*	*Engineering wound healing*	*Basic properties of Biomaterials*	*Potency of stem cells*	*Orthopedic applications*
S-3	SLO-1	*Current scope of development in tissue engineering*	*Sequence of events of wound healing*	*Disinfection and sterilization of biomaterials*	*Plasticity of stem cells*	*Stem cells and Gene therapy*
	SLO-2	*Use of tissue engineering in therapeutics*	*Three-Dimensional Cell Culture*	*Physico-chemical properties of biomaterials:*	*Sources of embryonic stem cells*	*Tissue engineering of bones*
S-4	SLO-1	*Components used in tissue engineering*	*Organ Culture*	*Mechanical (elasticity, yield stress, ductility, toughness, strength, fatigue, hardness, wear resistance)*	*Sources of hematopoietic and mesenchymal stem cells*	*Tissue engineering of cartilages*
	SLO-2	*Primary cells, cell lines and immortalization of cells*	*Organotypic Culture*	*Tribological (friction, wear, lubricity)*	*Stem Cell markers, FACS analysis*	*Neural tissue engineering*
S-5	SLO-1	*Measurement of tissue characteristics, appearance, cellular component*	*Introduction to Basic wound healing*	*Morphological and texture, Physical (electrical, optical, magnetic, thermical)*	*Differentiation of Stem cell systems- Liver*	*Skin tissue engineering*
	SLO-2	*Cellular fate processes, Cell differentiation, Cell migration*	*Applications of growth factors:*	*Chemical and biological properties*	*Differentiation of neuronal stem cells*	*Cardiovascular tissue Engineering*
S-6	SLO-1	*Direct Cell-Cell contact – Cell junctions in tissues*	*Role of VEGF/angiogenesis*	*Elements in contact with the surface of a biomaterial: blood composition, plasma proteins, cells, tissues*	*Types & sources of stem cell with characteristics:*	*Therapeutic applications*
	SLO-2	*Malfunctions in direct cell-cell contact signaling. Response to mechanical stimuli*	*Different approaches for angiogenesis and its importance*	*Role of Scaffolds in tissue engineering*	*Embryonic stem cells and Adult stem cells*	*Introduction to the basic principles for Biofabrication and 3D printing*
S-7	SLO-1	*Extracellular matrix (ECM) component and their regulation of cell behavior*	*Basic properties of the growth factors*	*Biopolymers*	*Comparison between embryonic and adult stem cells*	*Methods and materials, for Biofabrication and 3D printing*

	SLO-2	*Mechanical measurements of the ECM component*	*Cell-Matrix Interactions*	*Modifications of Biomaterials*	*Bone marrow, primordial germ cells*	*Applications of Biofabrication and 3D printing:*
S-8	SLO-1	*Physical properties of the ECM component*	*Cell-Cell Interactions*	*In vitro testing of biomaterials*	*Cancer stem cells*	*Lab-on-chip, Organ-on-chip*
	SLO-2	*Cell-ECM interactions – Binding to the ECM*	*Telomeres and Self-renewal*	*In vivo testing of biomaterials*	*Induced pleuripotent stem cells*	*Prosthetics and Implants*
S-9	SLO-1	*Modifying the ECM*	*Cell migration*	*Role of Nanotechnology*	*Culture of stem cells*	*Innovative bioactive research*
	SLO-2	*Malfunctions in ECM signaling*	*Control of cell migration in tissue engineering*	*Applications of Biomaterials*	*Immunomodulation of mesenchymal stem cell*	*Regenerative medicine*

Learning Resources	1. *Clemens Van Blitterswijk, Jan De Boer, "Tissue Engineering", 2nd Edition - Academic Press, 2014* 2. *Robert Lanza, Robert Langer, Joseph Vacanti,"Principles of Tissue Engineering", 4th Edition - Academic Press, 2013* 3. *John P. Fisher, Antonios G. Mikos, Joseph D. Bronzino, Donald R. Peterson, "Tissue Engineering: Principles and Practices", 1st Edition - CRC Press, 2017* 4. *Buddy D. Ratener, Allan S. Hoffman, Frederick J. Schoen, Jack E. Lemons, "Biomaterial Science: An Introduction to Material in Medicine", 3rd edition – Academic Press, 2013* 5. *Lijie Grace Zhang, John Fisher, Kam Leong, "3D Bioprinting and Nanotechnology in Tissue Engineering and Regenerative Medicine", 1st Edition - Academic Press, 2015*

Learning Assessment

	Bloom's Level of Thinking	Continuous Learning Assessment (50% weightage)								Final Examination (50% weightage)	
		CLA – 1 (10%)		CLA – 2 (15%)		CLA – 3 (15%)		CLA – 4 (10%)#			
		Theory	Practice	Theory	Practice	Theory	Practice	Theory	Practice	Theory	Practice
Level 1	Remember Understand	*40 %*	-	*30%*	-	*30%*	-	*30%*	-	*30%*	-
Level 2	Apply Analyze	*40 %*	-	*40%*	-	*40%*	-	*40%*	-	*40%*	-
Level 3	Evaluate Create	*20 %*	-	*30%*	-	*30%*	-	*30%*	-	*30%*	-
	Total	100 %		100 %		100 %		100 %		100 %	

CLA – 4 can be from any combination of these: Assignments, Seminars, Tech Talks, Mini-Projects, Case-Studies, Self-Study, MOOCs, Certifications, Conf. Paper etc.,

Course Designers

Experts from Industry	Experts from Higher Technical Institutions	Internal Experts
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Course Code	18BTE417T	Course Name	BIOREACTORS IN TISSUE ENGINEERING	Course Category	E	Professional Elective	L	T	P	C
							3	0	0	3

Pre-requisite Courses	Nil	Co-requisite Courses	Nil	Progressive Courses	Nil
Course Offering Department	Biotechonolgy	Data Book / Codes/Standards			

Course Learning Rationale (CLR):	The purpose of learning this course is to:
CLR-1 :	*Provide the basic concepts of tissue engineering and bioreactors from the perspective of engineers.*
CLR-2 :	*Identify the 3D- culture of stem cells and organogenesis*
CLR-3 :	*Identify the role of stem cells in clinical applications of different disease conditions.*
CLR-4:	*Identify the safety and efficacy of bioreactors*
CLR-5:	*Create the strategies for designing clinically relevant bioreactors*
CLR-6:	*Identify the usages of bioreactors and their advantages in tissue engineering*

Course Learning Outcomes (CLO):	At the end of this course, learners will be able to:	Learning 1: Level of Thinking (Bloom)	2: Expected Proficiency (%)	3: Expected Attainment (%)	PLO 1: Engineering Knowledge	2: Problem Analysis	3: Design & Development	4: Analysis, Design, Research	5: Modern Tool Usage	6: Society & Culture	7: Environment & Sustainability	8: Ethics	9: Individual & Team Work	10: Communication	11: Project Mgt. & Finance	12: Life Long Learning	13: PSO - 1	14: PSO - 2	15: PSO – 3
CLO-1 :	*Apply the basic understanding of large scale production stem cells in bioreactors*	1	85	85	H	-	-	H	-	-	-	H	-	-	-	H	H	H	H
CLO-2 :	*Discuss the 3D- culture systems and artificial organs*	2	80	80	M	-	-	M	-	-	-	M	-	-	-	H	H	H	H
CLO-3 :	*Identify the bioreactor based strategies to generate organoids*	2	85	80	H	-	-	M	-	-	-	M	-	-	-	H	H	H	H
CLO-4 :	*Understand the role of bioreactors in the development of drug development and therapy*	2	80	85	M	-	-	M	-	-	-	M	-	-	-	H	H	H	H
CLO-5 :	*Explain the large scale production of stem cells*	2	80	80	H	-	-	H	-	-	-	M	-	-	-	H	H	H	H
CLO-6 :	*Apply the clinical applications of bioreactors*	3	85	85	H	-	-	H	-	-	-	M	-	-	-	H	H	H	H

Duration (hour)		9	9	9	9	9
S-1	SLO-1 SLO-2	*Introduction to tissue engineering – Current scope of development; Cell as therapeutic agents*	*Bioreactors in Tissue Engineering; Tissue formation in Bioreactor systems – Generation of functional tissues*	*Bioreactors- Link between in vitro and in vivo studies*	*Biomaterials: Properties of Biomaterials ,Surface, bulk, mechanical and biological properties*	*Clinical applications - Stem cell therapy, Molecular therapy*
S-2	SLO-1 SLO-2	*cell numbers and growth rates, measurement of cell characteristics morphology, cell viability, motility and functions*	*Principles of functional tissue engineering – Functional tissue engineering and role of Biomechanics in a 3D environment*	*Novel approaches in bioreactor systems for stem cell seeding of vascularized bioscaffolds*	*Scaffolds & tissue engineering, Types of Biomaterials, biological and synthetic materials*	*In vitro organogenesis, Neurodegenrative diseases*
S-3	SLO-1 SLO-2	*Biochemical Basics for Nutrition and Growth of living Cells - Measurement of tissue characteristics, appearance, tissue types*	*Ex vivo engineering of living tissues – generation of mammalian tissue equivalents in vitro – Bioreactors role in tissue engineering of Cartilage*	*Bioreactor-based strategies with reconstructive applications of (Vascularized composite allotransplantation) VCA*	*Biopolymers, Applications of biomaterials,Modifications of Biomaterials*	*spinal cord injury, heart disease, diabetes, burns and skin ulcers*
S-4	SLO-1 SLO-2	*Tissue dynamics and Cell migration cellular component, ECM component, mechanical measurements and physical properties*	*Cardiovascular tissue (Cardiomyocytes, valves), Vascular tissue, musculoskeletal tissue and Skin –Bone*	*Stem cell cultivation in scaffold-bioreactor systems; Physiological biomimicry*	*Role of Nanotechnology. Sensing and Automation in bioreactor systems*	*muscular dystrophy, orthopedic applications*
S-5	SLO-1 SLO-2	*Complexity and organization of the Organ system; Bioreactors; History of Bioreactors*	*microfluidic devices and microbioreactors for stem cell micro environment – Perfusion bioreactors for granulocyte progenitor cell growth; Bioreactor stimulation*	*Understanding Mechanical forces on organs and functional aspects*	*Bioreactors in drug discovery and implant testing; Bioreactors in clinics*	*Stem cells and Gene therapy*
S-6	SLO-1 SLO-2	*Types of Bioreactors – Perfusion Bioreactors for 3D cultures, Spinner Flask Bioreactor*	*Mechanics and Controlled Parameters of Bioreactors – Temperature, pH, Dissolved oxygen (DO), Oxygen Diffusion*	*Control and Feedback Control in Mechatronics for Mechanical Stimulation; Scaffolds and Constructs for Bioreactor Systems (including adapted Fabrication Techniques)*	*Stem cell cultivation in scaffold-bioreactor systems;*	*Physiological models, tissue engineering therapies, product characterization*

S-7	SLO-1	*Rotating Wall Bioreactor, Compression Bioreactor, Strain Bioreactor*	*Nutrient Transport, Waste Removal; Predicting Mechanical Functionality of Engineered Tissues*	*Tissue architecture- Tissue types and Tissue components, Tissue repair*	*Large-scale bioreactor cultivation of pluripotent stem cells*	*components, safety, efficacy. Preservation – freezing and drying*
	SLO-2					
S-8	SLO-1	*static culture, stem cell cultivation in scaffold Bioreactor systems*	*Engineering stem cell niches in bioreactors- Oxygen tension, Scaffold/substrate cues*	*Basic wound healing events, Applications of growth factors*	*Engineering of functional bone tissue from human stem cells*	*Patent protection and regulation of of tissue-engineered products,ethical issues*
	SLO-2					
S-9	SLO-1	*Hydrostatic pressure Bioreactor, Flow Perfusion Bioreactor, Combined Bioreactor*	*Decellularized ECMs, Mechanical forces, Electrical stimulation, Flow shear rate, and paracrine and autocrine factors*	*Role of VEGF. Angiogenesis,Basic properties,Cell-Matrix& Cell-Cell Interactions, Control of cell migration in tissue engineering*	*Miniature bioreactors for precise, systematic studies of stem cell environments*	*Emerging trends in clinically relevant bioreactor design and future direction*
	SLO-2					

Learning Resources	*1. Molecular and cellular tissue engineering (The biomedical hand book, 4th edition), Joseph D. Bronzino and Donald R. Peterson, 2015* *2. Biomaterials science and Tissue engineering: Principles and methods (Cambridge IISc series) - Bikramjit Basu, 2017* *3. 3D Cell culture: Fundamental and applications in tissue engineering and regenerative medicine, Ranjana C. Dutta and Aroop K Dutta, 2018.* *4. Raphael Gorodetsky, Richard Schäfer. Cambridge: RSC publishing, c2011.Stem cell based tissue repair.*

SLO – Session Learning Outcome

Learning Assessment

	Bloom's Level of Thinking	Continuous Learning Assessment (50% weightage)								Final Examination (50% weightage)	
		CLA – 1 (10%)		CLA – 2 (15%)		CLA – 3 (15%)		CLA – 4 (10%)#			
		Theory	Practice	Theory	Practice	Theory	Practice	Theory	Practice	Theory	Practice
Level 1	Remember Understand	*40 %*	-	*30%*	-	*30%*	-	*30%*	-	*30%*	-
Level 2	Apply Analyze	*40 %*	-	*40%*	-	*40%*	-	*40%*	-	*40%*	-
Level 3	Evaluate Create	*20 %*	-	*30%*	-	*30%*	-	*30%*	-	*30%*	-
	Total	100 %		100 %		100 %		100 %		100 %	

CLA – 4 can be from any combination of these: Assignments, Seminars, Tech Talks, Mini-Projects, Case-Studies, Self-Study, MOOCs, Certifications, Conf. Paper etc.,

Course Designers

Experts from Industry	Experts from Higher Technical Institutions	Internal Experts
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2. Dr. Sudarshan Reddy *Oncosimis Biotech Pvt. Ltd. email: info@oncosimis.com*	*2. Dr. R. Ilangovan , University of Madras* *Ilnagovan2000@yahoo.com*	*2. Dr. R. Satish, SRMIST* *satishr@srmisst.edu.in*

Course Code	18BTE418T	Course Name	DEVELOPMENTAL BIOLOGY IN TISSUE ENGINEERING	Course Category	E	Professional Elective	L	T	P	C
							3	0	0	3

Pre-requisite Courses	Nil	Co-requisite Courses	Nil	Progressive Courses	Nil
Course Offering Department	Biotechonolgy	Data Book / Codes/Standards			

Course Learning Rationale (CLR):	*The purpose of learning this course is to:*
CLR-1 :	*Describe the biology of animal embryogenesis and development.*
CLR-2 :	*Recognize cell-cell interactions from the context of tissue engineering.*
CLR-3 :	*Analyse the role of stem cells and stem cell niches in organogenesis and tissue regeneration.*
CLR-4:	*Discuss the biology of organogenesis.*
CLR-5:	*Summarize the concepts of tissue and organ regeneration.*
CLR-6:	*Appraise the biology of ageing.*

Course Learning Outcomes (CLO):	*At the end of this course, learners will be able to:*	Learning 1: Level of Thinking (Bloom)	2: Expected Proficiency (%)	3: Expected Attainment (%)	PLO 1: Engineering Knowledge	2: Problem Analysis	3: Design & Development	4: Analysis, Design, Research	5: Modern Tool Usage	6: Society & Culture	7: Environment & Sustainability	8: Ethics	9: Individual & Team Work	10: Communication	11: Project Mgt. & Finance	12: Life Long Learning	13: PSO - 1	14: PSO - 2	15: PSO – 3
CLO-1 :	*Interpret the basics of embryology and cell signaling mechanisms.*	1	80	70			M	H				M		M		H	H	H	H
CLO-2 :	*Describe the types of cell specification and differentiation.*	2	80	75			M	H				M		M		H	H	H	H
CLO-3 :	*Appraise the role of stem cells in organ development.*	2	80	70			M	H				M		M		H	H	H	H
CLO-4 :	*Apply the genetics behind organogenesis.*	2	80	75			M	H				M		M		H	H	H	H
CLO-5 :	*Identify the developmental biology concepts behind tissue regeneration.*	2	80	70			M	H				M		M		H	H	H	H
CLO-6 :	*Analyze the genetics of ageing.*	2	80	75			M	H				M		M		H	H	H	H

Duration (hour)		9	9	9	9	9
S-1	SLO-1	*Differential cell affinity*	*Cell commitment*	*Introduction to germ layers*	*Overview of kidney development*	*Ageing*
	SLO-2	*Cadherins and cell adhesion*	*Levels of cell commitment*	*Ectoderm - Derivatives*	*Development of kidney tissue*	*Genes and ageing*
S-2	SLO-1	*Adhesion dynamics*	*Cell specification*	*Endoderm - Derivatives*	*Overview of reciprocal interactions*	*DNA repair enzymes in ageing*
	SLO-2	*Cell migration*	*Autonomous specification*	*Mesoderm - Derivatives*	*Mechanisms of reciprocal induction*	*Insulin signaling pathway in ageing*
S-3	SLO-1	*Induction and competence*	*Conditional specification*	*Neurulation*	*Lateral plate mesoderm*	*Stem cells and ageing*
	SLO-2	*Cell-cell interactions*	*Morphogen gradients*	*Formation of the neural tube*	*Specification of lateral plate mesoderm*	*Senescence*
S-4	SLO-1	*Paracrine factors*	*Syncytial specification*	*Patterning of neural tube – AP axis*	*Vasculogenesis*	*Epimorphic regeneration in Salamander*
	SLO-2	*Signal transduction cascades*	*Cell fate determination*	*Patterning of neural tube – DV axis*	*Initial formation of blood vessels*	*Blastema formation*
S-5	SLO-1	*The RTK pathway, the Jak-STAT pathway in development*	*The stem cell concept*	*Neural crest cells - Introduction*	*Angiogenesis*	*Morphallactic regeneration in Hydra*
	SLO-2	*The Wnt pathway and TGF-β pathway in development*	*Embryonic stem cells in developmet*	*Regionalization of neural crest cells*	*Sprouting of blood vessels*	*Activation gradients*
S-6	SLO-1	*Juxtacrine signaling in development*	*Adult stem cells in developmet*	*Paraxial mesoderm*	*Hematopoiesis*	*Regeneration in mammalian liver*
	SLO-2	*The Notch pathway in development*	*Stem cell potency*	*Specification of paraxial mesoderm*	*Sites of hematopoiesis*	*Compensatory regeneration*
S-7	SLO-1	*Cell patterning*	*Pluripotent stem cells in development*	*Cell types of somites*	*Hematopoietic stem cells (HSC)*	*Axonal regeneration*
	SLO-2	*Maintenance of differentiated state*	*Multipotent stem cells in development*	*Hox genes and cell fate specificity*	*HSC niche*	*Regeneration of neural tissues*
S-8	SLO-1	*Developmental signals from ECM*	*Stem cell niches*	*Somitogenesis*	*The Digestive tube – Overview*	*Regeneration of zebrafish fin tissue*
	SLO-2	*Integrin signaling in development*	*Regulatory microenvironments*	*Clock and wave front model*	*Specification of gut tissue*	*Molecular control of fin regeneration*
S-9	SLO-1	*Cell-Cell communication in development*	*Mesenchymal stem cells in development*	*Intermediate mesoderm*	*The Respiratory tube – Overview*	*Heart regeneration in zebrafish*
	SLO-2	*Epithelial-mesenchymal transition*	*Organogenesis – An introduction*	*Specification of intermediate mesoderm*	*Formation of respiratory tube*	*Cardiomyocyte plasticity during regeneration*

Learning Resources	1. *Developmental Biology (2016): Scott F. Gilbert and Michael J.F. Barresi, Eleventh Edition, Oxford University Press, Inc.* 2. *Essential Developmental Biology (2012): J.M.W. Slack, Third Edition, Wiley-Blackwell Publishers* 3. *Principles of Development (2015): Lewis Wolpert, Cheryll Tickle and Alfonso Arias, Fifth Edition, Oxford Publishers, Inc.*

Learning Assessment

	Bloom's Level of Thinking	Continuous Learning Assessment (50% weightage)								Final Examination (50% weightage)	
		CLA – 1 (10%)		CLA – 2 (15%)		CLA – 3 (15%)		CLA – 4 (10%)#			
		Theory	Practice	Theory	Practice	Theory	Practice	Theory	Practice	Theory	Practice
Level 1	Remember Understand	*40 %*	-	*30%*	-	*30%*	-	*30%*	-	*30%*	-
Level 2	Apply Analyze	*40 %*	-	*40%*	-	*40%*	-	*40%*	-	*40%*	-
Level 3	Evaluate Create	*20 %*	-	*30%*	-	*30%*	-	*30%*	-	*30%*	-
	Total	100 %		100 %		100 %		100 %		100 %	

CLA – 4 can be from any combination of these: Assignments, Seminars, Tech Talks, Mini-Projects, Case-Studies, Self-Study, MOOCs, Certifications, Conf. Paper etc.,

Course Designers

Experts from Industry	Experts from Higher Technical Institutions	Internal Experts
1. *Dr. A. Premkumar, Ph.D., GVK Biosciences, Hyderabad* *aprem70@yahoo.com*	1. *Dr. K. Subramaniam, Ph.D., IIT Madras, Chennai* *subbu@iitm.ac.in*	1. *Dr. S. Kirankumar, Ph.D., SRMIST* *kirankus@srmist.edu.in*
2. *Dr. M.C. Raja, Ph.D., Genotypic Technology, Bangalore* *genotypic@hotmail.com*	2. *Dr. Naren Ramanan, Ph.D., IISc, Bangalore* *naren@cns.iisc.ernet.in*	2. *Dr. R. Satish, Ph.D., SRMIST* *satishr@srmist.edu.in*

Course Code	18BTE419T	Course Name	ADVANCED IMMUNOLOGY AND VASCULAR TISSUE ENGINEERING	Course Category	E	Professional Elective	L	T	P	C
							3	0	0	3

Pre-requisite Courses	Nil	Co-requisite Courses	Nil	Progressive Courses	Nil
Course Offering Department	Biotechonolgy	Data Book / Codes/Standards			

Course Learning Rationale (CLR):	*The purpose of learning this course is to:*
CLR-1 :	*Provide the most recent advancement in the field of immunology from the perspective of bioengineers*
CLR-2 :	*Enrich with knowledge on immunobiology and immune responses related to regeneration and transplants*
CLR-3 :	*Recognizing the issue of shortage of organ donors as major limitations in the transplantation and finding solution for the same*
CLR-4:	*Learning of various treating methods for injury and the significance of vascular engineering*
CLR-5:	*Understanding the potentials of immunotherapy*
CLR-6:	*Train and develop skills among the students to explore strategies for stem cell therapy*

Course Learning Outcomes (CLO):	*At the end of this course, learners will be able to:*	Learning 1: Level of Thinking (Bloom)	Learning 2: Expected Proficiency (%)	Learning 3: Expected Attainment (%)	PLO 1: Engineering Knowledge	PLO 2: Problem Analysis	PLO 3: Design & Development	PLO 4: Analysis, Design, Research	PLO 5: Modern Tool Usage	PLO 6: Society & Culture	PLO 7: Environment & Sustainability	PLO 8: Ethics	PLO 9: Individual & Team Work	PLO 10: Communication	PLO 11: Project Mgt. & Finance	PLO 12: Life Long Learning	PLO 13: PSO - 1	PLO 14: PSO - 2	PLO 15: PSO – 3
CLO-1 :	*Acquire knowledge on the latest tools for diagnosis of diseases*	2	80	75	H	-	M	L	-	-	-	-	-	H	-	M	H	H	H
CLO-2 :	*Gain knowledge in molecular and immunological basis of diagnosis*	2	85	80	H	-	M	L	-	-	-	-	-	H	-	H	H	H	H
CLO-3 :	*Able to appreciate the relevance of clinical immunology*	2	80	75	H	-	M	L	-	-	-	M	-	H	-	H	H	H	H
CLO-4 :	*Acquire knowledge on vascular biology and vascular tissue engineering*	2	80	75	M	-	M	L	-	-	-	-	-	H	-	M	H	H	H
CLO-5 :	*Acquire knowledge on host vs Graft rejection and the significance of immune system in this process.*	2	85	80	H	-	M	L	-	-	-	-	-	H	-	M	H	H	H
CLO-6 :	*Understand the challenges behind successful transplantation or grafting and the significance of neovascularization*	2	80	75	H	-	M	L	-	-	-	H	-	H	-	M	H	H	H

Duration (hour)		9	9	9	9	9
S-1	SLO-1	*Organs and Cells of the Immune System – Primary and Secondary Lymphoid Organs*	*The Complement Cascades*	*Immunobiology of Transplantation*	*Stem cells – types and sources*	*Vascular system*
	SLO-2	*Mucosal and Cutaneous associated lymphoid tissue. (MALT & CALT)*	*The role of Major Histocompatibility Complex in Immune Response*	*Cells and Factors involved in Transplant Acceptance vs. Rejection*	*Stem cells in Regenerative Biology*	*Mechanisms of blood vessel formation*
S-2	SLO-1	*Mucosal Immunity*	*Autoimmune disease*	*Importance of Adaptive immunity functions in Graft Recognition*	*Stem cell Therapy for Skin Burns, Ulcers, Neurodegenerative diseases, Spinal cord injury*	*Hemangiogenesis*
	SLO-2	*Antigens – immunogens, haptens*	*Interpersonal compatibility*	*Importance of Innate immunity functions in Graft Recognition*	*Stem cell Therapy for Ulcers,*	*Lymphangiogenesis*
S-3	SLO-1	*Antibody Structure*	*T lymphocyte recognition restrictions*	*Molecular Aspects of Acute and Chronic Rejection*	*Stem cell Therapy for Neurodegenerative diseases, Spinal cord injury*	*Angiogenic factors and their receptors*
	SLO-2	*Antibody Function*	*Evolutionary diversity*	*The biological basis of Graft Verses Host Disease*	*Immunological considerations and the potential barriers for Stem cell therapy*	*Inflammation*
S-4	SLO-1	*Generation of antibody diversity*	*Basis of self – non-self discrimination and Autoimmune disorders*	*Embryonic stem cells*	*Clinical transplantation, Immune tolerance, Killer Immunoglobulin like receptors in transplantation*	*Angiogenesis*
	SLO-2	*B cell maturation*	*Kinetics of immune response, Hypersensitivity and their types*	*Expression of histocompatibility antigens*	*Immunosuppressive therapy*	*Tissue injury response*
S-5	SLO-1	*B cell activation and differentiation*	*HLA typing*	*T-cell response against u/dhESCs measured by functional assays*	*Significance of acellular grafts in regeneration*	*Importance of Vascularization in Tissue Engineering*
	SLO-2	*T-cell maturation activation and differentiation*	*Immunological considerations for Tissue Engineering*	*Interaction of natural killer cells with hESCs*	*Mast cells in allograft rejection*	*Angiogenesis and Vascular Remodeling*
S-6	SLO-1	*T-cell receptors*	*Stem cell Banking*	*Generation of patient-specific isogenic hESC lines*	*Graft-versus-host disease*	*Organization and Patterning of Endothelial Cells in Engineered Tissues*
	SLO-2	*Functional T Cell Subsets*	*Cell-cell co-operation*	*Immunological Aspects of Allogeneic mesenchymal stem cell therapy*	*Mouse models of graft-versus-host disease*	*Models for studying angiogenesis*

S-7	SLO-1	*Cell-mediated immune responses*	*Hapten-carrier system*	*Autologous Mesenchymal Stem Cell Therapies*	*Cytokines in Graft-versus-Host Disease*	*Blood Capillary analogues*
	SLO-2	*ADCC*	*Types of Tissue injury*	*CML of Haematopoietic stem cells*	*Potential barriers to engraftment of human pluripotent stem cells*	*Role of Vascular endothelial growth factors on Angiogenesis*
S-8	SLO-1	*Cytokines-properties, and receptors*	*Tissue injury and immune responses*	*allogenic transplantation of HSC*	*Cancer Stem Cells in Solid Tumors*	*Signaling pathways of Angiogenesis*
	SLO-2	*Cytokines and therapeutic uses*	*Immunoprophylaxis*	*Graft verses Leukemia*	*Immunologic targeting of cancer stem cell population*	*Micropatterning approaches to microvessel creation*
S-9	SLO-1	*Antigen processing*	*Immunotherapy*	*Targeting Malignant progenitors*	*Opportunities in Engineered tissue grafts*	*Stem cells for vascular regeneration*
	SLO-2	*Antigen presenting cells*	*Current status of Immunotherapy*	*Recent Advances in transplantation*	*Opportunities in Engineered tissue grafts*	*Stem cells and scaffolds for vascular regeneration*

Learning Resources	1. *The Immunological Barriers to Regenerative Medicine. Editors-Paul J. Fairchild, Humana Press 2013* 2. *Stem Cell Transplantation, edited by Carlos López-Larrea, Antonio López Vázquez, Beatriz Suárez Álvarez. Springer 2016* 3. *Vascularization: Regenerative Medicine and Tissue Engineering, edited by Eric M. Brey, CRC Press 2017* 4. *Kuby Immunology. Thomas J. Kindt, Richard A. Goldsby, W.H.Freeman, 2007.*

Learning Assessment

	Bloom's Level of Thinking	Continuous Learning Assessment (50% weightage)								Final Examination (50% weightage)	
		CLA – 1 (10%)		CLA – 2 (15%)		CLA – 3 (15%)		CLA – 4 (10%)#			
		Theory	Practice	Theory	Practice	Theory	Practice	Theory	Practice	Theory	Practice
Level 1	Remember Understand	*40 %*	-	*30%*	-	*30%*	-	*30%*	-	*30%*	-
Level 2	Apply Analyze	*40 %*	-	*40%*	-	*40%*	-	*40%*	-	*40%*	-
Level 3	Evaluate Create	*20 %*	-	*30%*	-	*30%*	-	*30%*	-	*30%*	-
	Total	100 %		100 %		100 %		100 %		100 %	

CLA – 4 can be from any combination of these: Assignments, Seminars, Tech Talks, Mini-Projects, Case-Studies, Self-Study, MOOCs, Certifications, Conf. Paper etc.,

Course Designers

Experts from Industry	Experts from Higher Technical Institutions	Internal Experts
1. Dr. Vani, Jeevan Stem Cell Foundation, Chennai, stemcell@jeevan.org	*1. Prof N. Srinivasan, Tissue Engineering and Regenerative Medicine, Dept. of Allied Health Sciences, Chettinad Academy of Research and Education, srinivasanibms@gmail.com*	*1 .Dr. N. Selvamururgan, SRMIST selvamun@srmist.edu.in*
2. Dr. Gokuladhas Krishnan, Director, Laboratory, World Stem Cell Clinic, Chennai, care@worldstemcellclinic.com	*2. Dr. S. Sittadjody, Research Fellow, Institute for Regenerative Medicine, Winston-Salem, USA. ssdjody@gmail.com*	*2. Dr. R. Satish, SRMIST satishr@srmist.edu.in*

Course Code	18BTE420T	Course Name	HUMAN GENETICS	Course Category	E	Professional Elective	L	T	P	C
							3	0	0	3

Pre-requisite Courses	18BTC104T	Co-requisite Courses		Progressive Courses	Nil
Course Offering Department	Biotechnology	Data Book / Codes/Standards	Nil		

Course Learning Rationale (CLR):	*The purpose of learning this course is to:*	Learning			Program Learning Outcomes (PLO)														
		1	2	3	1	2	3	4	5	6	7	8	9	10	11	12	13	14	15
CLR-1 :	*Categorize the pattern of inheritance in humans*																		
CLR-2 :	*Analyze human genome structure and organization*																		
CLR-3 :	*Use karyotype to analyze human chromosomal aberrations*																		
CLR-4:	*Apply different methods for mapping of genes in humans*																		
CLR-5:	*Compare genetic variations in human population and prenatal diagnosis*																		
CLR-6:	*Illustrate genetic principles in human biology studies*																		
Course Learning Outcomes (CLO):	*At the end of this course, learners will be able to:*	Level of Thinking (Bloom)	Expected Proficiency (%)	Expected Attainment (%)	Engineering Knowledge	Problem Analysis	Design & Development	Analysis, Design, Research	Modern Tool Usage	Society & Culture	Environment & Sustainability	Ethics	Individual & Team Work	Communication	Project Mgt. & Finance	Life Long Learning	PSO - 1	PSO - 2	PSO – 3
CLO-1 :	*Describe the human inheritance concepts and associated complications*	*2*	*80*	*70*	*H*	*H*	*H*	*H*		*M*	*L*	*H*	*H*	*H*		*H*	*H*	*H*	*H*
CLO-2 :	*Explain the regulation of human gene expression*	*2*	*80*	*75*	*H*	*H*	*H*	*H*			*M*	*H*	*H*	*H*		*H*	*H*	*H*	*H*
CLO-3 :	*Recognize the nature of human chromosome abnormalities*	*2*	*80*	*70*	*M*	*H*	*M*	*H*		*M*		*H*	*H*	*H*		*H*	*H*	*H*	*H*
CLO-4 :	*Identify the different methods of human disease gene identification*	*2*	*80*	*75*	*H*	*H*	*H*	*H*			*H*	*H*	*H*	*H*		*H*	*H*	*H*	*H*
CLO-5 :	*Discuss the importance of population screening and prenatal diagnosis*	*3*	*85*	*70*	*H*	*H*	*H*	*H*		*M*	*H*	*H*	*H*	*L*		*H*	*H*	*H*	*H*
CLO-6 :	*Appraise the basic concepts of human genetics*	*2*	*80*	*75*	*H*	*H*	*H*	*H*		*H*	*H*	*H*	*H*	*H*		*H*	*H*	*H*	*H*

Duration (hour)		9	9	9	9	9
S-1	SLO-1	*Human Genetics – Introduction*	*Human chromosome structure*	*Karyotyping*	*Genetic mapping*	*Genetic testing*
	SLO-2	*Modern Human Genetics*	*Human chromosome organization*	*Chromosome banding*	*Recombination fraction*	*Gene scanning*
S-2	SLO-1	*Monogenic inheritance*	*Mitochondrial genome organization*	*FISH technique*	*Genetic markers*	*Analysing specified sequence changes*
	SLO-2	*Incomplete dominance and Codominance*	*Limited autonomy of mitochondrial genome*	*Chromosome painting*	*Two point mapping*	*MLPA test*
S-3	SLO-1	*Uniparental disomy*	*Protein coding genes*	*Numerical chromosome abnormalities*	*Multipoint mapping*	*DNA profiling*
	SLO-2	*Penetrance, nonpenetrance*	*RNA genes*	*Aneuploidy*	*Fine mapping analysis*	*Applications of DNA profiling*
S-4	SLO-1	*Expressivity*	*microRNAs*	*Structural chromosome abnormalities*	*Segregation analysis*	*Personalized medicine*
	SLO-2	*Mitochondrial inheritance*	*Regulatory RNAs*	*Mosaicism*	*Linkage analysis*	*Drugs for specific genotypes*
S-5	SLO-1	*Late onset diseases*	*Overlapping genes*	*Autosomal abnormalities*	*Association studies*	*Prenatal diagnosis*
	SLO-2	*Disease anticipation, imprinting*	*Genes-within-genes*	*Sex chromosome abnormalities*	*Linkage disequilibrium*	*Cast study: Down syndrome*
S-6	SLO-1	*Heterogeneity, consanguinity*	*Noncoding DNA*	*Human reproductive disorders*	*Positional cloning*	*Population screening*
	SLO-2	*Pleiotropy, mosaicism*	*Satellite DNA*	*Congenital abnormalities*	*Candidate gene testing*	*Ethical implications*
S-7	SLO-1	*Mendelian pedigree patterns*	*Mini- and microsatellite DNA*	*Polyploidy*	*Position independent strategies*	*Pedigree construction*
	SLO-2	*Pedigree analysis*	*Transposon derived repeats*	*Mixoploidy*	*Case studies*	*Proband analysis*
S-8	SLO-1	*Multifactorial inheritance*	*Alternative transcription*	*X-inactivation*	*Duchenne muscular dystrophy*	*Pharmacogenetics*
	SLO-2	*Quantitative traits*	*Long range control of gene expression*	*Mosaicism due to X-inactivation*	*Cystic fibrosis*	*Genetic differences and drug metabolism*
S-9	SLO-1	*Polygenic theory*	*DNA methylation*	*Locus heterogeneity*	*Branchio-oto-renal syndrome*	*Genetic counseling*
	SLO-2	*Gene and genotype frequencies*	*Epigenetics*	*Clinical heterogeneity*	*Crohn disease*	*Importance of genetic counseling*

Learning Resources	1. Strachan, T., Read, A.P., "Human Molecular Genetics", 4th edition – Garland Science, 2012. 2. Jack J. Pasternak, "An introduction to Human Molecular Genetics," 2nd edition – Wiley Liss, 2005.

Learning Assessment

	Bloom's Level of Thinking	Continuous Learning Assessment (50% weightage)								Final Examination (50% weightage)	
		CLA – 1 (10%)		CLA – 2 (15%)		CLA – 3 (15%)		CLA – 4 (10%)#			
		Theory	Practice	Theory	Practice	Theory	Practice	Theory	Practice	Theory	Practice
Level 1	Remember Understand	*40 %*	-	*30%*	-	*30%*	-	*30%*	-	*30%*	-
Level 2	Apply Analyze	*40 %*	-	*40%*	-	*40%*	-	*40%*	-	*40%*	-
Level 3	Evaluate Create	*20 %*	-	*30%*	-	*30%*	-	*30%*	-	*30%*	-
	Total	100 %		100 %		100 %		100 %		100 %	

CLA – 4 can be from any combination of these: Assignments, Seminars, Tech Talks, Mini-Projects, Case-Studies, Self-Study, MOOCs, Certifications, Conf. Paper etc.,

Course Designers

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Dr. M.C. Raja, PhD, Genotypic Technologies, Bangalore *genotypic@hotmail.com*	*Dr. Partha P. Majumder, NIBG, Kalyani, West Bengal* *ppm1@nibmg.ac.in*	*Dr. M. Jeevankumar, SRMIST*

Course Code	18BTE421T	Course Name	HIGH THROUGHPUT TECHNIQUES IN ADVANCED BIOLOGY	Course Category	E	Professional Elective	L	T	P	C
							3	0	0	3

Pre-requisite Courses	NIL	Co-requisite Courses	NIL	Progressive Courses	Nil
Course Offering Department	Biotechnology	Data Book / Codes/Standards	NIL		

Course Learning Rationale (CLR):	*The purpose of learning this course is to:*
CLR-1 :	*List various high throughput techniques in biology and 2. applying these techniques in their own research*
CLR-2 :	*Describe the basics of genomics and its uses*
CLR-3 :	*Analyse qualitatively and quantitative the expression of protein*
CLR-4:	*Compare the differential expression of proteins and interpret it in biological context*
CLR-5:	*Practice advance high throughput techniques like lipidomics, epigenomics and metabolomics*

Course Learning Outcomes (CLO):	*At the end of this course, learners will be able to:*	Learning 1 Level of Thinking (Bloom)	2 Expected Proficiency (%)	3 Expected Attainment (%)	Program Learning Outcomes (PLO) 1 Engineering Knowledge	2 Problem Analysis	3 Design & Development	4 Analysis, Design, Research	5 Modern Tool Usage	6 Society & Culture	7 Environment & Sustainability	8 Ethics	9 Individual & Team Work	10 Communication	11 Project Mgt. & Finance	12 Life Long Learning	13 PSO - 1	14 PSO - 2	15 PSO – 3
CLO-1 :	*Describe the terminology, technology characteristics and stake holder benefits of high throughput technologies*	*1*	*90*	*80*	*H*	*H*	*H*	*H*	*L*	*M*	*L*	*H*	*H*	*H*	*H*	*H*	*H*	*H*	*H*
CLO-2 :	*Investigate genomic data, interpret the data in the population genetics and evolutionary genetic context*	*2*	*80*	*80*	*H*	*H*	*H*	*H*	*H*	*L*	*M*	*H*	*H*	*H*	*H*	*H*	*H*	*H*	*H*
CLO-3 :	*Measure the expression of genes, develop necessary expertise in using different computation tools*	*2*	*85*	*80*	*M*	*H*	*M*	*H*	*L*	*M*	*L*	*M*	*H*	*H*	*H*	*H*	*H*	*H*	*H*
CLO-4 :	*Quantify proteins qualitatively and quantitatively and categorize their interactions and modifications.*	*2*	*80*	*75*	*H*	*H*	*H*	*H*	*H*	*L*	*H*	*L*	*H*	*H*	*H*	*H*	*H*	*H*	*H*
CLO-5 :	*Distinguish Metabolomics, Epigenomics and lipdomics research and interpreting the data generated*	*3*	*75*	*75*	*H*	*H*	*H*	*H*	*L*	*H*	*H*	*H*	*L*	*L*	*H*	*H*	*H*	*H*	*H*
CLO-6 :	*Analyze high throughput data using software*	*3*	*70*	*75*	*H*	*H*	*L*	*H*	*H*	*L*	*L*	*H*	*M*	*M*	*H*	*H*	*M*	*H*	*H*

Duration (hour)		9	9	9	9	9
S-1	SLO-1	*History of technology advancement in biology*	*Introduction to Genome*	*Browser and databases for transcriptomics*	*Introduction to proteomics*	*Introduction to metabolomics*
	SLO-2	*What is high throughput biology*	*Ultrafine structure of gene*	*Tools for transcriptomics*	*Analytical Techniques in proteomics*	*Secondary metabolites and their role in biology*
S-2	SLO-1	*High content screening and their uses*	*Regulatory Landscapes of Mammalian Genomes*	*Search for transcription factor binding sites*	*Protein information databases*	*Metabolome of plants, animals and microbes*
	SLO-2	*High throughput screening in biology*	*Epigenetic Landscapes of Mammalian Genomes*	*miRNA targets and regulatory motifs*	*SwissPROT and UNIPROT*	*Metabolites and metabolomics*
S-3	SLO-1	*Technology characteristics of high throughput screening*	*Genome sequencing*	*Overview of Non-Coding RNAs*	*Mass spectrometry*	*Target analysis of metabolites*
	SLO-2	*Recent theories on High throughput screening*	*Genome assembly and annotation*	*iCLIP*	*ESI MS-MS*	*Metabolomic finger printing*
S-4	SLO-1	*How high throughput technologies empower the stake holders*	*Application of population genetics in genomics*	*Expressed Sequence Tag(EST) anlysis*	*Mass spectrometry ESI MALDI-TOF*	*Epigenome and Imprinting,*
	SLO-2	*Real world applications*	*Important principles in population genomics*	*Serial Analysis of Gene Expression (SAGE)*	*Peptide mass finger printing database*	*Does epigenetic regulation is an antithesis to Darwin's Theory of evolution?*
S-5	SLO-1	*Scalability of High through put screening*	*Comparative genomics of prokaryotes*	*Ribosome Profiling for ribosome-protected mRNA fragments*	*Targeted Mass spectrometry -Principles*	*Histone modification assay*
	SLO-2	*Evolvabilty of High through put screening*	*Comparative genomics of eukaryotes*	*What are RNA motifs and their relevance*	*Targeted Mass spectrometry - Applications*	*DNA Methylation assay*
S-6	SLO-1	*Exploring and replicating published research work*	*Functional genomics of prokaryotes*	*Experimental techniques 1- Micro array*	*Functional mass spectrometry principles*	*Genome wide assays and their relevance*
	SLO-2	*Reviews and their uses*	*Functional genomics of eukaryotes*	*2. RT-PCR as a validating tool*	*Functional mass spectrometry applications*	*Bisulphate sequencing and Direct detection of methylation*
S-7	SLO-1	*Need of open source research*	*Ecological genomics (Metagenomics) of microbes*	*Importance of reference gene*	*Overview of protein quantitation methods*	*Experimental methods for lipid extraction*

	SLO-2	*Power of open source research*	*Ecological genomics (Metagenomics) higher organisms*	*Analysis of differential gene expression*	*Quantitation of proteins using MS*	*Lipid assays*
S-8	SLO-1	*Comparison of available data quality*	*Pharmacokinetics basics*	*Generation of transcriptional regulatory networks*	*Post translational modification of proteins*	*Lipid detection techniques*
	SLO-2	*Comparison of methods for published data*	*Pharmacogenomics*	*Analysis of transcriptional regulatory networks*	*Analysis of post translational modification of proteins using MS*	*Lipid based imaging techniques*
S-9	SLO-1	*'OMICS' technologies*	*Application of genomics in public health*	*Genetic screens for protein network*	*Protein – Protein interactions*	*Lipid based disorders*
	SLO-2	*Current status of OMICS technologies*	*Application of genomics in industry*	*Understanding signaling pathways*	*Interactomics*	*Lipidomic profiling*

Learning Resources	1. *High-Throughput Next Generation Sequencing Methods and Applications, Kwon, Young Min, Ricke, Steven C. (Eds.), Humana press, 2011, UK* 2. *Proteomics: from protein sequence to function,* Pennington, Stephen R.; Dunn, Michael J. 1st Edition, 2000, *Oxford Publications, UK* 3. *Text /Video: Genomics and Proteomics: Principles, Technologies, and Applications, Devarajan Thangadurai (Editor), Jeyabalan Sangeetha(Editor), 1st edition,2015, Apple academic press, New York, USA.*

Learning Assessment

	Bloom's Level of Thinking	Continuous Learning Assessment (50% weightage)								Final Examination (50% weightage)	
		CLA – 1 (10%)		CLA – 2 (15%)		CLA – 3 (15%)		CLA – 4 (10%)#			
		Theory	Practice	Theory	Practice	Theory	Practice	Theory	Practice	Theory	Practice
Level 1	Remember Understand	*40 %*	-	*30%*	-	*30%*	-	*30%*	-	*30%*	-
Level 2	Apply Analyze	*40 %*	-	*40%*	-	*40%*	-	*40%*	-	*40%*	-
Level 3	Evaluate Create	*20 %*	-	*30%*	-	*30%*	-	*30%*	-	*30%*	-
	Total	100 %		100 %		100 %		100 %		100 %	

CLA – 4 can be from any combination of these: Assignments, Seminars, Tech Talks, Mini-Projects, Case-Studies, Self-Study, MOOCs, Certifications, Conf. Paper etc.,

Course Designers

Experts from Industry	Experts from Higher Technical Institutions	Internal Experts
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Course Code	18BTE422T	Course Name	METABOLIC ENGINEERING OF MICROBES	Course Category	E	Professional Elective	L	T	P	C
							3	0	0	4

Pre-requisite Courses	18BTC103J	Co-requisite Courses	Nil	Progressive Courses	Nil
Course Offering Department	Biotechnology	Data Book / Codes/Standards			

Course Learning Rationale (CLR):	*The purpose of learning this course is to:*
CLR-1 :	*Develop metabolically engineered organisms and products*
CLR-2 :	*Use tools and methods used for metabolic engineering of microbes*
CLR-3 :	*Analyze regulatory mechanisms in metabolic pathways*
CLR-4:	*Apply knowledge on design of a metabolic engineering in practice*
CLR-5:	*Analyze metabolic flux in biochemical pathways*
CLR-6:	*Study about thermodynamic principles of cellular processes*

Course Learning Outcomes (CLO):	*At the end of this course, learners will be able to:*	Learning 1	2	3	Program Learning Outcomes (PLO) 1	2	3	4	5	6	7	8	9	10	11	12	13	14	15
		Level of Thinking (Bloom)	Expected Proficiency (%)	Expected Attainment (%)	Engineering Knowledge	Problem Analysis	Design & Development	Analysis, Design, Research	Modern Tool Usage	Society & Culture	Environment & Sustainability	Ethics	Individual & Team Work	Communication	Project Mgt. & Finance	Life Long Learning	PSO - 1	PSO - 2	PSO – 3
CLO-1 :	*Discuss regulation of metabolic pathways*	*H*	*80*	*80*	*M*			*H*				*M*					*H*	*H*	*H*
CLO-2 :	*To gain insight into methods used for metabolic engineering*	*H*	*80*	*75*	*M*	*H*	*H*	*H*				*H*	*H*				*H*	*H*	*H*
CLO-3 :	*Develop plan and methods for metabolic engineering*	*H*	*75*	*75*	*M*	*H*	*H*	*H*	*H*			*H*	*H*				*H*	*H*	*H*
CLO-4 :	*Apply knowledge on tools and techniques used for metabolic engineering*	*H*	*75*	*75*	*M*	*H*	*H*	*H*	*H*	*H*	*H*	*H*	*H*				*H*	*H*	*H*
CLO-5 :	*To understand the product formation from metabolically engineered microbes*	*H*	*80*	*80*	*M*	*H*	*H*		*M*	*M*	*H*	*H*	*H*				*H*	*H*	*H*
CLO-6 :	*Design pathway engineering techniques for diverting metabolic flux into product formation*	*H*	*80*	*80*	*M*	*H*	*H*	*H*	*H*	*H*	*H*	*M*	*H*				*H*	*H*	*H*

Duration (hour)		10	10	10	10	10
S-1	SLO-1	*Basic concepts of metabolic engineering*	*Overview of metabolic pathways in microbes*	*Metabolic engineering for enhancing product formation*	*Tools for metabolic engineering*	*Important aspects of metabolic engineering*
	SLO-2	*Importance of metabolic engineering*	*Regulation of metabolic pathways*	*Acetone production*	*Classical mutagenesis techniques*	*Metabolic pathway analysis*
S-2	SLO-1	*Overview of cellular metabolism*	*Enzyme mediated pathway regulation*	*Amino acid production*	*Methods for screening mutants*	*Metabolic flux analysis*
	SLO-2	*Energy generation pathways in microbes*	*Mechanisms of enzyme action*	*Engineering pentose metabolism*	*Gene shuffling methods*	*Metabolic flux control*
S-3	SLO-1	*Anaplerotic reactions*	*Transcriptional control of enzyme activity*	*Starch and lignin degradation*	*Gene knockout using CRISPR*	*Methods to calculate metabolic flux*
	SLO-2	*Rate constants and reaction equillibrium*	*Enzyme turnover*	*Vitamin production*	*Cloning and expression of gene clusters*	*Metabolic component analysis*
S-4	SLO-1	*Fuelling reactions – glycolysis*	*Enzyme activity by translational control*	*Polyketide biosynthesis*	*Antisense RNA based methods*	*Linear pathway analysis*
	SLO-2	*Fermentation pathways*	*Reversible inhibition*	*Biopolymer production*	*Directed evolution for improving protein function*	*Branched pathway analysis*
S-5	SLO-1	*Catabolism of fats and amino acids*	*Irreversible inhibition*	*Production of novel compounds using metabolic engineering*	*Artificial chromosomes*	*Structure of a metabolic network*
	SLO-2	*Biosynthetic of polymers*	*Global regulation of metabolic pathways*	*Antibiotics and vitamins*	*Chromosomal engineering strategies*	*Flux distribution*
S-6	SLO-1	*Nucleic acid biosynthesis*	*Allosteric enzymes involved in metabolic regulation*	*Production of pigments*	*RNA engineering technologies*	*Flux analysis of metabolic networks*
	SLO-2	*Amino acid biosynthesis*	*Regulation of enzyme activity using feedback mechanism*	*Biopolymer production*	*Improving translational efficiency*	*Determination of Group Control Coefficient*
S-7	SLO-1	*Active transport*	*Sigmoidal kinetics*	*Pesticide degradation*	*Stimulation of product formation using precursor molecules*	*Thermodynamics of cellular processes*
	SLO-2	*Facilitated diffusion*	*Allosteric regulation of enzyme activity*	*Xenobiotic degradation*	*Multifunctional enzyme systems*	*Thermodynamic feasibility*

S-8	SLO-1	*Cellular energetics,*	*Co-operativity of allosteric enzymes*	*Metabolic engineering of mammalian cells*	*Engineering of secretory processing pathway*	*Metabolic models for growth*
	SLO-2	*yield coefficients*	*Examples of enzyme cooperativity*	*Cell cycle engineering*	*Phenotype microarrays*	*Models for product formation*
S-9	SLO-1	*Primary metabolite production*	*Branch point classification*	*Apoptosis control*	*HighThrougput Mutagenesis*	*Genome scale modeling of cellular metabolism*
	SLO-2	*Secondary metabolite production*	*Coupled reactions*	*Inhibition of cell proliferation*	*High Throughput screening*	*Cell free systems for metabolic engineering*

Learning Resources	1. *Gregory N. Stephanopolous, Aristous A. Aristoudou, Jens Neilsen, Metabolic engineering – Principles and methodologies , Academic press, (1998)* 2. *Quiong Chen – Microbial Metabolic Engineering – Methods and protocols – first edition – Humana Press (2011)* 3. *Christina Smoke – Metabolic Engineering Pathway Handbook – 2nd edition, CRC press (2017)*

SLO – Session Learning Outcome

Learning Assessment

	Bloom's Level of Thinking	Continuous Learning Assessment (50% weightage)								Final Examination (50% weightage)	
		CLA – 1 (10%)		CLA – 2 (15%)		CLA – 3 (15%)		CLA – 4 (10%)#			
		Theory	Practice	Theory	Practice	Theory	Practice	Theory	Practice	Theory	Practice
Level 1	Remember Understand	*40 %*	-	*30%*	-	*30%*	-	*30%*	-	*30%*	-
Level 2	Apply Analyze	*40 %*	-	*40%*	-	*40%*	-	*40%*	-	*40%*	-
Level 3	Evaluate Create	*20 %*	-	*30%*	-	*30%*	-	*30%*	-	*30%*	-
	Total	100 %		100 %		100 %		100 %		100 %	

CLA – 4 can be from any combination of these: Assignments, Seminars, Tech Talks, Mini-Projects, Case-Studies, Self-Study, MOOCs, Certifications, Conf. Paper etc.,

Course Designers

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Course Code	18BTE423T	Course Name	GENETICS OF CROP IMPROVEMENT	Course Category	E	Professional Elective	L	T	P	C
							3	0	0	3

Pre-requisite Courses	18BTC105J	Co-requisite Courses	Nil	Progressive Courses	Nil
Course Offering Department	Genetic Engineering	Data Book / Codes/Standards	Nil		

Course Learning Rationale (CLR):	*The purpose of learning this course is to:*
CLR-1 :	*Identify the important attributes that demonstrate high yield potential*
CLR-2 :	*Understanding the factors that control crop productivity.*
CLR-3 :	*Analyze Biotic and abiotic stress-plant interactions*
CLR-4:	*Explore plant-microbe beneficial interactions*
CLR-5:	*Analyze metabolic pathways for crop value addition*
CLR-6:	*compare, contrast and distinguish the right molecular strategies for crop improvement*

Course Learning Outcomes (CLO):	*At the end of this course, learners will be able to:*	Learning 1 Level of Thinking (Bloom)	2 Expected Proficiency (%)	3 Expected Attainment (%)
CLO-1 :	*Explain the genetic basis of crop productivity*	*1*	*85*	*75*
CLO-2 :	*Analyze the tools for crop improvement*	*2*	*90*	*80*
CLO-3 :	*Develop tolerance against abiotic stress*	*2*	*75*	*65*
CLO-4 :	*Develop tolerance against biotic stress*	*2*	*75*	*65*
CLO-5 :	*Analyze pathways to engineer value addition*	*3*	*70*	*60*
CLO-6 :	*Develop elite cultivars*	*3*	*70*	*60*

Program Learning Outcomes (PLO)

	1 Engineering Knowledge	2 Problem Analysis	3 Design & Development	4 Analysis, Design, Research	5 Modern Tool Usage	6 Society & Culture	7 Environment & Sustainability	8 Ethics	9 Individual & Team Work	10 Communication	11 Project Mgt. & Finance	12 Life Long Learning	13 PSO - 1	14 PSO - 2	15 PSO – 3
CLO-1		*H*	*M*	*L*	*M*	*M*	*M*		*M*	*H*		*H*	*H*	*H*	*H*
CLO-2		*H*	*M*	*L*	*M*	*M*			*M*	*H*		*H*	*H*	*H*	*H*
CLO-3		*M*	*L*	*L*	*L*	*M*	*M*		*M*	*H*		*H*	*H*	*H*	*H*
CLO-4		*M*	*L*	*L*	*L*	*M*	*M*		*M*	*H*		*H*	*H*	*H*	*H*
CLO-5		*M*	*L*	*L*	*L*	*M*	*M*		*M*	*H*		*H*	*H*	*H*	*H*
CLO-6		*M*	*L*	*L*	*H*	*H*	*H*		*M*	*H*		*H*	*H*	*H*	*H*

Duration (hour)		9	9	9	9	9
S-1	SLO-1	*Traditional breeding*	*Pest tolerance and agriculture sustainability*	*Abiotic stress and agriculture sustainability*	*Photosynthetic efficiency*	*Plant Metabolic Pathways and products*
	SLO-2	*Methods of breeding*	*Pathogens and insect pests*	*Major abiotic stresses*	*Regulation of photosynthesis*	*Signals cascade*
S-2	SLO-1	*Marker assisted breeding*	*Genetics of host-pathogen interactions*	*Biochemical basis of abiotic stresses*	*C3, C4, and CAM*	*Metabolic engineering for value addition*
	SLO-2	*Methods to generate markers*	*signal transduction*	*signal transduction*	*Molecular control of photosynthesis*	*Methods to modify metabolic pathway*
S-3	SLO-1	*Mutation breeding*	*Virulence- Avirulence in host–pathogens interaction*	*drought, salinity*	*Biological Nitrogen Fixation*	*Sugar metabolism*
	SLO-2	*Steps in mutation breeding*	*Molecular mechanism of virulence*	*Regulation of drought response*	*Molecular regulation of N fixation*	*Amino acid pathway*
S-4	SLO-1	*transgenic technology*	*Molecular strategies of pathogen tolerance*	*Temperature*	*Molecular basis of N fixation*	*Vitamin A and carotenoid pathway*
	SLO-2	*Over expression and knock outs*	*Approaches against fungal pathogens*	*Regulation of temperature respose*	*Enzymes involved in N fixation*	*vitamin A fortified rice*
S-5	SLO-1	*Loss of /Gain of function mutants*	*Approaches against bacterial pathogens*	*Stress signal transduction*	*Hormonal in plant growth and development*	*Fortified edible oil*
	SLO-2	*Genetic screens*	*Insect pest resistance*	*Key transcriptional factors in stress response*	*Plant Growth Promoting bacteria*	*Omega fatty acids*
S-6	SLO-1	*RNAi*	*Molecular strategies of insect pest tolerance*	*Reactive oxygen species*	*Phosphorus Solubilizing/Mobilizing bacteria*	*Secondary metabolites*
	SLO-2	*Genome editing*	*Biological control of insect pests*	*Regulation of ROS*	*Molecular basis of P mobilization*	*Industrially and medicinal metabolites*
S-7	SLO-1	*Zinc finger*	*multi-gene pyramiding*	*Molecular strategies for tolerance against abiotic stress*	*Sucrose as a signaling molecule*	*metabolic engineering to remove antinutritional compounds*
	SLO-2	*TALEN*	*Pathogenesis related proteins*	*calcium, nitric oxide and salicylic acid in plant defence*	*Vesicular Arbuscular Mycorrhiza*	*Phytates*
S-8	SLO-1	*CRISPR/Cas*	*Virus resistance*	*synthesis and functions of proline*	*Microbes that mimics stress response*	*Engineering to improve food digestibility*
	SLO-2	*CRISPR/Cas mechanism*	*Strategies of virus resistance*	*synthesis and functions of glycine betaine in stress tolerance*	*Nutrient translocation*	*Engineering for aesthetic value*
S-9	SLO-1	*GMO*	*Molecular methods to generate virus resistance*	*Role of hormones in stress response*	*Applications of plant – beneficial microbe association*	*Applications of metabolic engineering in crop improvement*
	SLO-2	*Regulation and Monitoring GM*	*Applications of genetic engineering in pest tolerance*	*Applications of genetic engineering in abiotic stress tolerance*	*Genetic engineering approaches to enhance plant growth and development*	*Applications of metabolic engineering in agricultural industry*

Learning Resources	1. *S. Mohan Jain and D.S. Brar Molecular Techniques in Crop Improvement 2nd edition. 2010 Springer. ISBN 978-90-481-2966-9 e-ISBN 978-90-481-2967-6* 2. *Khalid Rehman Hakeem and Parvaiz Ahmad Munir Ozturk. 2013. Springer. Crop Improvement New Approaches and Modern Techniques. ISBN 978-1-4614-7027-4 ISBN 978-1-4614-7028-1*

Learning Assessment

	Bloom's Level of Thinking	Continuous Learning Assessment (50% weightage)								Final Examination (50% weightage)	
		CLA – 1 (10%)		CLA – 2 (15%)		CLA – 3 (15%)		CLA – 4 (10%)#			
		Theory	Practice	Theory	Practice	Theory	Practice	Theory	Practice	Theory	Practice
Level 1	Remember Understand	*40 %*	-	*30%*	-	*30%*	-	*30%*	-	*30%*	-
Level 2	Apply Analyze	*40 %*	-	*40%*	-	*40%*	-	*40%*	-	*40%*	-
Level 3	Evaluate Create	*20 %*	-	*30%*	-	*30%*	-	*30%*	-	*30%*	-
	Total	100 %		100 %		100 %		100 %		100 %	

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Course Designers

Experts from Industry	Experts from Higher Technical Institutions	Internal Experts
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Course Code	18BTE424T	Course Name	MOLECULAR BIOLOGY OF INFECTIOUS DISEASES	Course Category	E	Professional Elective	L	T	P	C
							3	0	0	3

Pre-requisite Courses	18BTC103J	Co-requisite Courses	Nil	Progressive Courses	Nil
Course Offering Department	Biotechnology	Data Book / Codes/Standards	Nil		

Course Learning Rationale (CLR):	*The purpose of learning this course is to:*
CLR-1 :	*State the basics of infectious diseases*
CLR-2 :	*Discuss molecular pathogenesis of bacterial diseases*
CLR-3 :	*Discuss molecular pathogenesis of viral diseases*
CLR-4:	*Explain molecular pathogenesis of parasitic and fungal diseases*
CLR-5:	*Illustrate the molecular pathogenesis of fungal pathogens*
CLR-6:	*Recognize defense mechanisms of infectious microbes*

Course Learning Outcomes (CLO):	*At the end of this course, learners will be able to:*	Learning 1 Level of Thinking (Bloom)	2 Expected Proficiency (%)	3 Expected Attainment (%)	Program Learning Outcomes (PLO) 1 Engineering Knowledge	2 Problem Analysis	3 Design & Development	4 Analysis, Design, Research	5 Modern Tool Usage	6 Society & Culture	7 Environment & Sustainability	8 Ethics	9 Individual & Team Work	10 Communication	11 Project Mgt. & Finance	12 Life Long Learning	13 PSO - 1	14 PSO - 2	15 PSO – 3
CLO-1 :	*Describe the basics of molecular pathology of various infectious diseases*	*1*	*80*	*75*	*M*	*M*	*M*	*M*	*H*	*H*	*H*	*H*	*M*	*L*	*L*	*H*	*H*	*H*	*H*
CLO-2 :	*Investigate the molecular pathogenesis of bacterial pathogens*	*2*	*80*	*70*	*M*	*M*	*M*	*M*	*H*	*H*	*H*	*M*	*M*	*L*	*L*	*H*	*H*	*H*	*H*
CLO-3 :	*Investigate the molecular pathogenesis of viral pathogens*	*2*	*80*	*75*	*M*	*M*	*M*	*M*	*H*	*H*	*H*	*M*	*M*	*L*	*L*	*H*	*H*	*H*	*H*
CLO-4 :	*Examine the molecular pathogenesis of parasitic diseases*	*2*	*80*	*70*	*M*	*M*	*M*	*M*	*H*	*H*	*H*	*M*	*M*	*L*	*L*	*H*	*H*	*H*	*M*
CLO-5 :	*Explain the molecular pathogenesis of fungal infections*	*2*	*85*	*75*	*M*	*M*	*M*	*M*	*H*	*H*	*H*	*M*	*M*	*L*	*M*	*H*	*H*	*H*	*H*
CLO-6 :	*Recall the defense mechanisms of infectious microbes*	*3*	*90*	*80*	*M*	*M*	*M*	*M*	*H*	*H*	*H*	*M*	*M*	*L*	*M*	*H*	*H*	*H*	*H*

Duration (hour)		9	9	9	9	9
S-1	SLO-1	Historical perspective of infectious diseases	Morphology, pathogenicity of Cholera	Morphology, pathogenicity of HIV	Morphology and lifecycle of Malaria	Hide from immune surveillance
	SLO-2	Disease outbreak	Molecular biology of Cholera	Molecular biology of AIDS virus	Molecular biology of Malaria	Microbe escape mechanism
S-2	SLO-1	Microbial Toxins	Morphology, pathogenicity of Tuberculosis	Morphology and lifecycle of Dengue	Morphology and lifecycle of Wuchereria bancrofti	Antibiotic resistance mechanism
	SLO-2	Types of microbial toxins	Molecular biology of Tuberculosis	Molecular biology of Dengue	Molecular biology of Filariasis	Multiple drug resistance
S-3	SLO-1	Toxin assays	Enteric fever causes	Morphology, pathogenicity of Rabies virus	Morphology , transmission, pathogenesis of Leptospirosis	Evasion of phagocytosis
	SLO-2	Toxin genes	Molecular biology of Enteric Fever	Molecular biology of Rabies	Molecular biology of Leptospirosis	Evasion mechanism of phagocytosis
S-4	SLO-1	Water borne pathogens	Morphology and pathogenesis of Shigella	Structure and pathogenesis of Hepatitis virus	Morphology, pathogenicity of Treponema pallidum	Antigen Hyper variability
	SLO-2	Air borne Pathogens	Bacterial signals and cell responses during Shigella entry into epithelial cells	Molecular biology of Hepatitis	Molecular biology of Syphilis	Antigenic shift and drift
S-5	SLO-1	Soil borne pathogens	Insights into biology of Typhoid Toxin	Pathogenesis of papilloma virus	Fungal pathogens	Secreted modulators
	SLO-2	Pathogens transmitted via animals	Serovars of Salmonella	Molecular biology of cervical cancer	Molecular biology of Aspergillosis	Surface modulators
S-6	SLO-1	Mode of Entry of pathogens	Genetic and Molecular aspects of Helicobacter pyroli	Morphology and pathogenesis of Flu virus	Causes of Athletes foot	Interaction with Toll Like receptors
	SLO-2	Initiation of diseases	Molecular biology of Gastric ulcer	Molecular biology of Flu virus	Molecular biology of Athletes foot	Interference with Cytokines
S-7	SLO-1	General disease symptoms - External	Morphology and pathogenesis of botulism	Morphology and pathogenesis of Polio virus	Morphology , transmission, pathogenesis of Trypanosomia	Complement pathway inhibition
	SLO-2	Disease symptoms - Internal	Mode of action of botulism toxin	Molecular biology of Polio virus	Molecular biology of Sleeping sickness	Defense against competition
S-8	SLO-1	Virulence factors – Cell bound	Morphological identification methods	Genetic screens to understand signaling pathways	Molecular biology of Amoebiasis	Interfering with cell signaling
	SLO-2	Virulence factors - secreted	Culture based identification methods	Virus culturing	Molecular biology of Candidiasis	Examples
S-9	SLO-1	Virulence associated Genes	Serologic diagnostic methods of bacterial diseases	Serologic diagnostic methods of viral diseases	Serologic diagnostic methods of parasitic diseases	Pathogen signaling to repress antimicrobial compound synthesis
	SLo-2	Plasmid borne virulence associated genes	Molecular diagnostic methods of bacterial diseases	Molecular diagnostic methods of viral diseases	Molecular diagnostic methods of parasitic diseases	Pathogen structural barriers

Learning Resources	1. *Peter Williams, Julian Ketley & George Salmond, "Methods in Microbiology: Bacterial Pathogenesis, Vol. 27", Academic Press, 1998.* 2. *Rajan.R., "Medical Microbiology", MJP Publishers, 1st edition, 2007.*

Learning Assessment											
	Bloom's Level of Thinking	Continuous Learning Assessment (50% weightage)								Final Examination (50% weightage)	
		CLA – 1 (10%)		CLA – 2 (15%)		CLA – 3 (15%)		CLA – 4 (10%)#			
		Theory	Practice	Theory	Practice	Theory	Practice	Theory	Practice	Theory	Practice
Level 1	Remember Understand	*40 %*	-	*30%*	-	*30%*	-	*30%*	-	*30%*	-
Level 2	Apply Analyze	*40 %*	-	*40%*	-	*40%*	-	*40%*	-	*40%*	-
Level 3	Evaluate Create	*20 %*	-	*30%*	-	*30%*	-	*30%*	-	*30%*	-
	Total	100 %		100 %		100 %		100 %		100 %	

CLA – 4 can be from any combination of these: Assignments, Seminars, Tech Talks, Mini-Projects, Case-Studies, Self-Study, MOOCs, Certifications, Conf. Paper etc.,

Course Designers		
Experts from Industry	Experts from Higher Technical Institutions	Internal Experts
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Course Code	18BTE425T	Course Name	MOLECULAR DIAGNOSTICS	Course Category	E	Professional Elective	L	T	P	C
							3	0	0	3

Pre-requisite Courses	Nil	Co-requisite Courses	Nil	Progressive Courses	Nil
Course Offering Department	Biotechnology	Data Book / Codes/Standards	Nil		

Course Learning Rationale (CLR):	*The purpose of learning this course is to:*
CLR-1 :	*Explain hybridization based methods for diagnosis of genetic diseases*
CLR-2 :	*Discuss PCR based diagnosis*
CLR-3 :	*Discuss diagnosis by DNA Sequencing*
CLR-4:	*Explain about nucleic acid based diagnosis of infectious diseases*
CLR-5:	*Discuss immunological diagnosis of infectious diseases*
CLR-6:	*Explain molecular methods for molecular diagnostics*

Course Learning Outcomes (CLO):	*At the end of this course, learners will be able to:*	Learning 1: Level of Thinking (Bloom)	Learning 2: Expected Proficiency (%)	Learning 3: Expected Attainment (%)	PLO 1: Engineering Knowledge	PLO 2: Problem Analysis	PLO 3: Design & Development	PLO 4: Analysis, Design, Research	PLO 5: Modern Tool Usage	PLO 6: Society & Culture	PLO 7: Environment & Sustainability	PLO 8: Ethics	PLO 9: Individual & Team Work	PLO 10: Communication	PLO 11: Project Mgt. & Finance	PLO 12: Life Long Learning	PLO 13: PSO - 1	PLO 14: PSO - 2	PLO 15: PSO – 3
CLO-1 :	*Employ hybridization based methods for diagnosis of genetic diseases*	*2*	*75*	*70*	*M*	*H*	*H*	*H*	*H*	*H*	*L*	*M*	*H*	*H*	*H*	*H*	*H*	*H*	*H*
CLO-2 :	*Apply PCR based diagnosis*	*3*	*80*	*75*	*H*	*H*	*H*	*H*	*H*	*H*	*M*	*H*	*H*	*H*	*H*	*H*	*H*	*H*	*H*
CLO-3 :	*Design diagnostic method by DNA Sequencing*	*3*	*85*	*80*	*M*	*H*	*M*	*H*	*H*	*H*	*M*	*M*	*H*	*H*	*H*	*H*	*H*	*H*	*H*
CLO-4 :	*Apply nucleic acid based diagnosis of infectious diseases*	*2*	*80*	*75*	*H*	*H*	*H*	*H*	*H*	*M*	*H*	*L*	*H*	*H*	*H*	*H*	*H*	*H*	*H*
CLO-5 :	*Employ immunological diagnosis of infectious diseases*	*3*	*85*	*75*	*H*	*H*	*H*	*H*	*M*	*M*	*H*	*H*	*H*	*L*	*H*	*H*	*H*	*H*	*H*
CLO-6 :	*Analyze genetic and infectious diseases through molecular methods*	*2*	*80*	*75*	*H*	*H*	*H*	*H*	*L*	*M*	*M*	*M*	*H*	*H*	*H*	*H*	*H*	*H*	*H*

Duration (hour)		9	9	9	9	9
S-1	SLO-1	*Introduction to FISH*	*Introduction to PCR based diagnostics*	*Basics of DNA sequencing*	*Ribotyping*	*Agglutination test: Principle, method*
	SLO-2	*Types of FISH*	*End-point PCR*	*Mutation detection by sequencing*	*Applications of Ribotyping*	*Application of Agglutination test*
S-2	SLO-1	*Interphase FISH*	*ARMS PCR based diagnostics*	*Genome wide association studies*	*Pulse Field Gel Electrophoresis*	*ELISA's : principle, method and types*
	SLO-2	*Metaphase FISH,*	*Allele specific PCR*	*Application in Health care*	*Application of PFGE*	*Application of ELISA*
S-3	SLO-1	*Principles of Multicolor FISH*	*Restriction fragment length polymorphism (RFLP)*	*Next generation sequencing*	*Multiplex PCR for virulence factor detection*	*Immunofluorescence: Principle, method and types*
	SLO-2	*Multicolor FISH*	*Mutation detection using RFLP*	*Application in disease diagnosis*	*Application and limitations*	*Application of Immunofluorescence*
S-4	SLO-1	*Application of FISH*	*Multiplex PCR*	*Clinical exome sequencing*	*Recombinase polymerase amplification (RPA) assay*	*Western blots: Principle, Method, trouble shoot*
	SLO-2	*Limitations of FISH*	*Applications of multiplex PCR*	*Application in Health care*	*Application and limitations RPA*	*Application of Western blot*
S-5	SLO-1	*Principles of genomic hybridization*	*LAMP PCR*	*Linkage analysis*	*Sequencing for multidrug resistant markers*	*Clinical significance of HIV*
	SLO-2	*Comparative genomic hybridization*	*LAMP PCR for Molecular diagnisis*	*Linkage analysis for disease diagnosis*	*Applications and limitations*	*Case study: HIV detection*
S-6	SLO-1	*Introduction to DNA chips and Micro-arrays*	*Multiplex ligation probe dependent amplification (MLPA)*	*Marfan syndrome: Disease gene identification*	*DNA chips: Principle and method*	*Case study: Tuberculosis*
	SLO-2	*Diagnostics based on DNA chips and Micro-arrays*	*MLPA in disease diagnosis*	*Case study: Marfan syndrome*	*Gene chips for mutation screening in virulence genes*	*Diagnosis and challenges*
S-7	SLO-1	*Down syndrome*	*Real time PCR*	*Cystic fibrosis*	*Case study: MRSA,*	*Case study: Flu virus*

	SLO-2	*Case study: Diagnosis of Down syndrome*	*Application in diagnosis*	*Case study: cystic fibrosis*	*Diagnosis of MRSA*	*Diagnosis of Flu Virus*
S-8	SLO-1	*Digeorge syndrome*	*Sickel cell anaemia*	*Molecular aspects of diabetes*	*Case study: Vibrio cholerae*	*Case study: Dengue*
	SLO-2	*Case study: Diagnosis of Digeorge syndrome*	*Case study: Diagnosis of Sickel cell anaemia*	*Case study: Diagnosis of diabetes*	*Diagnosis of Vibrio cholerae*	*Diagnosis of Dengue virus*
S-9	SLO-1	*Childhood leukemia*	*Duchenne muscular dystrophy*	*Dibetes: Disease gene identification*	*Case study: Acinetobacter boumannii*	*Case study: chikungunya*
	SLO-2	*Case study: Diagnosis of Childhood leukemia*	*Case study: Diagnosis of Duchenne muscular dystrophy*	*Clinical application of dibetes gene identification*	*Diagnosis of Acinetobacter boumannii*	*Diagnosis of chikungunya*

Learning Resources	*1. Gersen, Keagle, " The Principles of Clinical Cytogenetics" 3rd edition - Springer-Verlag, Inc., 2013.* *2. Donnai, Read, "New Clinical Genetics" 3rd edition – Scion, Inc., 2015.* *3. Tang, Statton, "Advanced Techniques in Diagnostic Microbiology" Springer, Inc., 2013*

Learning Assessment

	Bloom's Level of Thinking	Continuous Learning Assessment (50% weightage)								Final Examination (50% weightage)	
		CLA – 1 (10%)		CLA – 2 (15%)		CLA – 3 (15%)		CLA – 4 (10%)#			
		Theory	Practice	Theory	Practice	Theory	Practice	Theory	Practice	Theory	Practice
Level 1	Remember Understand	*40 %*	-	*30%*	-	*30%*	-	*30%*	-	*30%*	-
Level 2	Apply Analyze	*40 %*	-	*40%*	-	*40%*	-	*40%*	-	*40%*	-
Level 3	Evaluate Create	*20 %*	-	*30%*	-	*30%*	-	*30%*	-	*30%*	-
	Total	100 %		100 %		100 %		100 %		100 %	

CLA – 4 can be from any combination of these: Assignments, Seminars, Tech Talks, Mini-Projects, Case-Studies, Self-Study, MOOCs, Certifications, Conf. Paper etc.,

Course Designers

Experts from Industry	Experts from Higher Technical Institutions	Internal Experts
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Course Code	18BTE426T	Course Name	GENE THERAPY	Course Category	E	Professional Elective	L	T	P	C
							3	0	0	3

Pre-requisite Courses	18BTC105J	Co-requisite Courses	Nil	Progressive Courses	Nil
Course Offering Department	Biotechnology	Data Book / Codes/Standards	Nil		

Course Learning Rationale (CLR):	*The purpose of learning this course is to:*
CLR-1 :	*Provide basic knowledge on gene therapy and its importance.*
CLR-2 :	*Identify an interest to know about the different types of gene therapy, its applications for diseases.*
CLR-3 :	*Develop awareness about the different methods of gene delivery and provide knowledge on vectors.*
CLR-4:	*Initiate interest on latest techniques in genome editing and understand its applications.*
CLR-5:	*Develop interest on applications and uses of gene therapy in treatment of disease.*
CLR-6:	*Prepare engineering students to know the recent advancements in gene therapy.*

Course Learning Outcomes (CLO):	*At the end of this course, learners will be able to:*	Learning 1	Learning 2	Learning 3	PLO 1	PLO 2	PLO 3	PLO 4	PLO 5	PLO 6	PLO 7	PLO 8	PLO 9	PLO 10	PLO 11	PLO 12	PLO 13	PLO 14	PLO 15
		Level of Thinking (Bloom)	Expected Proficiency (%)	Expected Attainment (%)	Engineering Knowledge	Problem Analysis	Design & Development	Analysis, Design, Research	Modern Tool Usage	Society & Culture	Environment & Sustainability	Ethics	Individual & Team Work	Communication	Project Mgt. & Finance	Life Long Learning	PSO - 1	PSO - 2	PSO – 3
CLO-1 :	*Apply knowledge about gene therapy in treating diseases.*	1	80	70	-	-	H	M	-	-	M	H	-	H	-	H	H	H	H
CLO-2 :	*Practice knowledge on different types of gene therapy and its applications.*	2	85	75	-	-	H	M	-	-	M	H	-	H	-	H	H	H	H
CLO-3 :	*Interpret knowledge on construction of viral vectors and usage of non-viral vectors to correct the genetic defect.*	2	80	70	H	-	H	M	-	-	M	H	-	H	-	H	H	H	H
CLO-4 :	*Use molecular aspects involved in genome editing in gene therapy.*	2	80	75	H	-	H	M	-	-	M	H	-	H	-	H	H	H	H
CLO-5 :	*Evaluate treatment of diseases addressed by gene therapy clinical trials.*	3	80	70	H	-	H	M	-	-	M	H	-	H	-	H	H	H	H
CLO-6 :	*Analyze recent advancements in gene therapy.*	2	80	70	H	-	H	M	-	-	M	H	-	H	-	H	H	H	H

Duration (hour)		9	9	9	9	9
S-1	SLO-1	*Introduction to Gene therapy*	*Embryo somatic gene therapy - Reproductive cloning*	*Gene delivery-An overview*	*Genome editing-Gene Targeting*	*Stem cells in gene therapy-gene therapy of hematopoietic stem cells*
	SLO-2	*Genes as drugs*	*Embryo somatic gene therapy - Therapeutic cloning*	*Methods of gene delivery*	*Genome editing Processes-Double strand break repair*	*Major Applications Procedures for Gene Transfer into Hematopoietic Stem Cells*
S-2	SLO-1	*Gene therapy – overview*	*Preimplantation genetic diagnosis-History, Indications and applications*	*Direct Inoculation of DNAs*	*Engineered Nucleases*	*Treatment of genetic diseases - gene therapy of cancer- Gene Therapy of Cancer Using Suicide Genes*
	SLO-2	*History of Gene Therapy*	*Preimplantation genetic diagnosis – Techniques and ethical issues*	*Direct Inoculation of RNAs*	*Meganucleases*	*Immunotherapy of Cancer*
S-3	SLO-1	*Types of gene therapy-somatic*	*Prenatal/ fetal gene therapy – Concepts and methods*	*Non-viral methods-Physical methods*	*Zinc Finger Nucleases*	*Treatment of genetic diseases - neurodegenerative disorders- Gene Therapy of Alzheimer's Disease*
	SLO-2	*Types of gene therapy- germ line*	*Prenatal/fetal gene therapy with case study –Tay Sach's disease*	*Non-viral methoods-Chenical methods*	*ZNFs as gene editing tools*	*Treatment of genetic diseases - neurodegenerative disorders- Gene Therapy of Parkinson's Disease*
S-4	SLO-1	*Methods of gene therapy-Ex vivo*	*Postnatal somatic gene therapy*	*Viral Vectors - Retroviral vectors- Structure*	*TALENs as gene editing tools*	*Gene Therapy of Huntington's Disease*
	SLO-2	*Methods of gene therapy- In-vivo*	*Germline gene therapy*	*Retroviral vectors- Mechanism and action Adenoviral vectors-Structure, Mechanism*	*CRISPR/Cas9 as gene editing tools- Introduction and Mechanism*	*Gene Therapy of Spinal Muscular Dystrophy*
S-5	SLO-1	*Vectors for gene therapy-viral*	*Methods of Germline gene therapy*	*Adenoviral vectors-Structure, Mechanism*	*CRISPR/Cas9 as gene editing tools- Applications*	*Gene Treatment of genetic diseases - Retinal Photo transduction and the Visual Cycle*
	SLO-2	*Vectors for gene therapy-non-viral*	*Germline gene therapy-Drawbacks*	*Adenoviral vectors- Advantages and disadvantages*	*Precision and efficiency of engineered nucleases*	*Gene Treatment of genetic diseases - Congenital Retinal degenerations*
S-6	SLO-1	*Diseases with dominant heredity*	*Suicide gene therapy – Current strategies*	*Adeno associated viral vectors-Structure, Mechanism*	*Multiplex automated Genome engineering*	*Gene Therapy of Retinal Neovascularization and Retinoblastoma*

	SLO-2	*Diseases with recessive heredity*	*Suicide gene therapy for Cancer*	*Adeno associated viral vectors- Advantages and disadvantages*	*Types of therapeutic genome modifications- Gene disruption*	*Treatment of genetic diseases - cardiovascular disorders-*
S-7	SLO-1	*Ex vivo gene therapy with case study-SCID (Causes)*	*Secretion gene therapy*	*Herpes simplex viral vectors –Structure*	*Types of therapeutic genome modifications- Non homologous end joining - NHEJ gene correction*	*Gene Therapy of Heart Failure*
	SLO-2	*Ex vivo gene therapy with case study-SCID (Treatment)*	*Immunotherapy*	*Herpes simplex viral vectors – Mechanism and Action*	*Types of therapeutic genome modifications- Non homologous end joining - NHEJ gene addiction*	*Therapeutic Angiogenesis*
S-8	SLO-1	*In vivo gene therapy with case study- Cystic fibrosis (Causes)*	*Gene therapy for infectious diseases- Nucleic acid-based gene therapy (Antisense DNA and RNA, Ribozymes, RNA decoys)*	*Envelope protein pseudo typing of viral vectors*	*Types of therapeutic genome modifications - Homology directed repair - HDR gene correction*	*Gene therapy of HIV infection - Natural History of HIV-1 Infection*
	SLO-2	*In vivo gene therapy with case study- Cystic fibrosis (Treatment)*	*Protein- based assays for gene therapy*	*Replication-competent vectors*	*Types of therapeutic genome modifications - Homology directed repair - HDR gene addition*	*General Considerations Gene Therapy of HIV Infection by Intracellular Immunization*
S-9	SLO-1	*Ethical problems in gene therapy*	*Target pathogens for antimicrobial gene therapy*	*Cis and trans-acting elements*	*Applications of Genome editing*	*Therapy of HIV Infection by Immunotherapy*
	SLO-2	*Social problems in gene therapy*	*Examples of clinical trials for infectious diseases*	*Hybrid vectors*	*Prospects and llimitations of Genome editing*	*Recent advances in gene therapy*

Learning Resources	1. *Evelyn B. Kelly, "Gene Therapy", Greenwood Press, 2007.* 2. *Mauro Giacca, "Gene Therapy", Springer Milan, 2010.* 3. *Peter J. Quesenberry, "Stem cell biology and gene therapy", John Wiley & Sons, 2002.*	4. *Roland W. Herzog, "A Guide to Human Gene Therapy", World Scientific Publishing Co Pvt. Ltd. 2010.* 5. *David Benjamin Turitz Cox et al "Therapeutic genome editing: prospects and challenges" Nature Medicine, Vol 21(2): 121- 131, 2015.*

Learning Assessment

	Bloom's Level of Thinking	Continuous Learning Assessment (50% weightage)								Final Examination (50% weightage)	
		CLA – 1 (10%)		CLA – 2 (15%)		CLA – 3 (15%)		CLA – 4 (10%)#			
		Theory	Practice	Theory	Practice	Theory	Practice	Theory	Practice	Theory	Practice
Level 1	Remember Understand	*40 %*	-	*30%*	-	*30%*	-	*30%*	-	*30%*	-
Level 2	Apply Analyze	*40 %*	-	*40%*	-	*40%*	-	*40%*	-	*40%*	-
Level 3	Evaluate Create	*20 %*	-	*30%*	-	*30%*	-	*30%*	-	*30%*	-
	Total	100 %		100 %		100 %		100 %		100 %	

CLA – 4 can be from any combination of these: Assignments, Seminars, Tech Talks, Mini-Projects, Case-Studies, Self-Study, MOOCs, Certifications, Conf. Paper etc.,

Course Designers		
Experts from Industry	*Experts from Higher Technical Institutions*	*Internal Experts*
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Course Code	18BTE427T	Course Name	FUNCTIONAL GENOMICS	Course Category	E	Professional Elective	L	T	P	C
							3	0	0	3

Pre-requisite Courses	Nil	Co-requisite Courses	Nil	Progressive Courses	Nil
Course Offering Department	Biotechnology	Data Book / Codes/Standards	Nil		

Course Learning Rationale (CLR):	*The purpose of learning this course is to:*
CLR-1 :	*Analyze the genome structure, organization and function across life.*
CLR-2 :	*Analyze about the comparative genomics of organelles and nuclear genomes across life*
CLR-3 :	*Apply different classical methods to study gene expression and whole transcriptome*
CLR-4:	*Compare various NGS techniques to study genome, exome, and transcriptomes.*
CLR-5:	*Infer the basics of metabolic pathways, transcription factors and genome editing.*
CLR-6:	*Analyze the applications of functional genomics in various sectors.*

Course Learning Outcomes (CLO):	*At the end of this course, learners will be able to:*	Learning 1: Level of Thinking (Bloom)	2: Expected Proficiency (%)	3: Expected Attainment (%)	PLO 1: Engineering Knowledge	2: Problem Analysis	3: Design & Development	4: Analysis, Design, Research	5: Modern Tool Usage	6: Society & Culture	7: Environment & Sustainability	8: Ethics	9: Individual & Team Work	10: Communication	11: Project Mgt. & Finance	12: Life Long Learning	13: PSO - 1	14: PSO - 2	15: PSO – 3
CLO-1 :	*Describe the basics of genome organization across life and study of gene function*	1	75	80	M	H	H	H	H				H			H	H	H	H
CLO-2 :	*Describe the genomics of organelle and nuclear genomes across life*	1	75	80	M	H	H	H	H				H			H	H	H	H
CLO-3 :	*Review the organization of transcriptome and classical methods to study gene expression*	2	70	80	M	H	H	H	H				H			H	H	H	H
CLO-4 :	*Describe about traditional and Next Generation Sequencing (NGS)platforms for the study of genome, exome and transcriptome*	2	60	75	H	H	H	H	H			H	H		H	H	H	H	H
CLO-5 :	*Describe about genes for metabolic pathways, transcription factors, genome editing.*	3	70	80	M	H	H	H	H			H	H			H	H	H	H
CLO-6 :	*Summarize the applications of functional genomics in various sectors.*	3	60	80	M	H	H	H	H		H	H	H		H	H	H	H	H

Duration (hour)		9	9	9	9	9
S-1	SLO-1	*Genome organization in Eukaryotes*	*Genome size, gene content*	*Transcriptome from Eukaryotes*	*DNA Sequencing*	*Study of Gene functions*
	SLO-2	*Structural level organization*	*Gene order*	*Transcriptome from prokaryotes*	*Sanger method of DNA Sequencing*	*Metabolic pathways-KEGG*
S-2	SLO-1	*Genome organization in Eukaryotes*	*Orthologs*	*Gene expression studies with mRNA*	*Automated DNA Sequencing*	*Transcription factors*
	SLO-2	*Sequence level organization*	*Paralogs*	*Gene expression studies with other RNAs*	*Next Generation Sequencing (NGS)*	*Signaling cascades controlled by Transcription factors*
S-3	SLO-1	*Genome organization in Prokaryotes*	*Comparative genomics*	*Classical methods to study gene expression*	*Principle and methodology of NGS Platforms*	*Genome editing*
	SLO-2	*Sequence level organization*	*Comparative genomics of bacteria*	*Northern hybridization*	*Principle and methodology of NGS Platforms*	*Targeted genome Editing*
S-4	SLO-1	*Genetic elements and their organization in Eukaryotes*	*Pangenome-metagenomics*	*Differential Display PCR*	*Third Generation Sequencing methods*	*Tools for genome editing*
	SLO-2	*Genetic elements and regulation of gene expression in eukaryotes*	*Microbiome*	*Serial Analysis of Gene Expression (SAGE)*	*Comparison of high-throughput sequencing methods and applications*	*CRISPR/cas9 genome editing*
S-5	SLO-1	*Genetic elements and their organization in prokaryotes*	*Horizontal gene transfer*	*Reverse transcriptase PCR (RT-PCR) to study gene expression*	*Genome sequencing*	*Genetic variations and diseases*
	SLO-2	*Genetic elements and regulation on gene expression in Prokaryotes*	*Organelle genomes*	*Methodology of RT-PCR*	*Genome assembly*	*Tools to study mendelian diseases*
S-6	SLO-1	*Forward genetics*	*Methods to study organelle genomes*	*Quantitative PCR (real time) to study gene expression*	*Gene Prediction*	*Genomics of monogenic disorders*
	SLO-2	*Classical Forward genetics*	*Comparative genomics of mitochondrial genomes*	*Methodology of realtime-PCR*	*High-throughput RNA sequencing*	*Genomics of polygenic disorders*
S-7	SLO-1	*Functional genomic analysis with Forward genetics*	*Comparative genomics of plastid genomes*	*High-throughput methods to study gene expression*	*RNA sequencing to study genome wide gene expression*	*Genomics in Diagnostics*
	SLO-2	*Methods in Forward genetics*	*Nuclear genomes*	*Study of Gene expression using Microarray*	*Differential gene expression analysis with RNAseq*	*Population genetics*

S-8	SLO-1	*Reverse Genetics*	*Comparative genomics of nuclear genomes*	*Principle of Microarray*	*Small RNA sequencing*	*Evolutionary genetics*
	SLO-2	*Functional genomic analysis with reverse genetics*	*Plant genomes*	*Methodology of Microarray*	*Targeted sequencing*	*Applications of functional genomics in agriculture*
S-9	SLO-1	*Classical Methods in Reverse genetics*	*Animal genomes*	*Study of splice variants*	*Exome sequencing*	*Applications of functional genomics in healthcare*
	SLO-2	*Current methods in Forward and reverse genetics*	*Comparison of plant and animal genomes*	*Correlation of mRNA and protein abundance*	*Amplicon sequencing*	*Applications of functional genomics in prokaryotes*

Learning Resources	*1. Pevsner. J., "Bioinformatics and Functional Genomics", 3rd edition, Wiley-Blackwell. 2015.* *2. Mount. D, "Bioinformatics: Sequence and Genome Analysis", 2nd Edition, Cold Spring Harbor Laboratory Press, New York. 2004.* *3. Primrose. S.B., Twayman. R.M., "Principles of Gene Manipulation and Genomics" 7th edition, Blackwell publishing. 2006.*

Learning Assessment

	Bloom's Level of Thinking	Continuous Learning Assessment (50% weightage)								Final Examination (50% weightage)	
		CLA – 1 (10%)		CLA – 2 (15%)		CLA – 3 (15%)		CLA – 4 (10%)#			
		Theory	Practice	Theory	Practice	Theory	Practice	Theory	Practice	Theory	Practice
Level 1	Remember Understand	*40 %*	-	*30%*	-	*30%*	-	*30%*	-	*30%*	-
Level 2	Apply Analyze	*40 %*	-	*40%*	-	*40%*	-	*40%*	-	*40%*	-
Level 3	Evaluate Create	*20 %*	-	*30%*	-	*30%*	-	*30%*	-	*30%*	-
	Total	100 %		100 %		100 %		100 %		100 %	

CLA – 4 can be from any combination of these: Assignments, Seminars, Tech Talks, Mini-Projects, Case-Studies, Self-Study, MOOCs, Certifications, Conf. Paper etc.,

Course Designers		
Experts from Industry	Experts from Higher Technical Institutions	Internal Experts
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Course Code	18BTE428T	Course Name	PLANT INTERACTIONS	Course Category	E	Professional Elective	L	T	P	C
							3	0	0	3

Pre-requisite Courses	18BTC108J	Co-requisite Courses	Nil	Progressive Courses	Nil
Course Offering Department	Biotechnology	Data Book / Codes/Standards	Nil		

Course Learning Rationale (CLR):	*The purpose of learning this course is to:*
CLR-1 :	*Relate the signaling mechanisms in the development of a plant's root, shoot, leaf and flower*
CLR-2 :	*Discuss the response of plants to physical stimuli and day-night cycle (circadian rhythm)*
CLR-3 :	*Explain the mechanisms in plant-microbe interaction, biotic and abiotic stresses*
CLR-4:	*Discuss about hyperaccumulators, heavy metal tolerance and phytoremediation*
CLR-5:	*Relate the role of phytochemicals in plants behavior and in facilitating plants growth*
CLR-6:	*Recognize the efforts taken by sessile plants for their survival and avoidance of stress.*

Course Learning Outcomes (CLO):	*At the end of this course, learners will be able to:*	Learning 1: Level of Thinking (Bloom)	2: Expected Proficiency (%)	3: Expected Attainment (%)
CLO-1 :	*Describe the perception and responses of plants to environmental stimuli and stress cues*	*2*	*85*	*80*
CLO-2 :	*Design transgenic plants (GMOs) for biotic and abiotic stress tolerance*	*3*	*85*	*80*
CLO-3 :	*Exploit light response plasticity for improved productivity*	*3*	*80*	*75*
CLO-4 :	*Demonstrate how plants compete with themselves and other plants for nutrients and sunlight*	*2*	*75*	*70*
CLO-5 :	*Examine the benefits of intercropping and crop rotation*	*2*	*80*	*75*
CLO-6 :	*Recall what a plant does in the course of its lifetime for better growth and productivity*	*3*	*80*	*75*

Program Learning Outcomes (PLO)

	1 Engineering Knowledge	2 Problem Analysis	3 Design & Development	4 Analysis, Design, Research	5 Modern Tool Usage	6 Society & Culture	7 Environment & Sustainability	8 Ethics	9 Individual & Team Work	10 Communication	11 Project Mgt. & Finance	12 Life Long Learning	13 PSO - 1	14 PSO - 2	15 PSO – 3
CLO-1	M	H		M	M	M	M	H		H	H	H	H	H	H
CLO-2	M	H		H	H	H	H	H	M	H	H	H	H	H	H
CLO-3	M	H	H	H	H	H	H	H		H	H	H	H	H	H
CLO-4	M	H	H	H	H	H	H	H		H	H	H	H	H	H
CLO-5	M	H	H	H	H	H	H	H	M	H	H	H	H	H	H
CLO-6	M	H	H	H	H	H	H	H	M	H	H	H	H	H	H

Duration (hour)		9	9	9	9	9
S-1	SLO-1	*Development biology of plants-an overview*	*Plant response to physical and light stimuli-an overview*	*Plant-microbe interaction-an overview*	*Plant adaptation to abiotic stresses-An overview*	*Plant-plant interactions*
	SLO-2	*Signal transduction using G proteins Calcium, MAPK*	*Response to gravity-gravitropism*	*Plant growth promoting rhizobacterium*	*Physiological and molecular response of plant to drought*	*Plant plasticity*
S-2	SLO-1	*One-component sensor regulatory system*	*Response to touch-thigmotropism*	*Root exudates*	*Physiological response to salinity*	*Allelopathy, secondary metabolites*
	SLO-2	*Two-component sensor regulatory system*	*Thigmotropism in shoots*	*Types of root exudates*	*Molecular mechanisms in salt tolerance*	*Volatiles*
S-3	SLO-1	*Stages of embryogenesis*	*Plant herbivory*	*Microbial secretions*	*Physiological response to cold*	*Plant's competitive behavior*
	SLO-2	*Genes in embryogenesis*	*Chemical and mechanical defenses*	*Microbe secreted plant hormones*	*Molecular mechanisms in cold tolerance*	*Behaviour based on memory*
S-4	SLO-1	*Plant growth hormones-auxin, cytokinin and gibberellin*	*Response to light-Phototropism*	*Quorum sensing*	*Physiological response to water logging*	*Co-operative behavior*
	SLO-2	*Ethylene and abscisic acid*	*Five models of auxin distribution in phototropism*	*Plant-microbe interaction*	*Molecular response to water logging*	*Facilitative behaviour*
S-5	SLO-1	*Anatomy of shoot apical meristem*	*Phytochromes-structure*	*Biofilm formation of PGPR*	*Physiological response to heat*	*Below ground competition*
	SLO-2	*Genes in the development of shoot apical meristem*	*Function of phytochromes*	*Biofilm visualization-confocal imaging*	*Molecular response to heat tolerance*	*Kith and Kin recognition*
S-6	SLO-1	*Structure of root apical meristem*	*Cryptochromes-structure*	*Phytopathogens*	*Physiological response to heavy metals*	*Alien recognition*
	SLO-2	*Genes in the development of root apical meristem*	*Function of cryptochromes*	*Phytopathoges of rice, wheat, tomato, onion, spinach*	*Genes involved in heavy metal accumulation, tolerance and resistance*	*Siblings recognition*
S-7	SLO-1	*Parts of a monoecious and dioecious flower*	*Circadian clock*	*Plant immunity*	*Hyperaccumulators*	*Shoot competition*
	SLO-2	*ABC model for flowering-florigenesis*	*Molecular mechanisms of light perception*	*Physical barriers*	*Phytoremediation*	*Root competition*
S-8	SLO-1	*Natural fertilization*	*TOC1, LHY and CCA genes*	*Systemic acquired resistance (SAR)*	*Phenotypic plasticity*	*Shade avoidance*
	SLO-2	*Artificial fertilization-apomixis and parthenocarpy*	*Model of circadian clock in Arabidopsis*	*Hormones in SAR*	*Root plasticity*	*Effect of phytochromes*

S-9	SLO-1	*Hormones in seed dormancy*	*Short day plants*	*Induced systemic resistance (ISR)*	*Soil physical constraints*	*Neighbor signaling as a warning to biotic stresses*
	SLO-2	*Hormones in seed germination*	*Long day plants*	*Hormones in ISR*	*Plant growth in non-conducive soil*	*Neighbor signaling as a warning to abiotic stresses*

Learning Resources	1. *Plant Environment Interactions, Second edition, by Robert E. Wilkinson., Marcel Dekker, Inc., 2000.* 2. *Principles of plant microbe interactions, by Ben Lugtenberg, Springer, 2015.*

Learning Assessment

	Bloom's Level of Thinking	Continuous Learning Assessment (50% weightage)								Final Examination (50% weightage)	
		CLA – 1 (10%)		CLA – 2 (15%)		CLA – 3 (15%)		CLA – 4 (10%)#			
		Theory	Practice	Theory	Practice	Theory	Practice	Theory	Practice	Theory	Practice
Level 1	Remember Understand	*40 %*	-	*30%*	-	*30%*	-	*30%*	-	*30%*	-
Level 2	Apply Analyze	*40 %*	-	*40%*	-	*40%*	-	*40%*	-	*40%*	-
Level 3	Evaluate Create	*20 %*	-	*30%*	-	*30%*	-	*30%*	-	*30%*	-
	Total	100 %		100 %		100 %		100 %		100 %	

CLA – 4 can be from any combination of these: Assignments, Seminars, Tech Talks, Mini-Projects, Case-Studies, Self-Study, MOOCs, Certifications, Conf. Paper etc.,

Course Designers

Experts from Industry	Experts from Higher Technical Institutions	Internal Experts
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ACADEMIC CURRICULA

Professional Elective Courses

CHEMICAL ENGINEERING

Regulations - 2018

SRM INSTITUTE OF SCIENCE AND TECHNOLOGY

(Deemed to be University u/s 3 of UGC Act, 1956)

Kattankulathur, Kancheepuram, Tamil Nadu, India

Course Code	18CHE351T	Course Name	RENEWABLE ENERGY ENGINEERING	Course Category	E	Professional Electives	L	T	P	C
							3	0	0	3

Pre-requisite Courses	NIL	Co-requisite Courses	NIL	Progressive Courses	NIL
Course Offering Department	Chemical Engineering	Data Book / Codes/Standards	NIL		

Course Learning Rationale (CLR):	*The purpose of learning this course is to:*
CLR-1 :	*Understand the importance, availability of renewable energy*
CLR-2 :	*Familiarize various aspects of wind energy*
CLR-3 :	*Familiarize various aspects of equipment's used to collect solar energy and various applications of solar energy*
CLR-4 :	*Familiarize various aspects of Biomass energy and utilization*
CLR-5 :	*Other renewable energy resources and hydrogen energy, storage , transmission, fuel cell*
CLR-6 :	*Expose to alternate energy*

Course Learning Outcomes (CLO):	*At the end of this course, learners will be able to:*	Learning			Program Learning Outcomes (PLO)														
		1	2	3	1	2	3	4	5	6	7	8	9	10	11	12	13	14	15
		Level of Thinking (bloom)	Expected Proficiency %)	Expected Attainment (%)	Engineering Knowledge	Problem Analysis	Design & Development	Analysis, Design, Research	Modern Tool Usage	Society & Culture	Environment & Sustainability	Ethics	Individual & Team Work	Communication	Project Mgt. & Finance	Life Long Learning	PSO - 1	PSO - 2	PSO –3
CLO-1 :	*Energy supply and demand, need for renewable recourses*	*1*	*75*	*70*	*L*	*L*	*L*				*L*						*H*	*H*	
CLO-2 :	*Evaluate the types and design of windmill*	*2*	*85*	*75*	*H*	*H*	*H*	*M*			*L*		*L*		*L*		*H*	*H*	*H*
CLO-3 :	*Know on various industrial Solar equipments for heat and electricity*	*2*	*80*	*75*	*H*	*M*	*M*	*M*			*L*		*L*		*L*		*H*	*H*	*H*
CLO-4 :	*Energy from biomass and reactor design*	*2*	*80*	*75*	*H*	*M*	*H*	*M*			*L*		*L*		*L*		*L*	*H*	*H*
CLO-5 :	*Wave energy, tidal energy ,OTEC, Geothermal, Hydrogen energy, storage, Fuel cell technology*	*2*	*80*	*75*	*M*	*L*	*L*	*L*			*L*		*L*		*L*	*L*	*L*	*H*	
CLO-6:	*Evaluate various renewable energy options*	*2*	*75*	*60*	*H*	*M*	*L*	*H*			*H*		*H*		*H*		*M*	*M*	*M*

Duration (hour)		9	9	9	9	9
S-1	SLO-1	*India's energy demand and supply,management*	*Availability of wind*	*Introduction on sun energy*	*Biomass, Biomass resources*	*Tidal energy*
	SLO-2	*Energy planning*	*Special features of wind energy*	*Solar angles*	*Composition, fuel properties*	*Tidal energy conversion*
S-2	SLO-1	*Energy needs for the future*	*Types of wind mills*	*Solar collectors*	*Biomass conversion technologies*	*Wave energy*
	SLO-2	*Regional prospects and stresses*	*The power from the wind*	*Types of collectors*	*Anaerobic digestion*	*Wave energy operation, applications*
S-3	SLO-1	*Status of global resources*	*Performance of wind mills*	*Flat plate and dish type*	*Direction combustion*	*OTEC*
	SLO-2	*India's renewable resources*	*Modern wind energy generators*	*Types of flat and dish types*	*Pyrolysis*	*Open and closed OTEC Cycles*
S-4	SLO-1	*Energy resources of India ,economic development,*	*Horizontal wind mills*	*Solar concentrators*	*Gasification*	*Geothermal energy*
	SLO-2	*Energy cropping*	*Vertical wind mills*	*Types of concentrators*	*Biogas technology,*	*Geothermal energy conversion*
S-5	SLO-1	*Energy conversion*	*Wind turbines*	*Solar pumping*	*Bioethanol*	*Energy operation, applications*
	SLO-2	*Energy storage*	*Design parameters*	*Problems in collectors*	*Biodiesel Production*	*Energy conversion*
S-6	SLO-1	*Advantages and Disadvantages of Non-Conventional source of energy*	*Design principles of wind turbine*	*Solar refrigeration*	*Community and institutional biogas plants*	*Hydro conversion*
	SLO-2	*Renewable energy resources*	*Horizontal and vertical axis types*	*Solar air cooling, Solar furnaces*	*Family biogas plants*	*Small hydro energy conversion*
S-7	SLO-1	*Potentials of recourses*	*Problems in wind mills*	*Solar power generation*	*Recent Developments in biomass technology*	*Fuel cell*
	SLO-2	*Achievements and applications*	*Problems in wind mills*	*Solar drying, stills and cooking*	*Energy farming*	*Fuel cell technology*
S-8	SLO-1	*Classification of Energy*	*Problems in wind mills*	*Photo voltaic cell principle*	*design consideration*	*Hydrogen energy production ,storage*
	SLO-2	*Classification of Energy resources,*	*Problems in wind mills*	*Photo voltaic cell types*	*Problems in digesters*	*Transmission, distribution*
S-9	SLO-1	*Conservation of energy*	*Wind power farms*	*Photo voltaic cell design*	*Problems in digesters*	*Fuel cell application*
	SLO-2	*Conservation techniques*	*Modern wind farms*	*Photo voltaic cell advancement*	*Applications of reactors*	*Fuel cell types*

Learning Resources	1. *Rai. G.D. "Non Conventional Energy Sources", Khanna Publishers, New Delhi, 1999.* 2. *"Renewable energy sources of conversion technology": Bansal..N.K Manfred Kleen Man and Michael Meliss, TMH Publication.* 3. *"Renewable Energy Sources and Emerging Technologies", Kothari. P, K C, Singal and Rakesh RanjanPHI Pvt. Ltd.,New Delhi, 2008*

Learning Assessment											
	Bloom's Level of Thinking	Continuous Learning Assessment (50% weightage)								Final Examination (50% weightage)	
		CLA – 1 (10%)		CLA – 2 (15%)		CLA – 3 (15%)		CLA – 4 (10%)#			
		Theory	Practice	Theory	Practice	Theory	Practice	Theory	Practice	Theory	Practice
Level 1	Remember Understand	*40 %*	-	*30 %*	-	*30 %*	-	*30 %*	-	*30%*	-
Level 2	Apply Analyze	*40 %*	-	*40 %*	-	*40 %*	-	*40 %*	-	*40%*	-
Level 3	Evaluate Create	*20 %*	-	*30 %*	-	*30 %*	-	*30 %*	-	*30%*	-
	Total	100 %		100 %		100 %		100 %		100 %	

CLA – 4 can be from any combination of these: Assignments, Seminars, Tech Talks, Mini-Projects, Case-Studies, Self-Study, MOOCs, Certifications, Conf. Paper etc.,

Course Designers		
Experts from Industry	Experts from Higher Technical Institutions	Internal Experts
1. *Mr. A. Subramaniam, PESCO Beam Environmental Solutions Pvt. Ltd.,*	1. *Dr. Lima Rose Miranda, Anna University, email: limamiranda2007@gmail.com*	1. *Dr. Anbalagan, SRM Inst. of Science & Technology, anbalagk@srmist.edu.in*
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Course Code	18CHE352T	Course Name	INTRODUCTION TO BIOCHEMICAL PRINCIPLES	Course Category	E	Professional Elective	L	T	P	C
							3	0	0	3

Pre-requisite Courses	NIL	Co-requisite Courses	NIL	Progressive Courses	NIL
Course Offering Department	Chemical Engineering	Data Book / Codes/Standards	NIL		

Course Learning Rationale (CLR):	*The purpose of learning this course is to:*
CLR-1 :	*Expose to the importance of biochemical process and products*
CLR-2 :	*Study the different fermentation media*
CLR-3 :	*Teach the principle of sterilization and growth kinetics methods*
CLR-4 :	*Study the stoichiometry and yield coefficient cell growth and product formation*
CLR-5 :	*understand the primary and secondary metabolites production process*
CLR-6 :	*study process flow for manufacture of biochemical products*

Course Learning Outcomes (CLO):	*At the end of this course, learners will be able to:*	Learning 1: Level of Thinking (bloom)	2: Expected Proficiency (%)	3: Expected Attainment (%)	PLO 1: Engineering Knowledge	2: Problem Analysis	3: Design & Development	4: Analysis, Design, Research	5: Modern Tool Usage	6: Society & Culture	7: Environment & Sustainability	8: Ethics	9: Individual & Team Work	10: Communication	11: Project Mgt. & Finance	12: Life Long Learning	13: PSO - 1	14: PSO - 2	15: PSO –3
CLO-1 :	*Identify industrial importance microorganism and storage methods in fermentation process*	3	80	75	L	L	L	M			L					M	H	L	L
CLO-2 :	*Student able to select and prepare good media for bio product production process*	3	90	85	L	L	L	M			M					L	H	L	L
CLO-3 :	*Learn the Sterilization methods and determine specific growth rate and monod equation calculation*	2	85	80	H	H	L	M			M					L	H	H	L
CLO-4 :	*Be able to solve elemental balances and product yield in biochemical reaction*	4	80	75	H	H	L	M			M					L	L	H	L
CLO-5 :	*Familiarize to draw flow diagrams of primary and secondary metabolites production processes*	2	90	85	H	L	H	M			L					L	M	M	H
CLO-6 :	*Analyze the design and unit operation involved in the biochemical process*	3	85	80	H	L	H	M			L					L	M	M	H

Duration (hour)		9	9	9	9	9
S-1	SLO-1	*Overview of biochemical engineering*	*Selection of good medium*	*Sterilization and function*	*Stoichiometry of microbial growth*	*Industrial fermentation process*
	SLO-2	*Classification of biochemical products*	*Medium requirements for fermentation processes*	*Types of Sterilization*	*General biochemical equation*	*Define primary metabolites*
S-2	SLO-1	*History of industrial microbiology*	*Energy source in fermentation media*	*Physical method: heat sterilization*	*Define Degrees of reduction*	*Production of primary metabolites*
	SLO-2	*Comparison of chemical and biochemical Processes*	*Components of fermentation media*	*Heat sterilization: pasteurization methods*	*Solving problem (degrees of reduction)*	*Selection of media and microbes for citric acid production*
S-3	SLO-1	*Block diagram of fermentation process*	*Classification of carbon source*	*Heat sterilization: Autoclave methods*	*Define respirator co efficient*	*Process flow diagram for citric acid production*
	SLO-2	*Upstream fermentation process*	*Carbohydrates: starch and cellulose source*	*Physical method: radiation sterilization*	*Solving problem (Respirator co-efficient)*	*Preparation of media and microbes for acetic acid production*
S-4	SLO-1	*Downstream fermentation process*	*Oil and fats source*	*Chemical method: liquid sterilization*	*Solving problem (Elemental balance)*	*Process flow diagram for acetic acid production*
	SLO-2	*Classification of Microorganisms*	*Nitrogen source and function*	*Chemical method: gas sterilization*	*Solving problem (Elemental balance)*	*Upstream process for amino acid production*
S-5	SLO-1	*Structure and function of microbial cells*	*Minerals source and function*	*Mechanical method: filtrations sterilization*	*Determination yield coefficient of substrate*	*Downstream process for amino acid production*
	SLO-2	*Isolation of micro- organisms-serial dilution method*	*Additives in media preparation*	*Factors affecting sterilization process*	*Solving problem (Yield coefficient of substrate)*	*Selection of media and microbes for ethanol production*
S-6	SLO-1	*Streak plate method*	*Growth factors and additives in media preparation*	*Batch sterilization*	*Determination yield coefficient of biomass*	*Process flow diagram for ethanol production*
	SLO-2	*Preservation of pure culture-storage at reduced temperature*	*Water and its function in media preparation*	*Thermal death kinetics of micro organisms*	*Solving problem (Yield coefficient of biomass)*	*Media preparation and selection of microbes for aceto butanol production*
S-7	SLO-1	*Storage in a dehydrated form*	*Designing of media for fermentation processes*	*Continuous sterilization: Indirect heating method*	*Determination yield coefficient of product*	*Process flow diagram for aceto butanol production*
	SLO-2	*Types of fermentation processes batch fermentation*	*Types of media*	*Continuous sterilization: direct heating method*	*Solving problem (Yield coefficient of products)*	*Define Secondary metabolites*
S-8	SLO-1	*Continuous fermentation*	*Simple and complex media*	*Phases of cell growth in batch cultures*	*Solving problem (Yield coefficient of products)*	*Preparation of media and microbes for Penicillin production*

	SLO-2	*Fed batch fermentation*	*Crude and natural media*	*Growth curve and doubling time calculation*	*Solving problem (Stoichiometric coefficient)*	*Process flow diagram for Penicillin production*
S-9	SLO-1	*Comparison of various fermentation processes*	*Different commercial media and function*	*Monod growth kinetic model*	*Solving problem (Stoichiometric coefficient)*	*Selection of media and microbes for vitamin production*
	SLO-2	*Applications of Biochemical Processes*	*Selection of good antifoaming agent*	*Solving problem (growth rate and monod constant)*	*Solving problem (Stoichiometric coefficient)*	*Process flow diagram for vitamin production*

Learning Resources	*4. Peter F.Stanbury, Allan Whitaker, Stephen J Hall"Principles of Fermentation Technology"2nd Edition, Butterworth – Heinemann (an imprint of Elsevier), 1995.* *5. Michael L.Shuler and Fikret Kargi, "Bioprocess Engineering Basic concepts", Prentice Hall, 2002.*	*6. Bailey, J.E. and Ollis, D.F. "Biochemical Engineering Fundamentals" 2nd Edition, McGraw– Hill, 1988.* *7. Casida Jr, L.E., "Industrial Microbiology", New Age International (P) Ltd.*

SLO – Session Learning Outcome

	Bloom's Level of Thinking	Continuous Learning Assessment (50% weightage)								Final Examination (50% weightage)	
		CLA – 1 (10%)		CLA – 2 (15%)		CLA – 3 (15%)		CLA – 4 (10%)#			
		Theory	Practice	Theory	Practice	Theory	Practice	Theory	Practice	Theory	Practice
Level 1	Remember Understand	40 %	-	30 %	-	30 %	-	30 %	-	30%	-
Level 2	Apply Analyze	40 %	-	40 %	-	40 %	-	40 %	-	40%	-
Level 3	Evaluate Create	20 %	-	30 %	-	30 %	-	30 %	-	30%	-
	Total	100 %		100 %		100 %		100 %		100 %	

CA – 4 can be from any combination of these: Assignments, Seminars, Tech Talks, Mini-Projects, Case-Studies, Self-Study, MOOCs, Certifications, Conf. Paper etc.,

Course Designers		
Experts from Industry	Experts from Higher Technical Institutions	Internal Experts
1. Mr. A. Subramaniam, PESCO Beam Environmental Solutions Pvt. Ltd.,	*1. Dr. Lima Rose Miranda, Anna University, email: limamiranda2007@gmail.com*	*1. Dr. K. Tamilarasan SRM Institute of Science and Technology tamilarasan.k@ktr.srmuniv.ac.in*
2. Mr. S. T. Kalaimani, CPCL, Chennai	*2. Dr. T. R. Sundararaman, Rajalakshmi Engineering College*	*2. Ms. S. Kiruthika SRM Inst. of Science & Technology, kiruthika.s@ktr.srmuniv.ac.in*

Course Code	18CHE353T	Course Name	ENERGY ENGINEERING AND TECHNOLOGY	Course Category	E	Professional Elective	L	T	P	C
							3	0	0	3

Pre-requisite Courses	NIL	Co-requisite Courses	NIL	Progressive Courses	NIL
Course Offering Department	Chemical Engineering	Data Book / Codes/Standards	NIL		

Course Learning Rationale (CLR):	*The purpose of learning this course is to:*
CLR-1 :	*Understand energy challenges and principles involved in energy engineering*
CLR-2 :	*Familiarize with energy conversion technologies*
CLR-3 :	*Acquire knowledge of nuclear energy, its potential in energy generation and challenges*
CLR-4 :	*Familiarize with energy storage and distribution technologies*
CLR-5 :	*Get exposure to energy conservation methods and awareness of developing technologies*
CLR-6 :	*Exposure to various energy resources, energy conversion and energy storage/distribution technologies*

Course Learning Outcomes (CLO):	*At the end of this course, learners will be able to:*	Learning 1 Level of Thinking (bloom)	2 Expected Proficiency (%)	3 Expected Attainment (%)	PLO 1 Engineering Knowledge	2 Problem Analysis	3 Design & Development	4 Analysis, Design, Research	5 Modern Tool Usage	6 Society & Culture	7 Environment & Sustainability	8 Ethics	9 Individual & Team Work	10 Communication	11 Project Mgt. & Finance	12 Life Long Learning	13 PSO - 1	14 PSO - 2	15 PSO –3
CLO-1 :	*Define the importance of energy science and energy technology and their principles*	1	80	75	H	L	L	L		H	H					H	H	L	L
CLO-2 :	*Analyse the various types of energy conversion technologies and powerplants*	2	80	70	H	L	H	M	H	H	M					H	H	L	L
CLO-3 :	*Remember the benefits of nuclear energy and their potential in energy generation*	1	80	75	H	L	H	M	M		H					H	H	H	H
CLO-4 :	*Identify the various the various energy storage and distribution technologies*	2	80	75	M	L	H	M			M					L	H	H	M
CLO-5 :	*Discover the types of energy conservation technologies*	2	80	75	M	M	H	M			H					H	H	M	H
CLO-6 :	*Familiar with the technologies of energy*	2	80	75	H	L	M	M			M					L	M	M	M

Duration (hour)		9	9	9	9	9
S-1	SLO-1	*Energy Overview*	*Types of energy conversion plants for various primary energy sources*	*Basics of nuclear fission*	*Energy storage systems*	*Principles of energy conservation*
	SLO-2	*A brief history of energy technology*	*Electrical route and Non-electrical route*	*Basics of nuclear fusion*	*Mechanical energy storage*	*Energy conservation approach*
S-2	SLO-1	*Forms of energy*	*Thermal power plant*	*Concept of binding energy*	*Pumped Hydroelectric Storage*	*Co-generation*
	SLO-2	*Types of energy*	*Coal fire thermal power plant*	*Nuclear fission reactors*	*Compressed Air storage*	*Types of Co-generation*
S-3	SLO-1	*Energy Chains*	*Gas-turbine power plants*	*Components of nuclear reactor*	*Energy storage via Flywheels*	*Waste heat utilization*
	SLO-2	*Energy demand*	*Components of Gas-turbine*	*Types of fission reactor*	*Electrical storage*	*Heat recovery boiler*
S-4	SLO-1	*Supply network*	*Open cycle Gas turbine power plant*	*Pressurized water reactor*	*The lead acid battery*	*Heat Recuperators*
	SLO-2	*Energy Resources*	*Closed cycle Gas-turbine Power plant*	*Benefits of nuclear energy*	*Basic battery theory*	*Classification of heat exchangers*
S-5	SLO-1	*Conventional energy resources*	*Gasification types*	*Nuclear fusion principle*	*Chemical storage*	*Heat Regenerators*
	SLO-2	*Non – Conventional energy resources*	*Integrated Coal Gasification combined cycle power plant*	*D-T fusion reactor*	*Energy storage via hydrogen*	*The Thermal wheel*
S-6	SLO-1	*Renewable Energy resources*	*Principles of MHD power*	*Requirements for nuclear fusion*	*Electro Magnetic Energy storage*	*Heat pumps Operating principles*
	SLO-2	*Non Renewable Energy resources*	*Open Cycle MHD Technologies*	*Ignition temperature, Driven systems and Energy break even condition*	*Thermal Energy storage*	*Applications of Heat pumps*
S-7	SLO-1	*Energy and environment*	*Closed Cycle MHD Technologies*	*Plasma Confinement*	*Sensible Heat storage*	*Heat pipe principle*
	SLO-2	*Climate change*	*Seeded inert gas system*	*Magnetic confinement*	*Latent Heat storage*	*Classification of Heat pipes*
S-8	SLO-1	*Global warming*	*Liquid metal system*	*Thermo Nuclear Function reactors*	*Materials for phase change energy storage*	*Applications of Heat pipes*
	SLO-2	*Effects of green house gases*	*Materials for MHD*	*Tokamak reactor*	*Distribution of energy*	*Stirling Engine*
S-9	SLO-1	*Carbon credit*	*Applications of MHD*	*Methods of plasma heating*	*Gas pipelines*	*General principles of Stirling Engine*
	SLO-2	*Applications of carbon credit*	*Advantages & Disadvantages of MHD*	*Inertial Confinement Fusion*	*Electricity transmission*	*Main components of the Stirling Engine*

Learning Resources	
	1. *Rai, G.D, Non-Conventional Sources of Energy, Khanna Publishers, New Delhi, 1999.*
	2. *Rao, S.and Parulakar B.B., Energy Technology, Khanna Publishers, New Delhi, 1994.*
	3. *John Andrews and Nick Jelley, Energy Science: Principles, Technologies, and Impacts, 2nd edition, Oxford University Press, 2013.*

Learning Assessment											
	Bloom's Level of Thinking	Continuous Learning Assessment (50% weightage)								Final Examination (50% weightage)	
		CLA – 1 (10%)		CLA – 2 (15%)		CLA – 3 (15%)		CLA – 4 (10%)#			
		Theory	Practice	Theory	Practice	Theory	Practice	Theory	Practice	Theory	Practice
Level 1	Remember Understand	40 %	-	30 %	-	30 %	-	30 %	-	30%	-
Level 2	Apply Analyze	40 %	-	40 %	-	40 %	-	40 %	-	40%	-
Level 3	Evaluate Create	20 %	-	30 %	-	30 %	-	30 %	-	30%	-
	Total	100 %		100 %		100 %		100 %		100 %	

CA – 4 can be from any combination of these: Assignments, Seminars, Tech Talks, Mini-Projects, Case-Studies, Self-Study, MOOCs, Certifications, Conf. Paper etc.,

Course Designers		
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2. Mr. S. T. Kalaimani, CPCL, Chennai	*2. Dr. T. R. Sundararaman, Rajalakshmi Engineering College*	*2. Dr. K. Tamilarasan SRM Institute of Science & Technology, tamilarasan.k@srmuniv.ac.in*

Course Code	18CHE354T	Course Name	POLYMER TECHNOLOGY	Course Category	E	Professional Elective	L	T	P	C
							3	0	0	3

Pre-requisite Courses	NIL	Co-requisite Courses	NIL	Progressive Courses	NIL
Course Offering Department	Chemical Engineering	Data Book / Codes/Standards	NIL		

Course Learning Rationale (CLR):	The purpose of learning this course is to:
CLR-1 :	*To familiarize the polymers, polymerization techniques and behavior in polymers*
CLR-2 :	*To familiarize the various types of thermoplastics, thermosetting and elastomers*
CLR-3 :	*To familiarize the various polymer processing techniques for polymers, rubbers and fibers*
CLR-4 :	*To impart knowledge on various testing methods and characterization of polymers*
CLR-5 :	*To impart knowledge on speciality polymers*
CLR-6 :	*Exposure on polymeric materials, processing techniques and testing methods*

Course Learning Outcomes (CLO):	At the end of this course, learners will be able to:	Learning 1: Level of Thinking (Bloom)	2: Expected Proficiency (%)	3: Expected Attainment (%)	PLO 1: Engineering Knowledge	2: Problem Analysis	3: Design & Development	4: Analysis, Design, Research	5: Modern Tool Usage	6: Society & Culture	7: Environment & Sustainability	8: Ethics	9: Individual & Team Work	10: Communication	11: Project Mgt. & Finance	12: Life Long Learning	13: PSO - 1	14: PSO - 2	15: PSO –3
CLO-1 :	*Memorize the basics of polymer science, polymerization and properties*	2	85	75	L	L	L	L								M	H	H	H
CLO-2 :	*Identify various types of thermoplastics, thermosetting and elastomers*	2	80	70	L	L	H	L								M	H	H	L
CLO-3 :	*Recognize the processing methods and techniques of polymers, resins and rubbers*	2	85	80	M	L	H	H								M	H	H	L
CLO-4 :	*Illustrate the various testing methods and characterization of polymers*	3	85	75	H	M	H	H								M	H	M	H
CLO-5 :	*Identify the importance of speciality polymers*	2	80	70	L	L	H	H								L	H	H	M
CLO-6 :	*Know the importance of polymers and their properties, preparation methods, testing and applications*	3	80	75	M	M	M	H								H	H	H	H

Duration (hour)		9	9	9	9	9
S-1	SLO-1	*Degree of polymerization*	*Thermoplastic Polymers*	*Processing of Thermoplastics and Thermosetting Plastics*	*Polymer Characterization Tests - Melt Flow Index*	*Speciality polymers*
	SLO-2	*Classification of Polymers*	*Commodity plastics -Polyolefins and vinyl polymers*	*Compounding and processing aids*	*Viscosity Test*	*Poly-Electrolytes*
S-2	SLO-1	*Chemistry of Polymerization –Addition Polymerization*	*Acrylic polymers*	*Compression Moulding*	*Thermal Characterization Techniques*	*Ionomers*
	SLO-2	*Free radical polymerization*	*Polystyrene*	*Injection Moulding*	*Thermal Gravimetric Analysis*	*Conducting Polymers*
S-3	SLO-1	*Ionic polymerization*	*Engineering plastics*	*Extrusion Moulding*	*Differential Scanning Calorimetry*	*Electro-Luminescent Polymers*
	SLO-2	*Condensation polymerization*	*Fluorine containing polymers*	*Blow Moulding*	*Thermo mechanical Analysis*	*Electrically conductive Polymers*
S-4	SLO-1	*Coordination polymerization*	*Polyamides*	*Rotational Moulding*	*Morphological properties*	*Thermoplastic Elastomers*
	SLO-2	*Molecular weight*	*Polyesters*	*Transfer Moulding*	*Transmission Emission Microscopy*	*TPEs*
S-5	SLO-1	*Crystallinity in polymers*	*Thermosetting resins*	*Processing of Rubbers –Mastication –Calendaring*	*Transmission Emission Microscopy*	*High Temperature Polymers*
	SLO-2	*Crystallisability and factors*	*Phenolic resins*	*Reaction Injection Moulding*	*X-ray Diffraction*	*Polymer Blends*
S-6	SLO-1	*Spherulites*	*Epoxy resins*	*Solution Casting*	*Mechanical Properties*	*Polymer Composites*
	SLO-2	*Polymer single crystals*	*Polyurethane resins*	*Reinforcing : Hand lay-up technique*	*Tensile Test*	*Nano-Composites*
S-7	SLO-1	*Glass Transition Temperature(Tg)*	*Silicone resins*	*Filament – winding technique*	*Impact Test*	*Interpenetrating Polymer Networks*
	SLO-2	*Factors influencing Glass Transition Temperature*	*Natural rubber – Isoprene rubber*	*Spray up technique*	*Hardness*	*Types of IPNS*
S-8	SLO-1	*Polymerization Techniques – Bulk polymerization*	*Butyl rubber*	*Fibre Spinning*	*Electrical properties – Di-Electric strength*	*Liquid Crystalline Polymers*
	SLO-2	*Solution polymerisation*	*Styrene Butadiene Rubber*	*Fibre drawing and post treatment of fibers*	*Di-Electric Constant*	*Types of LCPs*
S-9	SLO-1	*Suspension polymerisation*	*Chloroprene rubber*	*Elastomer Technology*	*Thermal Properties-Heat deflection temperature*	*Biomedical Polymers*
	SLO-2	*Emulsion polymerisation*	*Nitrile rubber*	*Vulcanization*	*Vicat Softening temperature*	*Applications in medical field*

Learning Resources	1. *V R Gowariker, Vasant R. Gowariker, N V Viswanathan, JayadevSreedhar,"Polymer Science", New Age International, 2nd Edition* 2. *Joel R.Fried, "Polymer Science and Technology", PHI, Eastern Economy Edition, 2nd Edition* 3. *Billmeyer F.W., Text book of Polymer Science, 3rd edn., Wiley, Singapore, 1984*	4. *D.H. Morton and Jones, Polymer Processing, Chapman and Hall, London, 1989.* 5. *Vishu Shah, "Handbook of Plastics Testing Technology", Wiley international publication* 6. *Maurice Morton, Rubber Technology, Van Nostrand Reinhold, New York, 2002*

Learning Assessment

	Bloom's Level of Thinking	Continuous Learning Assessment (50% weightage)								Final Examination (50% weightage)	
		CLA – 1 (10%)		CLA – 2 (15%)		CLA – 3 (15%)		CLA – 4 (10%)#			
		Theory	Practice	Theory	Practice	Theory	Practice	Theory	Practice	Theory	Practice
Level 1	Remember Understand	40 %	-	30 %	-	30 %	-	30 %	-	30%	-
Level 2	Apply Analyze	40 %	-	40 %	-	40 %	-	40 %	-	40%	-
Level 3	Evaluate Create	20 %	-	30 %	-	30 %	-	30 %	-	30%	-
	Total	100 %		100 %		100 %		100 %		100 %	

CA – 4 can be from any combination of these: Assignments, Seminars, Tech Talks, Mini-Projects, Case-Studies, Self-Study, MOOCs, Certifications, Conf. Paper etc.,

Course Designers

Experts from Industry	Experts from Higher Technical Institutions	Internal Experts
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2. *Mr. S. T. Kalaimani, CPCL, Chennai*	2. *Dr. T. R. Sundararaman, Rajalakshmi Engineering College*	

Course Code	15CHE355T	Course Name	SUSTAINABLE ENGINEERING	Course Category	E	Professional Elective	L	T	P	C
							3	0	0	3

Pre-requisite Courses	Nil	Co-requisite Courses	Nil	Progressive Courses	Nil
Course Offering Department	Chemical Engineering	Data Book / Codes/Standards	Nil		

Course Learning Rationale (CLR):	*The purpose of learning this course is to:*
CLR-1 :	*Understand the concept of green chemistry and sustainability*
CLR-2 :	*Understand the role of catalysts and green solvents*
CLR-3 :	*Understand sustainable engineering and design of process equipment*
CLR-4 :	*Analyze various industrial examples of sustainable manufacturing processes*
CLR-5 :	*Understand the economic and safety considerations of sustainable engineering.*
CLR-6 :	*Understand the significance of sustainability in chemical reactions and processes, design of equipments, economics and safety*

		Learning			Program Learning Outcomes (PLO)														
		1	2	3	1	2	3	4	5	6	7	8	9	10	11	12	13	14	15
Course Learning Outcomes (CLO):	*At the end of this course, learners will be able to:*	Level of Thinking (loom)	Expected Proficiency %)	Expected Attainment (%)	Engineering Knowledge	Problem Analysis	Design & Development	Analysis, Design, Research	Modern Tool Usage	Society & Culture	Environment & Sustainability	Ethics	Individual & Team Work	Communication	Project Mgt. & Finance	Life Long Learning	PSO - 1	PSO - 2	PSO –3
CLO- 1 :	*Identify the greener routes of chemical synthesis*	*2*	*80*	*75*		*L*		*M*			*M*		*L*				*M*		
CLO-2 :	*Choose the proper catalyst (chemical/biological) and solvent for a process*	*3*	*80*	*75*		*M*	*M*	*M*									*M*		
CLO-3 :	*Apply the concepts of sustainability in chemical processes and operations*	*3*	*85*	*80*	*H*	*M*	*M*	*M*	*M*		*M*		*M*				*M*	*M*	
CLO-4 :	*Critically analyze the sustainable industrial processes by comparing with conventional routes*	*3*	*80*	*75*		*M*	*M*	*M*			*M*		*M*				*M*	*M*	
CLO-5:	*Apply the economics and safety aspects to sustainable chemistry*	*2*	*80*	*75*	*M*	*M*	*M*	*H*		*M*	*M*	*M*	*H*				*M*	*M*	*M*
CLO-6 :	*Apply the knowledge of sustainability in Chemical industries*	*2*	*80*	*75*	*M*	*M*	*M*	*H*		*M*	*M*	*M*	*M*				*M*	*M*	*M*

Duration (hour)		9	9	9	9	9
S-1	SLO-1	*Introduction to the course*	*Catalysis and Green Chemistry*	*Process and operations*	*Case studies*	*Introduction to the economics of green and sustainable chemistry*
	SLO-2	*Green Chemistry-Definition*	*Catalysis and Green Chemistry*	*Industry perception*	*The Kalundborg Model*	*Chemical Manufacturing and Economic Theory*
S-2	SLO-1	*Principles of Green Chemistry and Examples*	*Examples of green catalysis in industrially significant reactions*	*Reactions*	*Ibuprofen: A Green Manufacturing Alternative*	*Plant (Microscale) Scale Economics*
	SLO-2	*Principles of Green Chemistry and Examples*	*Biocatalysis and Green Chemistry*	*Reactor design*	*Supercritical Carbon Dioxide*	*Corporate Economics*
S-3	SLO-1	*Use of Greener Synthetic Pathways*	*Biocatalysis: Advantages Within Industrial Applications*	*Micro-reactors and micromixers*	*The Pharmaceutical Industries and Green Chemistry*	*Macroeconomics*
	SLO-2	*Use of Greener Synthetic Pathways*	*Biocatalysis: Challenges to Make Biocatalysis Industrially Viable*	*Novel processes and routes*	*Sildenafil Citrate*	*Economic Impact of Green Chemistry*
S-4	SLO-1	*Use of Greener Synthetic Pathways*	*Homogenous Biocatalysis in Water-Organic Solvent Mixtures and in Organic Solvents*	*Unit operations*	*Sertraline Manufacture*	*Business Strategies Regarding Application of Green Chemistry*
	SLO-2	*Use of Greener Reaction Conditions*	*Homogenous Biocatalysis in Water-Organic Solvent Mixtures and in Organic Solvents*	*Unit operations*	*The Polymer Industry*	*Incorporation of Green Chemistry in Process*
S-5	SLO-1	*Use of Greener Reaction Conditions*	*Uses of biocatalysts*	*Heat exchangers*	*Pesticides, Antifoulants, and Herbicides*	*Design for Sustainability*
	SLO-2	*Design of Greener Chemicals*	*Uses of biocatalysts*	*Heat exchangers*	*Fire Extinguishers and Flame Retardants*	*Case Studies Demonstrating the Economic Benefits of Green Chemistry and Design*
S-6	SLO-1	*Design of Greener Chemicals*	*Alternate solvents*	*Distillation columns*	*The food and flavor industry*	*Inherent safety; Safe reactor design*
	SLO-2	*Green Engineering - Definition*	*Alternate solvents*	*Absorption towers*	*The surfactant industry*	*Safety management and hazard identification*
S-7	SLO-1	*Principles of Green Engineering*	*Safer/green solvents*	*Bubble columns*	*The semiconductor manufacture industry*	*Issues related to transportation and atmospheric losses*
	SLO-2	*Principles of Green Engineering*	*Water as solvent*	*Membrane processes*	*The dye industry*	*The purification step and associated hazards*
S-8	SLO-1	*Principles of Green Engineering*	*Solvent-free conditions*	*Liquid-liquid centrifuges*	*The textile industry*	*Process variables - Reaction temperature, pressure, concentration, pH*
	SLO-2	*Principles of Green Engineering*	*Ionic liquids*	*Extraction columns*	*The tannery industry*	*Effects of operating costs on safety*
S-9	SLO-1	*Sustainability*	*Supercritical CO_2*	*Reactions with separation processes*	*The sugar and distillery industries*	*Waste and effluent, dust/particle handling*
	SLO-2	*Sustainability*	*Supercritical water*	*Reactions with separation processes*	*The paper and pulp industry*	*Safety and risk assessment*

Learning Resources	1. *Mukesh Doble and Anil Kumar Kruthiventi, "Green Chemistry and Engineering", Elsevier Science and Technology Books, 2007.* 2. *Anne E. Marteel-Parrish and Martin A. Abraham, "Green Chemistry and Engineering - A pathway to sustainability", John Wiley & Sons, 2014.*	3. *Cost of inherent safety and profit-risk model*

Learning Assessment											
	Bloom's Level of Thinking	Continuous Learning Assessment (50% weightage)								Final Examination (50% weightage)	
		CLA – 1 (10%)		CLA – 2 (15%)		CLA – 3 (15%)		CLA – 4 (10%)#			
		Theory	Practice	Theory	Practice	Theory	Practice	Theory	Practice	Theory	Practice
Level 1	Remember Understand	40 %	-	30 %	-	30 %	-	30 %	-	30%	-
Level 2	Apply Analyze	40 %	-	40 %	-	40 %	-	40 %	-	40%	-
Level 3	Evaluate Create	20 %	-	30 %	-	30 %	-	30 %	-	30%	-
	Total	100 %		100 %		100 %		100 %		100 %	

CA – 4 can be from any combination of these: Assignments, Seminars, Tech Talks, Mini-Projects, Case-Studies, Self-Study, MOOCs, Certifications, Conf. Paper etc.,

Course Designers		
Experts from Industry	Experts from Higher Technical Institutions	Internal Experts
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2. *Mr. S. T. Kalaimani, CPCL, Chennai*	2. *Dr. T. R. Sundararaman, Rajalakshmi Engineering College*	2. *Dr. K. Deepa SRM Institute of Science & Technology, deepak1@srmist.edu.in*

Course Code	18CHE356T	Course Name	INDUSTRIAL POLLUTION PREVENTION AND CONTROL	Course Category	E	Professional Elective	L	T	P	C
							3	0	0	3

Pre-requisite Courses	NIL	Co-requisite Courses	NIL	Progressive Courses	NIL
Course Offering Department	Chemical Engineering	Data Book / Codes/Standards	Nil		

Course Learning Rationale (CLR):	*The purpose of learning this course is to:*
CLR-1 :	*know about the industrial activities and fates of industrial contaminants*
CLR-2 :	*know about the environmental regulations*
CLR-3 :	*know about the solid waste and disposal methods*
CLR-4 :	*know about the principles of water treatment*
CLR-5 :	*know about the air pollution control methods*
CLR-6:	*know about the sources and treatment options for environmental issues*

		Learning			Program Learning Outcomes (PLO)														
		1	2	3	1	2	3	4	5	6	7	8	9	10	11	12	13	14	15
Course Learning Outcomes (CLO):	*At the end of this course, learners will be able to:*	Level of Thinking (loom)	Expected Proficiency %)	Expected Attainment (%)	Engineering Knowledge	Problem Analysis	Design & Development	Analysis, Design, Research	Modern Tool Usage	Society & Culture	Environment & Sustainability	Ethics	Individual & Team Work	Communication	Project Mgt. & Finance	Life Long Learning	PSO - 1	PSO - 2	PSO –3
CLO-1 :	*Identify the major industries that creates pollutants and how it affects the environment*	*1*	*85*	*75*		*L*		*L*		*H*	*H*		*M*			*H*	*H*	*L*	*L*
CLO-2 :	*Implement the rules and regulations in specific industries*	*1*	*75*	*70*		*H*		*H*	*L*		*H*	*M*	*M*				*H*	*L*	*L*
CLO-3 :	*Identify the solid waste produced and implement the disposal methods*	*1*	*85*	*75*	*M*	*M*	*H*	*M*			*L*					*H*	*M*	*H*	*H*
CLO-4 :	*Identify different water treatment methods used in industry and able to implement the methods wherever necessary*	*1*	*85*	*75*	*H*	*H*	*M*	*M*			*M*	*M*	*L*			*H*	*M*	*H*	*H*
CLO-5 :	*Identify the sources of air pollution and able to control the air pollution*	*1*	*85*	*75*	*H*	*H*	*M*	*M*			*M*	*M*	*L*			*H*	*M*	*H*	*H*
CLO-6 :	*Identify the pollution nature and able to bring the solution*	*1*	*75*	*70*	*H*	*H*	*M*	*M*			*M*	*M*	*L*			*H*	*M*	*H*	*M*

Duration (hour)		9	9	9	9	9
S-1	SLO-1	*Introduction*	*Environmental regulations prevention vs control of industrial pollution.*	*Solid waste and disposal methods sources and types of solid waste*	*Principles of water treatment primary, secondary and tertiary treatments*	*Air pollution control methods introduction to particulate emission control*
	SLO-2	*Introduction*	*Prevention vs control of industrial pollution*	*Sources and types of solid waste*	*Principles of water treatment secondary treatments*	*Gravitational settling chambers-cyclone separators, fabric filters*
S-2	SLO-1	*Industrial activity and environment*	*Prevention vs control of industrial pollution*	*Processing methods, disposal- principle, practices and methods*	*Principles of water treatment secondary treatments*	*Gravitational settling chambers-cyclone separators, fabric filters*
	SLO-2	*Industrial activity and environment*	*Prevention vs control of industrial pollution*	*Processing methods, disposal- principle, practices and methods*	*Principles of water treatment secondary treatments*	*Electrostatic precipitators, wet scrubbers, absorbers control.*
S-3	SLO-1	*Industrial activity and environment*	*Prevention vs control of industrial pollution*	*Processing methods, disposal- principle, practices and methods*	*Principles of water treatment tertiary treatments*	*Control of oxides of nitrogen*
	SLO-2	*Industrial activity and environment*	*Prevention vs control of industrial pollution*	*Processing methods, disposal- principle, practices and methods*	*Principles of water treatment tertiary treatments*	*Control of oxides of nitrogen*
S-4	SLO-1	*Fates of industrial contaminants*	*Environment policies and regulations to encourage pollution prevention*	*Energy from solid waste, waste management hierarchy*	*Principles of water treatment tertiary treatments*	*Control of oxides of nitrogen*
	SLO-2	*Fates of industrial contaminants*	*Environment policies and regulations to encourage pollution prevention*	*Energy from solid waste, waste management hierarchy*	*Principles of water treatment tertiary treatments*	*Control of oxides of nitrogen*
S-5	SLO-1	*Case studies on industrial contaminants*	*Environment policies and regulations to encourage pollution prevention*	*Energy from solid waste, waste management hierarchy*	*Advanced waste water treatments*	*Control of sulphur dioxide*
	SLO-2	*Case studies on industrial contaminants*	*Environment policies and regulations to encourage pollution prevention*	*Energy from solid waste, waste management hierarchy*	*Advanced waste water treatments*	*Control of sulphur dioxide*
S-6	SLO-1	*Industrialization and sustainable development*	*Environment friendly chemical processes*	*Energy from solid waste, waste management hierarchy*	*Advanced waste water treatments*	*Control of sulphur dioxide*
	SLO-2	*Industrialization and sustainable development*	*Environment friendly chemical processes*	*Energy from solid waste, waste management hierarchy*	*Advanced waste water treatments*	*Control of sulphur dioxide*

S-7	SLO-1	*Sustainability strategies*	*Environment friendly chemical processes*	*Energy from solid waste, waste management hierarchy*	*Advanced waste water treatments*	*Control of carbon monoxide and hydrocarbons*
	SLO-2	*Sustainability strategies*	*Environment friendly chemical processes*	*Energy from solid waste, waste management hierarchy*	*Advanced waste water treatments*	*Control of carbon monoxide and hydrocarbons*
S-8	SLO-1	*Barriers to sustainability*	*Regulations for clean environment and implication for industries*	*Hazardous waste, biomedical waste, and nuclear waste.*	*Recovery of metals from process effluents*	*Noise pollution measurements and its control*
	SLO-2	*Barriers to sustainability*	*Regulations for clean environment and implication for industries*	*Hazardous waste, Biomedical waste, and Nuclear waste.*	*Recovery of metals from process effluents*	*Noise pollution measurements and its control*
S-9	SLO-1	*Pollution prevention in achieving sustainability*	*Regulations for clean environment and implication for industries*	*Hazardous waste, Biomedical waste, and Nuclear waste.*	*Recovery of metals from process effluents*	*Noise pollution measurements and its control*
	SLO-2	*Pollution prevention in achieving sustainability*	*Regulations for clean environment and implication for industries*	*Hazardous waste, Biomedical waste, and Nuclear waste.*	*Recovery of metals from process effluents*	*Noise pollution measurements and its control*

Learning Resources	1. *Bishop.P, "Pollution Prevention: Fundamentals and Practice", McGraw Hill International Edn., McGraw Hill Book Co., Singapore, 2000* 2. *Freeman.H.M, "Industrial Pollution Prevention Hand Book", McGraw Hill, 1995* 3. *James. G. Mann and Liu.Y.A, "Industrial Water Reuse and Waste Water Minimization", McGraw Hill, 1999*	4. *Rose.G.R.D, "Air pollution and Industry", Van Nostrand Reinhold Co., NewYork 1972* 5. *Pandey.G.N and Carney.G.C, "Environmental Engineering", Tata McGraw Hill, New Delhi,1989* 6. *Kapoor.B.S, "Environmental Engineering", 3rd Edn., Khanna publishers,1997*

Learning Assessment

	Bloom's Level of Thinking	Continuous Learning Assessment (50% weightage)								Final Examination (50% weightage)	
		CLA – 1 (10%)		CLA – 2 (15%)		CLA – 3 (15%)		CLA – 4 (10%)#			
		Theory	Practice	Theory	Practice	Theory	Practice	Theory	Practice	Theory	Practice
Level 1	Remember Understand	40 %	-	30 %	-	30 %	-	30 %	-	30%	-
Level 2	Apply Analyze	40 %	-	40 %	-	40 %	-	40 %	-	40%	-
Level 3	Evaluate Create	20 %	-	30 %	-	30 %	-	30 %	-	30%	-
	Total	100 %		100 %		100 %		100 %		100 %	

CA –4 can be from any combination of these: Assignments, Seminars, Tech Talks, Mini-Projects, Case-Studies, Self-Study, MOOCs, Certifications, Conf. Paper etc.,

Course Designers

Experts from Industry	Experts from Higher Technical Institutions	Internal Experts
1. *Mr. A. Subramaniam, PESCO Beam Environmental Solutions Pvt. Ltd.,*	1. *Dr. Lima Rose Miranda, Anna University, email: limamiranda2007@gmail.com*	1. *Dr. B. Karunanithi SRM Inst. of Science & Technology, karunab@srmist.edu.in*
2. *Mr. S. T. Kalaimani, CPCL, Chennai*	2. *Dr. T. R. Sundararaman, Rajalakshmi Engineering College*	2. *Dr. S. Vishali SRM Inst. of Science & Technology, vishalis@srmist.edu.in*

Course Code	18CHE357T	Course Name	ENZYME ENGINEERING	Course Category	E	Professional Elective	L	T	P	C
							3	0	0	3

Pre-requisite Courses	Nil	Co-requisite Courses	Nil	Progressive Courses	Nil
Course Offering Department	Chemical Engineering	Data Book / Codes/Standards	Nil		

Course Learning Rationale (CLR):	*The purpose of learning this course is to:*
CLR-1 :	*Understand the mechanism of enzyme action and learn about the different classes of enzymes*
CLR-2 :	*Understand the kinetics of enzyme action and identify the types of inhibition*
CLR-3 :	*Understand the need for enzyme immobilization and learn the different methods of immobilization*
CLR-4 :	*Analyze the effect of various physicochemical factors on enzyme activity*
CLR-5 :	*Understand the various applications of enzymes*
CLR-6 :	*Appreciate the various mechanisms of enzyme action and its industrial applications*

Course Learning Outcomes (CLO):	*At the end of this course, learners will be able to:*	Learning			Program Learning Outcomes (PLO)														
		1	2	3	1	2	3	4	5	6	7	8	9	10	11	12	13	14	15
		Level of Thinking (loom)	Expected Proficiency %)	Expected Attainment (%)	Engineering Knowledge	Problem Analysis	Design & Development	Analysis, Design, Research	Modern Tool Usage	Society & Culture	Environment & Sustainability	Ethics	Individual & Team Work	Communication	Project Mgt. & Finance	Life Long Learning	PSO - 1	PSO - 2	PSO –3
CLO- 1 :	*Comprehend the basic concepts about enzymes, mechanism of enzyme action, and the classification of enzymes*	*2*	*85*	*80*	*L*	*L*	*M*				*M*		*L*				*M*		
CLO-2 :	*Identify and estimate the kinetic parameters and type of inhibition using various kinetic plots*	*3*	*80*	*75*	*M*	*M*	*M*	*M*									*M*		
CLO-4 :	*Choose the immobilization technique based on the requirements of the process*	*3*	*80*	*75*	*M*	*M*	*M*	*M*			*M*		*M*				*M*		
CLO-4 :	*Identify the circumstances of enzyme deactivation and select the reaction conditions wisely*	*3*	*80*	*75*	*M*	*M*	*M*	*M*	*L*		*M*		*M*				*M*		
CLO-5:	*Discern the practical applications of enzymes*	*2*	*80*	*75*	*M*	*M*	*M*	*H*	*M*		*M*		*H*				*M*	*M*	*M*
CLO-6 :	*Apply the knowledge of enzymes for suitable industries*	*2*	*75*	*70*	*M*	*M*	*H*	*H*	*M*		*M*		*M*				*M*	*M*	*M*

Duration (hour)		9	9	9	9	9
S-1	SLO-1	Action of enzymes	Kinetics of enzyme action	Enzyme immobilization technology	Deactivation enzyme kinetics	Application of enzyme in analysis
	SLO-2	Action of enzymes	Introduction to enzyme kinetics	Introduction to immobilization	Deactivation enzyme kinetics	Application of enzyme in analysis
S-2	SLO-1	Classification of enzymes	Kinetics of single substrate reactions	Types of immobilization	Mechanisms of reversible enzyme modulation	Enzyme electrode
	SLO-2	Classification of enzymes	Estimation of Michelis-Menten parameters	Adsorption	Mechanisms of reversible enzyme modulation	Enzyme electrode
S-3	SLO-1	Mechanisms of enzyme action	Kinetics plots	Matrix entrapment	The effect of pH on enzyme activity	Design of enzyme electrodes
	SLO-2	Mechanisms of enzyme action	Problems on M-M kinetics	Encapsulation	The effect of pH on enzyme activity	Design of enzyme electrodes
S-4	SLO-1	Concept of active site	Problems on M-M kinetics	Cross linking	The effect of temperature on enzyme activity	Applications of enzyme electrodes as biosensors in industry
	SLO-2	Concept of active site	Mechanisms of multi-substrate reactions	Covalent binding	The effect of temperature on enzyme activity	Applications of enzyme electrodes as biosensors in industry
S-5	SLO-1	Energetics of enzyme substrate complex formation	Inhibitors	Advantages and disadvantages of different immobilization techniques	Enzyme deactivation	Applications of hydrolytic enzymes
	SLO-2	Energetics of enzyme substrate complex formation	Types of inhibition mechanisms	Advantages and disadvantages of different immobilization techniques	Enzyme deactivation	Applications of hydrolytic enzymes
S-6	SLO-1	Specificity of enzyme action	Competitive inhibition	Immobilization enzyme kinetics	Mechanisms and manifestations of protein denaturation	Applications of hydrolytic enzymes
	SLO-2	Specificity of enzyme action	Uncompetitive inhibition	Immobilization enzyme kinetics	Mechanisms and manifestations of protein denaturation	Applications of hydrolytic enzymes
S-7	SLO-1	Principles of catalysis	Non-competitive inhibition	Effects of external mass-transfer resistance	Deactivation models and kinetics	Applications of non-hydrolytic enzymes
	SLO-2	Principles of catalysis	Comparison of different type of inhibition	Effects of external mass-transfer resistance	Deactivation models and kinetics	Applications of non-hydrolytic enzymes
S-8	SLO-1	Collision theory	Problems on enzyme inhibition	Analysis of intraparticle diffusion and reaction	Mechanical forces acting on enzymes	Applications of non-hydrolytic enzymes
	SLO-2	Collision theory	Problems on enzyme inhibition	Analysis of intraparticle diffusion and reaction	Strategies for enzyme stabilization	Applications of non-hydrolytic enzymes
S-9	SLO-1	Transition state theory	Problems on enzyme inhibition	Simultaneous film and intraparticle mass-transfer resistances	Problems on enzyme de-activation kinetics	Enzymes used in current and developing industry
	SLO-2	Transition state theory	Problems on enzyme inhibition	Simultaneous film and intraparticle mass-transfer resistances	Problems on enzyme de-activation kinetics	Enzymes used in current and developing industry

Learning Resources	1. *Palmer, Trevor "Enzymes : Biochemistry, Biotechnology, Clinical Chemistry", Affiliated East-West Press Pvt. Ltd., 2004* 2. *Bailey, J.E. and Ollis, D.F. "Biochemical Engineering Fundamentals" 2nd Edition, McGraw– Hill, 1988.* 3. *Michael L.Shuler and Fikret Kargi, "Bioprocess Engineering Basic concepts", Prentice Hall, 1992.*

Learning Assessment

	Bloom's Level of Thinking	Continuous Learning Assessment (50% weightage)								Final Examination (50% weightage)	
		CLA – 1 (10%)		CLA – 2 (15%)		CLA – 3 (15%)		CLA – 4 (10%)#			
		Theory	Practice	Theory	Practice	Theory	Practice	Theory	Practice	Theory	Practice
Level 1	Remember Understand	40 %	-	30 %	-	30 %	-	30 %	-	30%	-
Level 2	Apply Analyze	40 %	-	40 %	-	40 %	-	40 %	-	40%	-
Level 3	Evaluate Create	20 %	-	30 %	-	30 %	-	30 %	-	30%	-
	Total	100 %		100 %		100 %		100 %		100 %	

CA –4 can be from any combination of these: Assignments, Seminars, Tech Talks, Mini-Projects, Case-Studies, Self-Study, MOOCs, Certifications, Conf. Paper etc.,

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2. *Mr. S. T. Kalaimani, CPCL, Chennai*	2. *Dr. T. R. Sundararaman, Rajalakshmi Engineering College*	2. *Dr. K. Deepa SRM Institute of Science & Technology, deepak1@srmist.edu.in*

Course Code	18CHE358T	Course Name	FERTILIZER TECHNOLOGY	Course Category	E	Professional Elective	L	T	P	C
							3	0	0	3

Pre-requisite Courses	NIL	Co-requisite Courses	NIL	Progressive Courses	NIL
Course Offering Department	Chemical Engineering	Data Book / Codes/Standards	NIL		

Course Learning Rationale (CLR):	*The purpose of learning this course is to:*
CLR-1 :	*Understand the importance of fertilizers and growth potential of fertilizer Industries*
CLR-2 :	*Learn the various nitrogen fertilizers production processes*
CLR-3 :	*Familiarize the different phosphate fertilizers and its manufacturing processes*
CLR-4 :	*Understand the Importance of compound fertilizers and production processes*
CLR-5 :	*Learn the process flow diagram of miscellaneous fertilizers*
CLR-6 :	*Identify Biofertilizers*

Course Learning Outcomes (CLO):	*At the end of this course, learners will be able to:*	Learning 1: Level of Thinking (Bloom)	Learning 2: Expected Proficiency (%)	Learning 3: Expected Attainment (%)	PLO 1: Engineering Knowledge	PLO 2: Problem Analysis	PLO 3: Design & Development	PLO 4: Analysis, Design, Research	PLO 5: Modern Tool Usage	PLO 6: Society & Culture	PLO 7: Environment & Sustainability	PLO 8: Ethics	PLO 9: Individual & Team Work	PLO 10: Communication	PLO 11: Project Mgt. & Finance	PLO 12: Life Long Learning	PLO 13: PSO - 1	PLO 14: PSO - 2	PLO 15: PSO –3
CLO-1 :	*Identify the chronological development of fertilizer industry*	2	90	85	L	L	L	L			H		L			M	H	M	L
CLO-2 :	*Recognize the raw materials and processes for manufacture of nitrogenous fertilizers*	2	85	75	M	L	M	L			M		M			M	H	M	L
CLO-3 :	*Understand the block diagram of phosphate fertilizers*	2	85	80	M	L	M	L			M		M			M	M	H	L
CLO-4 :	*Review the flow diagrams of potassium and compound fertilizers*	2	90	80	M	L	L	L			M		M			M	H	H	L
CLO-5 :	*Classify the miscellaneous fertilizers and production process*	2	85	75	M	L	M	L			M		M			M	M	L	H
CLO-6 :	*Develop the application of Biofertilizers*	2	85	80	M	L	M	L			M		M			M	M	L	H

Duration (hour)		9	9	9	9	9
S-1	SLO-1	*Overview of plant nutrients*	*Ammonia- -physical and chemical properties, applications*	*Importance of phosphate fertilizers*	*Overview of potash fertilizers*	*Biofertilizers*
	SLO-2	*Functions of nutrients*	*Feedstock's for Ammonia production*	*Phosphate fertilizers-various types*	*Types of potash fertilizers*	*Importance of Biofertilizers*
S-2	SLO-1	*Classification of soil nutrients-macro and micro nutrients*	*Ammonia production via steam reforming*	*Raw materials selection for Phosphate fertilizers*	*Physical, chemical properties and uses of Potassium Chloride,*	*Types of biofertilizers*
	SLO-2	*Fundamentals of soil nitrogen*	*Reactions involved, advantages and disadvantages*	*Preparation of raw materials - Phosphate Rock, Sulphur, Pyrites*	*Physical, chemical properties and uses of Potassium nitrate, Potassium sulphate*	*Benefits of Biofertilizers*
S-3	SLO-1	*Fundamentals of soil Phosphorus*	*Partial oxidation method for ammonia production*	*Sulphuric acid-Raw material including storage and handling*	*Selection of raw materials for manufacture of potassium chloride*	*Preparation of a Biofertilizers*
	SLO-2	*Fundamentals of soil potassium*	*Storage and Transportation of Ammonia*	*Processes for the production of sulphuric acid*	*Process flow diagram for potassium chloride production*	*Precautions to use Biofertilizers*
S-4	SLO-1	*Need of fertilizer*	*Nitric acid-chemical and physical properties, applications*	*Production processes of Phosphoric acid - Dihydrate processes*	*Production flow sheet for potassium nitrate*	*Fluid Fertilizers*
	SLO-2	*Fertilizer specifications*	*Manufacture of nitric acid Storage and transportation*	*Hemihydrate and recrystalliztion processes*	*Production flow sheet for potassium sulphate*	*Fluid Fertilizers*
S-5	SLO-1	*Classification of fertilizers*	*Production of Ammonium chloride*	*Single super phosphate-Agriculture use*	*Role of compound fertilizers*	*Controlled release fertilizers*
	SLO-2	*Classification of fertilizers*	*Physical and Chemical properties, application*	*Production process for SSP*	*Compound fertilizer production Technology*	*Types of Controlled release fertilizers*
S-6	SLO-1	*Requisite of fertikzers*	*Ammonium sulphate- method of manufacture*	*Selection of raw material & process condition for Triple super phosphate*	*Processes for manufacturing compound fertilizers*	*Environmental issues related to the use of fertilizers*
	SLO-2	*Fertilizer Terminology and defintions*	*Characteristics, specification, storage handling and applications*	*Process flow diagram for TSP*	*Processes for manufacturing compound fertilizers*	*Impact of fertilizer on the Environment*
S-7	SLO-1	*Organic manures versus synthetic fertilizers*	*Feedstock for urea production*	*Raw material and process condition for Ammonium phosphate synthesis*	*Importance of NPK fertilizers*	*Soil and air Pollution from fertilizer industry*
	SLO-2	*Role of organic manures*	*Urea production and storage*	*Manufacture of Ammonium phosphate*	*Process flow sheet for the manufacture of NPK fertilizer using mixed acid route*	*Water pollution from fertilizer industry*

S-8	SLO-1	*Growth of fertilizer Industry in India*	*Methods of Production, characteristics and specification - Ammonium Nitrate*	*Fundamental of Nitro phosphates*	*Nitro phosphate route for NPK fertilizers*	*Fertilizer plants effluent treatment and disposal*
	SLO-2	*Growth of fertilizer Industry in India*	*storage and handling of Ammonium Nitrate*	*Manufacture of nitro phosphates*	*Nitro phosphate route for NPK fertilizers*	*Corrosion problems in fertilizer industries*
S-9	SLO-1	*Location of fertilizer Industry in India*	*Production of calcium Ammonium nitrate(CAN)*	*Other phosphate fertilizers-Enriched super phosphate*	*Advantages of compound fertilizers*	*Case study of selected fertilizer plants with environmental aspects.*
	SLO-2	*Location of fertilizer Industry in India*	*Granulation of CAN*	*Application of super phosphate*	*Application of compound fertilizers*	*Case study*

Learning Resources	1. *Hand book of Fertilizer Association of India, New Delhi, 1998* 2. *Slack A.V., Chemistry & Technology of Fertilizers, Interscience, New York, 1967* 3. *NPTEL Notes-IITM/Fertilizer Technology*

Learning Assessment

	Bloom's Level of Thinking	Continuous Learning Assessment (50% weightage)								Final Examination (50% weightage)	
		CLA – 1 (10%)		CLA – 2 (15%)		CLA – 3 (15%)		CLA – 4 (10%)#			
		Theory	Practice	Theory	Practice	Theory	Practice	Theory	Practice	Theory	Practice
Level 1	Remember Understand	40 %	-	30 %	-	30 %	-	30 %	-	30%	-
Level 2	Apply Analyze	40 %	-	40 %	-	40 %	-	40 %	-	40%	-
Level 3	Evaluate Create	20 %	-	30 %	-	30 %	-	30 %	-	30%	-
	Total	100 %		100 %		100 %		100 %		100 %	

CA – 4 can be from any combination of these: Assignments, Seminars, Tech Talks, Mini-Projects, Case-Studies, Self-Study, MOOCs, Certifications, Conf. Paper etc.

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2. *Mr. S. T. Kalaimani, CPCL, Chennai*	2. *Dr. T. R. Sundararaman, Rajalakshmi Engineering College*	2. *Dr. K. Tamilarasan SRM Inst. of Science & Technology, tamilark@srmist.edu.in*

Course Code	18CHE359T	Course Name	PETROLEUM TECHNOLOGY	Course Category	E	Professional Elective	L	T	P	C
							3	0	0	3

Pre-requisite Courses	NIL	Co-requisite Courses	NIL	Progressive Courses	NIL
Course Offering Department	Chemical Engineering	Data Book / Codes/Standards	NIL		

Course Learning Rationale (CLR):	*The purpose of learning this course is to:*
CLR-1 :	*Understand the formation and evaluation of crude oil, overview of petroleum refining processes, Distillation*
CLR-2 :	*Understand the Evaluation and testing, properties, Petroleum refining processes*
CLR-3 :	*Understand the Thermal and catalytic cracking, treatment techniques*
CLR-4 :	*Understand the production of fuels, lubricating oil, storage and transportation*
CLR-5 :	*Understand the production of olefin gases, intermediates compounds and important petrochemicals*
CLR-6:	*Understand the overview of petroleum refining process*

Course Learning Outcomes (CLO):	*At the end of this course, learners will be able to:*	Learning 1: Level of Thinking (Bloom)	Learning 2: Expected Proficiency (%)	Learning 3: Expected Attainment (%)	PLO 1: Engineering Knowledge	PLO 2: Problem Analysis	PLO 3: Design & Development	PLO 4: Analysis, Design, Research	PLO 5: Modern Tool Usage	PLO 6: Society & Culture	PLO 7: Environment & Sustainability	PLO 8: Ethics	PLO 9: Individual & Team Work	PLO 10: Communication	PLO 11: Project Mgt. & Finance	PLO 12: Life Long Learning	PLO 13: PSO - 1	PLO 14: PSO - 2	PLO 15: PSO – 3
CLO-1 :	*Comprehend the potential growth of petrochemical industries, distillation characteristics*	*1*	*75*	*70*	*L*		*L*										*H*	*H*	
CLO-2 :	*Comprehend the thermal properties of petroleum fractions*	*1*	*75*	*70*	*M*		*M*										*H*	*H*	*M*
CLO-3 :	*Comprehend the conversion of petroleum, hydrodesulfurisation*	*1*	*80*	*75*	*H*		*M*										*H*	*H*	
CLO-4 :	*Comprehend the fuel, storage and transportation -characteristics*	*1*	*80*	*75*	*M*		*M*				*L*						*H*	*H*	*M*
CLO-5 :	*Comprehend the flow sheets of important petrochemicals*	*1*	*80*	*75*	*M*		*H*										*H*	*H*	
CLO-6:	*Comprehend the salient features of petroleum engineering*	*1*	*80*	*70*	*H*		*H*				*L*						*H*	*H*	*M*

Duration (hour)		9	9	9	9	9
S-1	SLO-1	*Origin of crude*	*Octane number*	*Thermal cracking*	*Overview of Refinery Products*	*Petro chemicals definition*
	SLO-2	*Origin of crude*	*Cetane number, Diesel index, their determination and importance*	*Thermal cracking in vapor, liquid and mixed phase*	*Refinery Products*	*Overview of petrochemical*
S-2	SLO-1	*Formation*	*Petroleum refining processes*	*Catalytic cracking*	*Production of aviation gasoline*	*Importance and growth potential of petrochemical in india*
	SLO-2	*Formation theories*	*Petroleum Products*	*Houdry fixed bed*	*Properties*	*Petrochemical types*
S-3	SLO-1	*Migration of crude*	*Evaluation of Crude Oil*	*Fluidized bed*	*Motor fuel, kerosene, fuel*	*Reforming and cracking: Cracking of Naphtha*
	SLO-2	*Accumulation of petroleum*	*Testing of Petroleum Products*	*Catalytic bed*	*Diesel oil, tractor fuel and jet*	*Production of C2 and C3 Compounds*
S-4	SLO-1	*Types of crude*	*general processing, topping*	*Reforming process*	*Lubricating oil manufacture*	*Production of intermediate chemicals: Acrylonitrile,*
	SLO-2	*Crude classification*	*vacuum distillations*	*Alkylation process*	*Petroleum waxes and asphalts*	*ethylene oxide*
S-5	SLO-1	*Formation and Evaluation of Crude Oil.*	*Physical properties*	*Conversion of petroleum gases into motor fuel with alkylation*	*Storage of petroleum products*	*Higher olefins*
	SLO-2	*General processing of crude*	*Thermal properties*	*Flow digram*	*Types of storage*	*Benzene*
S-6	SLO-1	*Atmospheric distillation of crude*	*Properties of petroleum fractions*	*Polmerization*	*Tanks*	*Toluene*
	SLO-2	*Flow diagram*	*Thermal properties*	*Hydrogenation and dehydrogenation*	*Bullets*	*Xylene*
S-7	SLO-1	*Distillation condition*	*Flash point, fire point*	*Treatment techniques*	*Special types of spheres*	*Polymerization process*
	SLO-2	*Distillation products*	*Viscosity factor*	*Removal of Sulphur Compounds*	*Transportation of petroleum products,road, rail,*	*Plastics*
S-8	SLO-1	*Vacuum distillations*	*Petroleum refining processes*	*Dewaxing*	*Sea and pipeline;*	*Ethenic polymers*
	SLO-2	*Flow diagram*		*Clay Treatment and Hydrofining*	*Types of transportation*	*Polyvinyl chloride*
S-9	SLO-1	*Primary process*	*Refining flow diagram*	*Desulphurization,*	*Safety norms*	*Synthetic fibers- polyesters- polyesters ribbon,*
	SLO-2	*Secondary process*		*Solvent Treatment Processes*	*Importance of pipeline transportation.*	*Polyethylene Terephthalate*

Learning Resources	1. *BhaskaraRao. B.K, "A Text on Petroleum Chemicals", 4thEdn.,Khanna Publishers, New Delhi, 2007* 2. *Nelson.W.L, "Petroleum Refinery Engineering", McGraw Hill Publishing Company Limited, 1985.* 3. *GopalaRao M. and Marshall Sittig. "Dryden's Outlines of Chemical Technology", 3rd Edn.,East-West Press, New Delhi, 1997.*

Learning Assessment											
	Bloom's Level of Thinking	Continuous Learning Assessment (50% weightage)								Final Examination (50% weightage)	
		CLA – 1 (10%)		CLA – 2 (15%)		CLA – 3 (15%)		CLA – 4 (10%)#			
		Theory	Practice	Theory	Practice	Theory	Practice	Theory	Practice	Theory	Practice
Level 1	Remember Understand	40 %	-	30 %	-	30 %	-	30 %	-	30%	-
Level 2	Apply Analyze	40 %	-	40 %	-	40 %	-	40 %	-	40%	-
Level 3	Evaluate Create	20 %	-	30 %	-	30 %	-	30 %	-	30%	-
	Total	100 %		100 %		100 %		100 %		100 %	

CA – 4 can be from any combination of these: Assignments, Seminars, Tech Talks, Mini-Projects, Case-Studies, Self-Study, MOOCs, Certifications, Conf. Paper etc.,

Course Designers		
Experts from Industry	Experts from Higher Technical Institutions	Internal Experts
1. *Mr. A. Subramaniam, PESCO Beam Environmental Solutions Pvt. Ltd.,*	1. *Dr. Lima Rose Miranda, Anna University, email: limamiranda2007@gmail.com*	1. *Dr. Anbalagan, SRM Inst. of Science & Technology, anbalagan.k@ktr.srmuniv.ac.in*
2. *Mr. S. T. Kalaimani, CPCL, Chennai*	2. *Dr. T. R. Sundararaman, Rajalakshmi Engineering College*	2. *Dr. M. Magesh kumar SRM Inst. of Science & Technology, mageshkumar.m@ktr.srmuniv.ac.in*

Course Code	18CHE360T	Course Name	PRINCIPLES OF MEMBRANE SEPARATION	Course Category	E	Professional Elective	L	T	P	C
							3	0	0	3

Pre-requisite Courses	NIL	Co-requisite Courses	NIL	Progressive Courses	NIL
Course Offering Department	Chemical Engineering	Data Book / Codes/Standards	NIL		

Course Learning Rationale (CLR):	*The purpose of learning this course is to:*
CLR-1 :	*Know about membranes, their nature, characteristics and their role in water purification and other separation processes in industries vis-a-vis conventional separation processes.*
CLR-2 :	*Understand the various methods of preparation of membranes in different configurations and their structural & performance characteristics.*
CLR-3 :	*Understand the principles, mechanism of transport, applications and performance characteristics of pressure driven membrane processes.*
CLR-4 :	*Understand the principles, characteristics and applications of membrane processes driven by electrical and concentration gradients*
CLR-5 :	*Designing of membranebased systems from laboratory studies for various applications including desalination.*
CLR-6	*Understand the potential of membrane process for various applications*

Course Learning Outcomes (CLO):	*At the end of this course, learners will be able to:*	Learning 1	2	3	Program Learning Outcomes (PLO) 1	2	3	4	5	6	7	8	9	10	11	12	13	14	15
		Level of Thinking (loom)	Expected Proficiency %)	Expected Attainment (%)	Engineering Knowledge	Problem Analysis	Design & Development	Analysis, Design, Research	Modern Tool Usage	Society & Culture	Environment & Sustainability	Ethics	Individual & Team Work	Communication	Project Mgt. & Finance	Life Long Learning	PSO - 1	PSO - 2	PSO –3
CLO-1 :	*Prepare the membrane and characterize them with respect to their performance.*	*3*	*80*	*75*	*H*	*H*				*M*		*L*					*H*		
CLO-2 :	*know the basic principles, philosophy and process flow diagram for pressure driven membrane processes.*	*2*	*75*	*70*	*H*	*H*	*H*				*M*						*H*		
CLO-3 :	*Use membrane contactors for study of separations based on solvent extraction, gaseous separation, forward osmosis etc.*	*2*	*75*	*70*	*M*	*H*	*H*	*H*	*M*	*M*	*H*	*M*	*H*				*H*		
CLO-4 :	*Appreciate and apply concepts such as hybrid systems, zero liquid discharge, value recovery etc*	*1*	*90*	*80*	*H*	*M*		*H*		*H*	*M*	*M*					*H*	*M*	*M*
CLO-5 :	*Process design of desalination systems for seawater, brackish water and industrial waste water.*	*2*	*80*	*60*	*M*	*H*	*H*			*H*							*H*	*M*	*M*
CLO-6	*Understand the basis of design for different membrane separation process*	*3*	*80*	*70*	*H*	*M*	*H*	*H*	*M*		*M*						*H*	*H*	*M*

Duration (hour)		9	9	9	9	9
S1	SLO-1:	*Definition of membrane - distinguishing features of membrane processes over conventional processes.*	*Pressure driven membrane processes: commonalities and distinguishing features.*	*Pretreatment options – related to recovery and specific flux- selection of High Pressure pump - post treatment systems*	*Deign of module arrangements – controlling parameters – staggered configurations. Concept of Pass and Stage.*	*Forward osmosis for desalination – process principles – membranes used- osmotic pouches – challenges & limitations*
S2	SLO-1:	*Types and classification of membranes. Porous and non-porous; asymmetric/symmetric / composite and TFC*	*Ultra-filtration: features characterization, transport mechanism and operating features*	*Energy recovery systems – cleaning and maintenance aspects*	*Post treatment and cleaning systems.*	*Pervaporation concepts - applications*
S3	SLO-1:	*Structural characterization of membranes: pore size/pore-size distribution, contact angle*	*Principles behind reverse osmosis and nano-filtration: features and characteritics.*	*Applications of MF/UF in waste water treatment – comparison with conventional operations. Design approach for UF*	*High Pressure pump /energy recovery systems*	*Membrane contactors applications in gaseous separation / solvent extraction.*
S4	SLO-1:	*Classification of membrane processes based on driving forces – membrane requirements for each of the processes*	*Definition of SR,Rec and product flux, Performance characteristics of membranes with recovery, feedconc. And temperature of water.*	*Membrane Bio reactors – concept and applications*	*Once through /recycle mode of operation of RO plants*	*Zero liquid discharge -concept – how membrane processes can achieve*
S5	SLO-1:	*Membrane preparation techniques / sheet / tubular / capillary /hollow fibre - assembly as membrane element & modules*	*Transport mechanisms through membranes: Preferential sorption – capillary flow mechanism – concept and transport equations*	*Application of NF and RO – comparison of the processes based on membrane characteristics, operating aspects and performance.*	*Basic concepts of electrically driven membrane processes – membrane characteristics – comparison with pressure driven processes*	*Hybrid membrane systems – an analysis with a case study.*
S6	SLO-1:	*Relative charcteristics of different module configurations and advantages and limitations of the modules during applications.*	*Irreversible thermodynamics model – coupled flow – transport equations*	*.Design of RO /NF systems – approach -basic elements*	*Electro-dialysis – process description- membrane characteristics – EDR - limitations – energy consumption – lack of energy recovery*	*Value recovery – isolation of spent streams at source- techniques like size-enhanced – UF/ combo membrane processes or*

S7	SLO-1:	*Review of solution properties relevant to membrane processes. -colligative, zeta potential, diffusive flow, capillary flow.*	*Solution Diffusion model – concept and equations*	*Feed water characteristics and pretreatment requirements -discussion on fouling, scaling and chemical environments.*	*Electro-electro-dialysis and bipolar electrolysis- process principles – applications-challenges*	*Environmental aspects of membrane processes – concentrate disposal -spent membrane disposal*
S8	SLO-1:	*Definition of osmosis, osmotic pressure and osmotic equilibrium. – problems to illustrate variation of osmotic pressure with temperature and concentration. Relevance of contact angle /zeta potential etc. angle*	*Comparison of three models – use of transport equations for estimating membrane area and solute concentration in the permeate.*	*Preteatment equipments – monitoring aspects of pretreatment performance – SDI ORP*	*Fuel cells / type of membranes used – different types of Fuel Cells - challenges*	*Cost elements and analysis of low temperature desalination systems / opportunity costs / sustainability criteria*
S9	SLO-1:	*Thermodynamic concepts for the mnimum energy for membrane separation estimation of minimum energy based on colligative properties.*	*Laboratory experiments using single element to collect data for designing larger plants. role of each subsystem*	*Flow sheet of SWRO/NF plant. Role of each subsystem. Batch Vs continuous system*	*Membrane distillation- process philosophy for desalination – type of membranes. VMD, AGMD, DCMD*	*Environmental issues – Environmental impact analysis of thermal / membrane desalination plants.*

Learning Resources	1. *Peter Marcel Mulder : Basic Principles of Membrane Technology Springer (India) Private Ltd. New Delhi(2007) ISBN978-81-8128-683-3* 2. *W.S.Winston HO and K.K.Sirkar(Ed): Membrane Hand Book Von Nostrand Reinhold (1992)* 3. *Kaushik Nath Membrane Separation Processes PHI learning Pvt.Ltd.(2016) ISBN 10 :8120352912*

SLO – Session Learning Outcome

Learning Assessment

	Bloom's Level of Thinking	Continuous Learning Assessment (50% weightage)								Final Examination (50% weightage)	
		CLA – 1 (10%)		CLA – 2 (15%)		CLA – 3 (15%)		CLA – 4 (10%)#			
		Theory	Practice	Theory	Practice	Theory	Practice	Theory	Practice	Theory	Practice
Level 1	Remember Understand	40 %	-	30 %	-	30 %	-	30 %	-	30%	-
Level 2	Apply Analyze	40 %	-	40 %	-	40 %	-	40 %	-	40%	-
Level 3	Evaluate Create	20 %	-	30 %	-	30 %	-	30 %	-	30%	-
	Total	100 %		100 %		100 %		100 %		100 %	

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Course Designers

Experts from Industry	Experts from Higher Technical Institutions	Internal Experts
1. Mr. A. Subramaniam, PESCO Beam Environmental Solutions Pvt. Ltd.,	*1. Dr. Lima Rose Miranda, Anna University, email: limamiranda2007@gmail.com*	*1. Dr. S. Prabhakar SRM Inst. of Science & Technology, sivaprabha50@gmail.com*
2. Mr. S. T. Kalaimani, CPCL, Chennai	*2. Dr. T. R. Sundararaman, Rajalakshmi Engineering College*	

Course Code	18CHE361T	Course Name	SAFETY AND HAZARD ANALYSIS IN PROCESS INDUSTRIES	Course Category	E	PROFESSIONAL ELECTIVE	L	T	P	C
							3	0	0	3

Pre-requisite Courses	NIL	Co-requisite Courses	NIL	Progressive Courses	NIL
Course Offering Department	Chemical Engineering	Data Book / Codes/Standards	Nil		

Course Learning Rationale (CLR):	The purpose of learning this course is to:
CLR-1 :	*familiarize Basics of Industrial Safety Management.*
CLR-2 :	*Various aspects of Chemical plant safety*
CLR-3 :	*Various aspects of Industrial accidents and Fire safety*
CLR-4 :	*Hazard identification techniques*
CLR-5 :	*Various aspect of industrial hygiene and Occupational Health hazards, Safety legislation in chemical industries*
CLR-6 :	*Learning Basic Industrial safety Management, Safety of chemical Plants, Identification of Hazards, Industrial Hygiene, Occupational Hazards and safety legislation in Chemical Industries*

Course Learning Outcomes (CLO):	At the end of this course, learners will be able to:	Learning 1: Level of Thinking (loom)	Learning 2: Expected Proficiency %)	Learning 3: Expected Attainment (%)	PLO 1: Engineering Knowledge	PLO 2: Problem Analysis	PLO 3: Design & Development	PLO 4: Analysis, Design, Research	PLO 5: Modern Tool Usage	PLO 6: Society & Culture	PLO 7: Environment & Sustainability	PLO 8: Ethics	PLO 9: Individual & Team Work	PLO 10: Communication	PLO 11: Project Mgt. & Finance	PLO 12: Life Long Learning	PLO 13: PSO - 1	PLO 14: PSO - 2	PLO 15: PSO –3
CLO-1 :	*Know the Basics of Industrial Safety Management.*	2	80	70	L	M	M			L	M		H	H		H	H	M	M
CLO-2 :	*Understand the Various aspects of Chemical plant safety*	3	80	75	M	H				M	H	M	H	H		M	H	M	M
CLO-3 :	*Understand the Various aspects of Industrial accidents and Fire safety*	3	80	75	L	M	M	M		H	H	M	H	H		M	H	M	M
CLO-4 :	*Able to use Hazard identification techniques*	3	85	80	M	M		M	M	M	H						H	M	M
CLO-5 :	*Know the Various aspect of industrial hygiene and Occupational Health hazards, Safety legislation in chemical industries*	3	80	75	L		M	M		L	H		H				H	L	L
CLO-6 :	*Will be able to Control the Accidents in Chemical Industries By applying the acquired knowledge from Course Learning Rationle*	1	75	70	M	H	M	M	M	M	H	M	H	H		H	H	H	M

Duration (hour)		9	9	9	9	9
S1	SLO-1	*INDUSTRIAL SAFETY MANAGEMENT Importance of Safety consciousness in Indian Chemical Industries -*	*- CHEMICAL PLANT SAFETY Chemical process Industries - Setting and Layout of a Chemical plant*	*ACCIDENT AND THEIR PREVENTION Definitions, H. W. Henrich, Frank bird & Multiple Causation theories of accident occurrences, Classification, Causes, Costs*	*HAZARD IDENTIFIATION TECHNIQUES Safety Appraisal - Risk Assessment -Hazard identification techniques with examples such as FMEA, CMA, Fault Tree Analysis*	*INDUSTRIAL HYGIENE AND OCCUPATIONAL HEALTH HAZARDS Concepts - Industrial and Occupational health hazards, Housekeeping, human factors and error, stress at work,*
S2	SLO-1	*Development of Industrial Health and Safety,*	*Safety in transportation, storage and handling of hazardous chemicals*	*Industrial accidents, Principles of Accident prevention, Accident prevention technique*	*Preliminary Hazard Analysis (PHA), Hazard and operability (HAZOP) study*	*Personnel protective equipments, Role of trade unions in Industrial safety and health*
S3	SLO-1	*Safety Organization –Polices- Culture -Planning- Promotion – Inspection –Rules- Responsibility – Supervision,*	*Chemical process hazards and their control - First degree and second degree hazards. Lines of defense*	*Plant and Chemical job safety analysis, Accident proneness vocational guidance*	*Quantitative risk analysis-Out line of methodology, Consequences analysis*	*SAFETY AND LAW Introduction to ILO,*
S4	SLO-1	*Safety Committee – role of safety functionaries*	*High pressure - High temperature operations – Case studies*	*Safety performance measurement tools - FR. SR, (FSI), Safe T-Score, Accident rate per 1000 workers,*	*Quantitative risk analysis-Out line of methodology, Consequences analysis*	*Safety legislation in India, Factories act 1948*
S5	SLO-1	*Safety Committee – role of safety functionaries,*	*Emergency preparation: On-site and Offsite*	*Disabling injury index, Accident Compensation Statutes*	*Calculation of release rates of liquids under ambient pressure and liquids under pressure,*	*Employees welfare and legislation , Provisions relating to safety , health & environment in other important legislations*
S6	SLO-1	*Elements of work place Safety Program,*	*Safety aspects of maintenance in chemical plant*	*Accident Investigation reporting and Analysis*	*Calculation of dispersion of released gases and vapors and platting of equal concentration contours*	*Indian boilers act and regulations, Indian electricity act and rules*
S7	SLO-1	*Economic and Social Benefits from Safety Program*	*Effective steps to implement safety procedures-Periodic Advice and checking to follow safety procedures and rules*	*Case studies*	*Dow (Index) Fire and Explosion Index*	*Indian explosives act and rules, Mines act, Petroleum act and rules*
S8	SLO-1	*Effective Safety Education and Training*	*Safe guarding of Machines – Ergonomics*	*Conditions -Fire triangle- Classification of fires, Common causes of industrial fires, Fire protection systems- prevention*	*Dow (Index) Fire and Explosion Index*	*Environmental protection act.*

S9	SLO-1	*Communication at various levels of production and operation, Safety slogans*	*Proper selection and replacement of handling equipment -Safe handling and operation of materials and machineries*	*Case studies, Safety in Explosive*	*System of Risk Analysis*	*Environmental protection act.*

Learning Resources	*1. Sharma. A M "Safety and Health in Industry" -A Hand book, BS Publications , 2009* *2. Fulekar. M.H, "Industrial Hygiene and Chemical Safety", I.K International Publishing house Pvt Ltd., 2006.*	*3. Fawcett .H.H, and Wood .W.S, Safety and Accident Prevention in Chemical Operations, John Wiley & sons, U.S.A.,1965* *4. Willie Hammer &Dennis Price, Occupational safety management and Engineering, Prentice Hall, 2001* *5. William Handley, Industrial safety hand book, McGraw- Hill, 1969 6. Daniel. A, Crowl& Joseph. F Louvar Chemical Process safety: fundamentals with applications, Prentice Hall international series*

Learning Assessment											
	Bloom's Level of Thinking	Continuous Learning Assessment (50% weightage)								Final Examination (50% weightage)	
		CLA – 1 (10%)		CLA – 2 (15%)		CLA – 3 (15%)		CLA – 4 (10%)#			
		Theory	Practice	Theory	Practice	Theory	Practice	Theory	Practice	Theory	Practice
Level 1	Remember Understand	40 %	-	30 %	-	30 %	-	30 %	-	30%	-
Level 2	Apply Analyze	40 %	-	40 %	-	40 %	-	40 %	-	40%	-
Level 3	Evaluate Create	20 %	-	30 %	-	30 %	-	30 %	-	30%	-
	Total	100 %		100 %		100 %		100 %		100 %	

CA – 4 can be from any combination of these: Assignments, Seminars, Tech Talks, Mini-Projects, Case-Studies, Self-Study, MOOCs, Certifications, Conf. Paper etc.,

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2. Mr. S. T. Kalaimani, CPCL, Chennai	*2. Dr. T. R. Sundararaman, Rajalakshmi Engineering College*	

Course Code	18CHE362T	Course Name	FUNDAMENTALS OF DESALINATION	Course Category	E	Professional Elective	L	T	P	C
							3	0	0	3

Pre-requisite Courses	NIL	Co-requisite Courses	NIL	Progressive Courses	NIL
Course Offering Department	Chemical Engineering	Data Book / Codes/Standards	NIL		

Course Learning Rationale (CLR):	The purpose of learning this course is to:
CLR-1 :	*Understand the relevance of desalination technologies and to realize the application of basic principles of solution chemistry and thermodynamics for understanding the processes of desalination.*
CLR-2 :	*Understand the nature and behavior of the membranes under different imposed parameters and hence to learn the process features and design philosophy of Reverse Osmosis desalination.*
CLR-3 :	*Understand the features of different variants of thermal desalination processes including the role of accessories such as vacuum and control systems, process design philosophy, operational and maintenance aspects.*
CLR-4 :	*To impart knowledge on the use of renewable sources of energy and other desalination processes including those on the Research and Development mode.*
CLR-5 :	*To impart knowledge on decision making synergizing technical, economical and environmental aspects.*
CLR – 6:	*Understanding the comparative challenges and advantages of various desalination process*

Course Learning Outcomes (CLO):	At the end of this course, learners will be able to:	Learning 1 Level of Thinking (bloom)	2 Expected Proficiency (%)	3 Expected Attainment (%)	PLO 1 Engineering Knowledge	2 Problem Analysis	3 Design & Development	4 Analysis, Design, Research	5 Modern Tool Usage	6 Society & Culture	7 Environment & Sustainability	8 Ethics	9 Individual & Team Work	10 Communication	11 Project Mgt. & Finance	12 Life Long Learning	13 PSO - 1	14 PSO - 2	15 PSO –3
CLO-1 :	*Appreciate the need for desalination and realise the theoretical limitations. Estimate minimum energy requirement based on colligative properties and second law of thermodynamics.*	3	80	75	H	M				M		L					H		
CLO-2 :	*know the basic principles, philosophy and process flow-sheet of RO and thermal desalination processes*	2	75	70	H	M	M										H	M	M
CLO-3 :	*Relate environmental parameters, process requirement, use requirements and economics for final system selection*	2	75	70	H	H	H	M		M	H	L	L				H		
CLO-4 :	*Have awareness about the renewable sources, their limitation and their utilization for desalination*	1	90	80	H	H		M		H	M	L					H	M	L
CLO-5 :	*Realise challenges of the technology and develop new systems for desalination such as forward osmosi/membrane distillation.*	2	80	60	M	H	M										H		
CLO-6	*Select appropriate desalination system depending upon the environment*	2	75	65	H	M	M	H		H	M						H	M	M

Duration (hour)		9	9	9	9	9
S1	SLO-1	*Global and Indian Water Scenario: need for desalination*	*Pressure driven membrane processes- comparative characteristics -structure- operational -applications- transport mechanisms*	*Design and operational aspects of brackish water desalination plants.*	*Post treatment of Thermal plant product / why and how?*	*Comparative analysis of desalination processes – energy, feed quantity, pretreatment , product quality etc.*
S2	SLO 1	*Structural properties of water, solution properties, classification natural water, variation of seawater composition with depth and latitude.*	*Role of UF and NF in water treatment & Desalination*	*Basic components of Thermal desalination – Basic properties of steam – saturated / unsaturated / superheated steam and their applications – definition and meaning of Performance Ratio.*	*Electro-dialysis – process description- membrane characteristics – EDR - limitations – energy consumption – lack of energy recovery*	*Scale up characteristics of Desalination plants / comparative aspects on operational aspects.*
S3	SLO 1	*Types of contaminants in water – Brackish water and industrial water - anthropogenic and geogenic contaminants. Conventional methods of water treatment*	*Fundamentals of reverse osmosis desalination process -transport equations.*	*Variation of Seawater properties such as BPE, boiling point, specific heat etc. with temperature, pressure Corrosion aspects with reference hot seawater*	*Membrane distillation- process philosophy for desalination – type of membranes. VMD, AGMD, DCMD*	*Cost elements membrane based desalination plants / optimization approach – recovery/product quality*
S4	SLO-1	*Meaning and description of desalination - Basic elements of Desalination Energy requirements*	*Basic flow sheet of RO desalination – role of each subsystem.- basic terms Solute rejection/ percent recovery / membrane water flux*	*Flashing / boiling distinction – single effect evaporation – purpose & function of evaporator / condenser. Why PR is <1 for single effect*	*Forward osmosis for desalination – process principles – membranes used- osmotic pouches – challenges & limitations*	*Cost elements of thermal plant using steam – optimization with respect overall cost*
S5	SLO-1	*Meaning of thermodynamic minimum energy requirement- estimation through colligative properties*	*Pretreatment need for RO – unit operation and processes used – Scaling potential -monitoring of pretreatment performance – SDI- ORP*	*Why and how of seawater pretreatment – Scaling potential Why multistage / multi-effect – process requirement: vacuum systems (ejectors), demisters – pumps/limitation of top temperature.*	*Low temperature distillation – waste heat – advantages & limitations – ocean thermal energy desalination – energy consumption – unique features. - example*	*Cost elements and analysis of low temperature desalination systems / opportunity costs / sustainability criteria*

S6	SLO-1	*Concept of Exergy – energy of mixing /de-mixing. Estimation of minimum energy at practical situations.*	*Description of membrane – membrane element – module – array - selection of membrane configuration – performance features. Membrane arrangement – staggered configuration – Staging/Passing*	*MSF – description of the process flowsheet- heat recovery / reject /brine heater: explanation of each sub system. Once through and recirculation systems*	*Solar based desalination systems – solar distillation – solar thermal systems – solar PV -RO*	*Environmental issues – Environmental impact analysis of thermal / membrane desalination plants.*
S7	SLO-1	*Classification of desalination processes based on energy source / driving forces etc.- Basic features*	*Performance characteristics of as a function of temperature, pressure and salinity*	*MED – description – process flowsheet- parallel /series feed flow systems*	*Dual purpose plants – advantages – applications*	*Selection of desalination system – Approach*
S8	SLO 1	*Membrane – definition- types of membranes -*	*High Pressure pump features and selection. Energy recovery systems.*	*Vapor – compression Thermo vapor compression / mechanical vapor compression - specific features*	*hybrid Desalination – meaning and purpose – thermal- RO , NF -RO*	*Case study - for drinking water / industrial grade water*
S9	SLO 1	*Asymmetric/homogenous- membrane preparation techniques and characteristics Membrane configuration/ comparative features*	*Post treatment – need and methods – cleaning in place*	*Comparative features of all the thermal processes – capacity, maintenance, energy / cooling water requirements etc.*	*Design considerations for inland brackish water reverse osmosis plants*	*Challenging desalination systems – freeze desalination – humidification – dehumidification systems*

Learning Resource	1. *H.T. El-Dessouky, H.M. Ettouney, Fundamentals of salt water Desalination , Elsevier 2002*

Learning Assessment											
	Bloom's Level of Thinking	Continuous Learning Assessment (50% weightage)								Final Examination (50% weightage)	
		CLA – 1 (10%)		CLA – 2 (15%)		CLA – 3 (15%)		CLA – 4 (10%)#			
		Theory	Practice	Theory	Practice	Theory	Practice	Theory	Practice	Theory	Practice
Level 1	Remember Understand	40 %	-	30 %	-	30 %	-	30 %	-	30%	-
Level 2	Apply Analyze	40 %	-	40 %	-	40 %	-	40 %	-	40%	-
Level 3	Evaluate Create	20 %	-	30 %	-	30 %	-	30 %	-	30%	-
	Total	100 %		100 %		100 %		100 %		100 %	

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1. *Mr. A. Subramaniam, PESCO Beam Environmental Solutions Pvt. Ltd.,*	1. *1. Dr. Lima Rose Miranda, Anna University, email: limamiranda2007@gmail.com*	1. *Dr. S. Prabhakar SRM Inst. of Science & Technology, sivaprabha50@gmail.com*
2. *Mr. S. T. Kalaimani, CPCL, Chennai*	2. *2. Dr. T. R. Sundararaman, Rajalakshmi Engineering College*	

Course Code	18CHE363T	Course Name	AIR POLLUTION CONTROL ENGINEERING	Course Category	E	PROFESSIONAL ELECTIVE	L	T	P	C
							3	0	0	3

Pre-requisite Courses	NIL	Co-requisite Courses	NIL	Progressive Courses	NIL
Course Offering Department	Chemical Engineering	Data Book / Codes/Standards	NIL		

Course Learning Rationale (CLR):	*The purpose of learning this course is to:*
CLR-1 :	*Understand the effect of pollution on human health and the necessity to control the pollutants*
CLR-2 :	*Know how to measure the concentration of the pollutants by models and experiments.*
CLR-3 :	*Different types of pollutants available and their control*
CLR-4 :	*Know how Know how to Control the Oxides of Sulphur, Nitrogen*
CLR-5 :	*Analyze the Effect of Pollutants on Atmosphere*
CLR-6 :	*Realize the effect of pollutants on living things, Control of Pollutants*

Course Learning Outcomes (CLO):	*At the end of this course, learners will be able to:*	Learning 1 Level of Thinking (Bloom)	Learning 2 Expected Proficiency (%)	Learning 3 Expected Attainment (%)	PLO 1 Engineering Knowledge	2 Problem Analysis	3 Design & Development	4 Analysis, Design, Research	5 Modern Tool Usage	6 Society & Culture	7 Environment & Sustainability	8 Ethics	9 Individual & Team Work	10 Communication	11 Project Mgt. & Finance	12 Life Long Learning	13 PSO - 1	14 PSO - 2	15 PSO –3
CLO-1 :	*Understand the effect of pollution on human health and the necessity to control the pollutants*	*1*	*80*	*75*						*H*	*H*		*H*	*H*		*M*	*H*	*M*	*M*
CLO-2 :	*Know how to measure the concentration of the pollutants by models and experiments.*	*1*	*75*	*70*	*M*	*M*	*H*	*H*			*H*			*M*			*H*	*M*	*H*
CLO-3 :	*Different types of pollutants available and their control*	*2*	*75*	*70*	*M*	*M*	*H*	*H*		*H*	*H*		*H*			*M*	*H*	*M*	*M*
CLO-4 :	*Know how Know how to Control the Oxides of Sulphur, Nitrogen*	*2*	*80*	*75*	*M*		*H*	*M*		*H*	*H*			*M*		*M*	*H*	*M*	*M*
CLO-5 :	*Analyze the Effect of Pollutants on Atmosphere*	*2*	*80*	*75*	*M*			*H*		*H*	*H*					*M*	*H*	*M*	*M*
CLO-6 :	*Will be able to analyse the effect of pollutants,Types of pollutants,Contolling of pollutants*	*1*	*75*	*70*	*H*	*H*	*H*	*H*		*H*	*H*						*H*	*M*	*M*

Duration (hour)		9	9	9	9	9
S-1	SLO-1	*Introduction to Air pollution Control : History of Air pollution control : Dirty Air removal or Emission control*	*Air pollution measurements, Emission Estimates : Representative Samples, Concentration determination*	*General ideas in Air Pollution Control: Minimizing Volumetric Flow rate and pressure drop – Efficiency, Penetration, Decontamination factor*	*CONTROL OF OXIES OF SULPHUR, NITROGEN AND HYDROCARBONS, CARBON DI OXIDE*	*EFFECT OF AIR POLLUTANT TO ATMOTSPHERE*
S-2	SLO-1	*History of Air pollution control: One Problem or Family of Problems ? Emission, Transport, Receptors Units and Standards*	*Standard Analytical Methods, Emission factor, Visible emission*	*Homogeneous and Non homogeneous Pollutants, Volume and Composition of Combustion Products*	*Control of Volatile Organic Compounds (VOC): Vapour Pressure, Equilibrium Vapour Content, Evaporation , VOCs, Control Alternatives*	*The motor Vehicle Problem : Overview of the problem of Air Pollution from Motor Vehicles, Internal Combustion Engines,*
S-3	SLO-1	*Air pollution effects : Effect of Air pollution on Human Health Animal Experiments, Regulations to protect Human Health*	*Meteorology for Air pollution Control Engineers : Horizontal Atmospheric motion, Vertical Atmospheric Motion,*	*The nature of Particulate Pollutants : Primary and Secondary Particulates*	*Vapour Pressure, Equilibrium Vapour Content, Evaporation , VOCs, Control Alternatives*	*The motor Vehicle Problem : Overview of the problem of Air Pollution from Motor Vehicles, Internal Combustion Engines,*
S-4	SLO-1	*Effect on Property Effect on Visibility*	*Wind velocity and direction, Temperature Inversions, Fumigations, Stagnations*	*Settling Velocity and Drag forces, Paricle Size Distribution Functions, Behavior of Particles in the Atmosphere*	*Control of Sulfur Oxides : Overview of Sulphur Problem, Removal of reduced Sulphur Compounds from Petroleum and Natural Gas streams*	*Diesel Engines, Gas Turbine Engines*
S-5	SLO-1	*Air pollution Control Laws and regulations*	*Air pollutant Concentration Models: Fixed – Box Models,*	*Control of Primary Particulates : Wall Collection devices, Dividing Collection Devices*	*Control of Sulfur Oxides : Overview of Sulphur Problem, Removal of reduced Sulphur Compounds from Petroleum and Natural Gas streams*	*Diesel Engines, Gas Turbine Engines*
S-6	SLO-1	*Air pollution Control Laws and regulations*	*Diffusion Model*	*Control of Primary Particulates : Wall Collection devices, Dividing Collection Devices*	*Removal of Sulphur dioxide from Rich, Lean Waste Gases Alternatives to "Burn and Then Scrub"*	*Air pollutants and Global Climate : Global Warming,*
S-7	SLO-1	*Air pollution control Philosophies : The Emission Standard Philosophy, Advantages and Disadvantages*	*Long Term Average Uses of Gaussian Plume Models*	*Control of Primary Particulates : Wall Collection devices, Dividing Collection Devices*	*Control of Nitrogen Oxides : Overview of Nitrogen Oxides Problem*	*Air pollutants and Global Climate : Global Warming,*

S-8	SLO-1	*Air pollution control Philosophies. The Air Quality Standard Philosophy, Advantages and Disadvantages*	*Multiple Cell Models, R*	*Control of Primary Particulates : Wall Collection devices, Dividing Collection Devices*	*Control of Nitrogen Oxides : Overview of Nitrogen Oxides Problem*	*Stratospheric Ozone Depletion and Chloroflurocarbons, Acid rains*
S-9	SLO-1	*Emission Tax Philosophy, Cost benefit Philosophy*	*Receptor – Oriented and Source Oriented Air pollution Models*	*Control of Primary Particulates : Wall Collection devices, Dividing Collection Devices*	*Control of Nitrogen Oxide Emissions*	*Indoor Air Pollution : Indoor and outdoor Concentrations, Models, Control of Indoor Air Quality*

Learning Resources	1. *Noel De Nevers "Air Pollution Control Engineering" Internationa Editions 1995 MaGraw – Hill,Inc* 2. *Bhartia.S.C "Environmental Pollution and Control in Chemical Process Industries"* 3. *Perry and Chilton (Editors) "Perry's Chemical Engineer's Hand book*

Learning Assessment

	Bloom's Level of Thinking	Continuous Learning Assessment (50% weightage)								Final Examination (50% weightage)	
		CLA – 1 (10%)		CLA – 2 (15%)		CLA – 3 (15%)		CLA – 4 (10%)#			
		Theory	Practice	Theory	Practice	Theory	Practice	Theory	Practice	Theory	Practice
Level 1	Remember Understand	40 %	-	30 %	-	30 %	-	30 %	-	30%	-
Level 2	Apply Analyze	40 %	-	40 %	-	40 %	-	40 %	-	40%	-
Level 3	Evaluate Create	20 %	-	30 %	-	30 %	-	30 %	-	30%	-
	Total	100 %		100 %		100 %		100 %		100 %	

CA – 4 can be from any combination of these: Assignments, Seminars, Tech Talks, Mini-Projects, Case-Studies, Self-Study, MOOCs, Certifications, Conf. Paper etc.,

Course Designers

Experts from Industry	Experts from Higher Technical Institutions	Internal Experts
1. *Mr. A. Subramaniam, PESCO Beam Environmental Solutions Pvt. Ltd.,*	1. *Dr. Lima Rose Miranda, Anna University, email: limamiranda2007@gmail.com*	1. *Dr. B. Karunanithi, SRMIST karunan@srmist.edu.in*
2. *Mr. S. T. Kalaimani, CPCL, Chennai*	2. *Dr. T. R. Sundararaman, Rajalakshmi Engineering College*	

Course Code	18CHE364T	Course Name	FINE CHEMICALS TECHNOLOGY	Course Category	E	PROFESSIONAL ELECTIVE	L	T	P	C
							3	0	0	3

Pre-requisite Courses	NIL	Co-requisite Courses	NIL	Progressive Courses	NIL
Course Offering Department	Chemical Engineering	Data Book / Codes/Standards	NIL		

Course Learning Rationale (CLR):	*The purpose of learning this course is to:*
CLR-1 :	*Understand the basic fundamentals of drug chemistry*
CLR-2 :	*Learn the various chemical reactions involved in drug formulation*
CLR-3 :	*Exposure on basic concepts and principles of drug production techniques*
CLR-4 :	*Impart the knowledge of various parameters involved in the formulation and development of various dosage forms*
CLR-5 :	*Familiarize the concept of the pharmaceutical industrial manufacturing practices*
CLR 6 :	*Learn the quality aspects in Pharmaceutical industry*

Course Learning Outcomes (CLO):	*At the end of this course, learners will be able to:*	Learning 1	Learning 2	Learning 3	PLO 1	PLO 2	PLO 3	PLO 4	PLO 5	PLO 6	PLO 7	PLO 8	PLO 9	PLO 10	PLO 11	PLO 12	PLO 13	PLO 14	PLO 15
		Level of Thinking (loom)	Expected Proficiency (%)	Expected Attainment (%)	Engineering Knowledge	Problem Analysis	Design & Development	Analysis, Design, Research	Modern Tool Usage	Society & Culture	Environment & Sustainability	Ethics	Individual & Team Work	Communication	Project Mgt. & Finance	Life Long Learning	PSO - 1	PSO - 2	PSO –3
CLO-1 :	*Identify the basic concept of drug formulation and their importance in Pharmaceutical Industry*	2	90	85	L	L	M	L			M		M			M	H	L	L
CLO-2 :	*Recognize the different types of reactions involved in bulk drug production*	2	80	75	L	L	M	M			M		L			M	L	M	L
CLO-3 :	*Review the techniques involved in production of drugs*	2	80	80	M	L	M	L			M		M			M	L	H	L
CLO-4 :	*Implement the methods for drug development*	3	75	70	M	L	M	M			M		M			M	L	H	M
CLO-5 :	*Investigate the production planning, scheduling and quality management*	4	80	75	M	M	H	L			M		M			M	L	M	M
CLO 6:	*Understand the importance of quality attributes of pharmacy products*	3	80	75	L	L	M	L			H		M			M	L	L	H

Duration (hour)		9	9	9	9	9
S-1	SLO-1	*Overview of fine chemicals and bulk drugs*	*Production of fine chemicals*	*Bulk drug production*	*Overview of drug Formulation and Pre-formulation development*	*Overview of production plants*
	SLO-2	*Characteristic features of fine chemicals manufacture*	*Unit operations involved in production*	*Selection of Raw materials for bulk drugs production*	*Solid and Semi-solid dosage forms*	*Types of production plants*
S-2	SLO-1	*Catalysis in fine chemistry*	*Chemical conversion processes for drug formulation*	*Various Bulk drugs*	*Tablet formulation techniques*	*Dedicated and multipurpose plants*
	SLO-2	*Selectivity Engineering*	*Alkylation- reactions involved*	*Production Techniques*	*Compressed tablets*	*Mixed plants*
S-3	SLO-1	*Process development*	*Drug production by Carboxylation*	*Reaction for bulk drugs*	*Capsules*	*Equipments in multipurpose plants-Reactors*
	SLO-2	*Separation methods, Production plants*	*Caboxylation –reactions and process*	*Flow Sheet for bulk drugs*	*Capsules*	*filters ,centrifuges*
S-4	SLO-1	*Concept of fine drugs*	*Condensation*	*bulk drug production*	*Polymers and Powder formulation*	*Driers, extractors*
	SLO-2	*Bulk drugs and their manufacture*	*Cyclisation*	*Equipments for bulk drug production*	*Milling process*	*evaporators*
S-5	SLO-1	*Evolution of process*	*Dehydration*	*Paracetamol*	*Granulation Techniques –Wet Granulation*	*Production cost*
	SLO-2	*Process selection: process profile analysis*	*Esterification*	*Aspirin*	*Dry Granulation*	*capital investment costs, operating costs*
S-6	SLO-1	*Factors influencing Process choice*	*Halogenation*	*Ibuprofen,*	*Coating techniques in drugs*	*Batch process*
	SLO-2	*cleaner and safer technologies*	*Reaction and process involved*	*Diazepam*	*Coating techniques in drugs*	*Designing of batch plants.*
S-7	SLO-1	*waste minimization*	*Oxidation*	*Darvon*	*Topical formulation*	*production planning*
	SLO-2	*The role of catalysis in waste minimization*	*Sulfonation*	*Niacinamide*	*cutaneous and Inhaled*	*production planning*
S-8	SLO-1	*Research in pharmaceutical Industries*	*Complex Chemical conversions*	*Chloramphenicol*	*Polymeric nanoparticles formulation methods*	*Production scheduling*
	SLO-2	*Development strategies in pharmaceutical Industries*	*Complex Chemical conversions*	*Erythromycin*	*Targeting*	*Production scheduling*
S-9	SLO-1	*Basic drug formulation*	*Industrial Fermentation products*	*Antimicrobial agent*	*Microparticles*	*Principles of good manufacturing practices*
	SLO-2	*Radiopharmaceuticals*	*Industrial Fermentation products*	*Antimicrobial agent*	*Microparticles synthesis for drug delivery system*	*Quality control*

Learning Resources	1. *AndrzejCybulski , Jacob A. Moulijn , M.M. Sharma , Roger A. Sheldon "Fine Chemicals Manufacture: Technology and Engineering" Elseiver ScienceB.V,2001* 2. *Rawlins E.A, Bentleys Text Book of Pharmaceutics, A.I.T.B.S.Publisher& Distributors, Delhi, 1996* 3. *B.M. Mithal., "A textbook of Pharmaceutical formulation", published by vallabhprakashan, 15th reprint 2013, ISBN 81-85731-04-7*	3. *Rebecca A.Bader, David., "Engineering Polymer systems for improved drug" Wiley publication, December 2013, ISBN: 979-1-118-09847-9* 4. *Shah, K.M., "Hand Book of Industrial Chemistry", Vol. I and II, Multi-Tech Publishing Co, 1999*

Learning Assessment											
	Bloom's Level of Thinking	Continuous Learning Assessment (50% weightage)								Final Examination (50% weightage)	
		CLA – 1 (10%)		CLA – 2 (15%)		CLA – 3 (15%)		CLA – 4 (10%)#			
		Theory	Practice	Theory	Practice	Theory	Practice	Theory	Practice	Theory	Practice
Level 1	Remember Understand	40 %	-	30 %	-	30 %	-	30 %	-	30%	-
Level 2	Apply Analyze	40 %	-	40 %	-	40 %	-	40 %	-	40%	-
Level 3	Evaluate Create	20 %	-	30 %	-	30 %	-	30 %	-	30%	-
	Total	100 %		100 %		100 %		100 %		100 %	

CA – 4 can be from any combination of these: Assignments, Seminars, Tech Talks, Mini-Projects, Case-Studies, Self-Study, MOOCs, Certifications, Conf. Paper etc.,

Course Designers		
Experts from Industry	Experts from Higher Technical Institutions	Internal Experts
1. Mr. A. Subramaniam, PESCO Beam Environmental Solutions Pvt. Ltd.,	*1. Dr. Lima Rose Miranda, Anna University, email: limamiranda2007@gmail.com*	*1. Ms. S. Kiruthika SRM Inst. of Science & Technology, kiruthika. s @ktr.srmuniv.ac.in*
2. Mr. S. T. Kalaimani, CPCL, Chennai	*2. Dr. T. R. Sundararaman, Rajalakshmi Engineering College*	*2. Dr. P. Muthamilselvi SRM Inst. of Science & Technology, muthamilselvi.p@ktr.srmuniv.ac.in*

Course Code	18CHE365T	Course Name	WASTE WATER TREATMENT	Course Category	E	Professional Elective	L	T	P	C
							3	0	0	3

Pre-requisite Courses	NIL	Co-requisite Courses	NIL	Progressive Courses	NIL
Course Offering Department	Chemical Engineering	Data Book / Codes/Standards	NIL		

Course Learning Rationale (CLR):	*The purpose of learning this course is to:*
CLR-1 :	*study characteristic of waste water*
CLR-2 :	*Familiarize the different conventional wastewater treatment methods*
CLR-3 :	*Introduce students to the unit operations and processes used in the advanced treatment of wastewater.*
CLR-4 :	*Pollution control methods used in a few typical chemical process industries*
CLR-5 :	*Learn issues involved in water reduce, recover and reuse*
CLR-6:	*Get wholesome knowledge of water treatment processes*

Course Learning Outcomes (CLO):	*At the end of this course, learners will be able to:*	Learning 1: Level of Thinking (loom)	Learning 2: Expected Proficiency (%)	Learning 3: Expected Attainment (%)	PLO 1: Engineering Knowledge	PLO 2: Problem Analysis	PLO 3: Design & Development	PLO 4: Analysis, Design, Research	PLO 5: Modern Tool Usage	PLO 6: Society & Culture	PLO 7: Environment & Sustainability	PLO 8: Ethics	PLO 9: Individual & Team Work	PLO 10: Communication	PLO 11: Project Mgt. & Finance	PLO 12: Life Long Learning	PLO 13: PSO - 1	PLO 14: PSO - 2	PLO 15: PSO –3
CLO-1 :	*Examine various characteristic of waste water*	*4*	*80*	*75*	*H*			*M*			*M*					*M*	*H*		
CLO-2 :	*Understand the different conventional treatment process*	*2*	*80*	*70*	*H*			*M*			*M*					*M*			*H*
CLO-3 :	*Review the advanced wastewater treatment process*	*2*	*80*	*75*	*H*			*M*			*M*					*M*	*H*		*H*
CLO-4 :	*Understand the block diagram of various industrial effluent treatment*	*2*	*80*	*75*	*H*			*M*			*M*					*M*	*H*		*M*
CLO-5 :	*Understand the different concept of reduce, recover and reuse of waste water*	*2*	*80*	*75*	*M*			*H*			*M*					*M*	*H*		*M*
CLO-6:	*To select appropriate water treatment system to conserve water*	*2*	*80*	*70*	*H*			*H*			*H*						*H*		*H*

Duration (hour)		9	9	9	9	9
S-1	SLO-1	*Waste water sources*	*Philosophy of waste treatment*	*Aim of the advanced wastewater Treatment*	*Water treatment in chemical process industries*	*Volume reduction – concept of water recovery*
	SLO-2	*Industrial waste water*	*Preliminary treatment process*	*Types of advanced wastewater Treatment*	*Characteristics of pulp and paper industry waste water*	*Volume reduction: recycle*
S-2	SLO-1	*Agricultural waste water*	*Primary treatment :- screens filters process*	*Removal of suspended solid*	*Pulp and paper industry waste water treatment process*	*Concept of common effluent treatment plants*
	SLO-2	*Domestic waste water*	*Primary treatment: gravity settling process*	*Coagulation process*	*Characteristics of fertilizer industry waste water*	*Concept of common effluent treatment plants*
S-3	SLO-1	*Quantum of waste water produced by industries*	*Secondary treatment - Aerobic treatment process*	*Flocculation process*	*Fertilizer industry waste water treatment process*	*Philosophy of waste treatment*
	SLO-2	*Comparison of world and Indian scenario*	*Activated sludge treatment process*	*Removal of dissolved solids*	*Physio chemical characteristics of tannery effluent*	*Conventional dilute & disperse*
S-4	SLO-1	*Assessment of waste water composition*	*Different types of activated sludge process*	*Ion exchange treatment process*	*Chrome treat process*	*current philosophy treat and dispose*
	SLO-2	*Types of water pollutants*	*Biological processes in activated sludge process*	*Osmosis and reverse osmosis process*	*Overview of tannery effluent treatment*	*Future philosophy; recover and reuse*
S-5	SLO-1	*Water pollutants effects*	*Attached growth aerobic processes*	*Electro dialysis process*	*Characteristics of petroleum refinery waste water*	*Wealth from waste*
	SLO-2	*waste water sampling*	*Tricking filters process*	*Removal of nitrogen compound in water*	*Overview of refinery effluent treatment*	*Value recovery – need for value recovery*
S-6	SLO-1	*Waste water analysis*	*Rotating biological contactors*	*Phosphate removal from waste water*	*Characteristics of petrochemical effluent*	*Water conservation*
	SLO-2	*Determination of organic content: BOD,COD,DO*	*Anaerobic treatment process*	*Removal of dissolved organic compounds*	*Petrochemical effluent treatment process*	*Types of reuse waste water*
S-7	SLO-1	*Determination of inorganic content*	*Design of Anaerobic digester*	*Adsorption process*	*Characteristics of sugar industry waste water*	*Zero Liquid Discharge*
	SLO-2	*Determination of carbonate ions*	*Mechanism of anaerobic degradation*	*Different membrane processes*	*Overview of sugar effluent treatment process*	*Zero Liquid Discharge*
S-8	SLO-1	*Determination of alkalinity*	*Sludge Treatment: Volume Reduction*	*Membrane treatment: MF, UF and NF*	*Physio chemical characteristics of distilleries effluent*	*Regulations for treatment*

	SLO-2	*Determination of TSS and TDS*	*Sludge Treatment - Dewatering; Sludge drying; Composting*	*Different types of dis infection process*	*Distilleries industry waste water treatment process*	*ALARA concept*
S-9	SLO-1	*Determination of physical characteristics*	*Sludge Treatment: Fluidized bed incineration*	*Dis infection: chlorination process*	*Characteristics of textile industry waste water*	*Pollution control board regulations*
	SLO-2	*Determination of bacteriological measurements*	*Sludge Disposal methods*	*Dis infection: chlorination process uv-treatment*	*Overview of textile effluent treatment process*	*Pollution control board regulations*

Learning Resources	1. *Rao C.S., Environmental Pollution Control Engineering, Wiley Eastern Limited, 1991* 2. *Eldridge, E.F, "Industrial Waste Treatment Practice", McGraw-Hill Book Company, Inc., New York, NY, 1942* 3. *Metcalf & Eddy, "Wastewater Engineering Treatment and Reuse", 4th Edn., Tata McGraw-Hill Publishing Company, New Delhi, 2003*

Learning Assessment

	Bloom's Level of Thinking	Continuous Learning Assessment (50% weightage)								Final Examination (50% weightage)	
		CLA – 1 (10%)		CLA – 2 (15%)		CLA – 3 (15%)		CLA – 4 (10%)#			
		Theory	Practice	Theory	Practice	Theory	Practice	Theory	Practice	Theory	Practice
Level 1	Remember Understand	40 %	-	30 %	-	30 %	-	30 %	-	30%	-
Level 2	Apply Analyze	40 %	-	40 %	-	40 %	-	40 %	-	40%	-
Level 3	Evaluate Create	20 %	-	30 %	-	30 %	-	30 %	-	30%	-
	Total	100 %		100 %		100 %		100 %		100 %	

CA – 4 can be from any combination of these: Assignments, Seminars, Tech Talks, Mini-Projects, Case-Studies, Self-Study, MOOCs, Certifications, Conf. Paper etc.,

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2. *Mr. S. T. Kalaimani, CPCL, Chennai*	2. *Dr. T. R. Sundararaman, Rajalakshmi Engineering College*	2. *Dr. K. Tamilarasan SRM Inst. of Science & Technology, tamilarasan.k@srmuniv.ac.in*

Course Code	18CHE366T	Course Name	CHEMICAL PROCESS OPTIMIZATION	Course Category	E	PROFESSIONAL ELECTIVES	L	T	P	C
							3	0	0	3

Pre-requisite Courses	NIL	Co-requisite Courses	NIL	Progressive Courses	NIL
Course Offering Department	Chemical Engineering	Data Book / Codes/Standards	Nil		

Course Learning Rationale (CLR):	*The purpose of learning this course is to:*
CLR-1 :	*understand the basic concepts of optimization*
CLR-2 :	*introduce the optimization methods for multivariable functions*
CLR-3 :	*familiarize the single variable function optimization*
CLR-4 :	*introduce the linear programming method and unconstrained optimization*
CLR-5 :	*understand the optimization methods in chemical process*
CLR-6:	*understand optimization techniques for types of functions, linear programming method, unconstrained optimization and optimization of chemical process*

Course Learning Outcomes (CLO):	*At the end of this course, learners will be able to:*	Learning 1: Level of Thinking (loom)	Learning 2: Expected Proficiency %)	Learning 3: Expected Attainment (%)	PLO 1: Engineering Knowledge	PLO 2: Problem Analysis	PLO 3: Design & Development	PLO 4: Analysis, Design, Research	PLO 5: Modern Tool Usage	PLO 6: Society & Culture	PLO 7: Environment & Sustainability	PLO 8: Ethics	PLO 9: Individual & Team Work	PLO 10: Communication	PLO 11: Project Mgt. & Finance	PLO 12: Life Long Learning	PLO 13: PSO - 1	PLO 14: PSO - 2	PLO 15: PSO –3
CLO-1 :	*remember and recollect the basic concepts of optimization*	2	85	75	H	H	H	H									H	H	L
CLO-2 :	*apply methods for multivariable function optimization*	3	75	70		H	H	H	M								H	M	L
CLO-3 :	*understand the single variable function optimization*	3	85	75	M	H	H	H	M								H	L	L
CLO-4 :	*Solve linear programming and unconstrained optimization problems*	3	85	75		H	H	H	M								H	L	L
CLO-5 :	*calculate optimized conditions for chemical processes*	3	85	75	H	H	H	H	M								L	H	H
CLO-6 :	*calculate optimized variables for different functions, solve linear programming problems and optimized conditions for real chemical processes*	3	85	75	H	H	H	H	M								H	H	L

Duration (hour)		9	9	9	9	9
S-1	SLO-1	*Need for optimization*	*Unimodal and multi modal functions*	*Optimization of unconstrained functions*	*Concept and applications of linear programming*	*Heat transfer and energy conservation*
	SLO-2	*Hierarchy of levels of optimization*	*Unconstrained multivariable optimization*	*Newton method of uni – dimensional search*	*Geometry of linear programming problems*	*Optimizing recovery of waste heat*
S-2	SLO-1	*Applications and essential features of optimization problems*	*Random search method grid search method*	*Quasi-newton method*	*Standard form for linear programs*	*Optimal design of a distillation column*
	SLO-2	*Statement of an optimization problem*	*Univariate search*	*Problems based on newton and quasi – newton method*	*Basic linear programming definitions*	*Optimal design of a distillation column*
S-3	SLO-1	*Terms used in optimization*	*Simplex search method nelder – mead method*	*Problems based on newton and quasi – newton method*	*Equivalent systems and elementary operations*	*Optimal pipe diameter*
	SLO-2	*Classification of optimization problems*	*Hooke-jeeves procedure*	*Problems based on newton and quasi – newton method*	*Concept of pivoting and use of pivot operations*	*Optimal pipe diameter*
S-4	SLO-1	*Formulation of the objective functions*	*Steepest descent method*	*Quadratic interpolation method*	*Simplex method for linear programming problems*	*Minimum work of compression*
	SLO-2	*Problem based on objective function formation*	*Steepest descent method*	*Quadratic interpolation method*	*Simplex method for linear programming problems*	*Minimum work of compression*
S-5	SLO-1	*Necessary and sufficient conditions for optimum*	*Conjugate gradient method*	*Cubic interpolation method*	*Problem based on simplex method*	*Modeling chemical reactors*
	SLO-2	*Steps to solve optimization problems*	*Conjugate gradient method*	*Cubic interpolation method*	*Problem based on simplex method*	*Classification of reactors*
S-6	SLO-1	*Problems based on analytical optimization methods*	*Problems based on conjugate gradient method*	*Problems based on cubic and quadratic interpolation method*	*Integer programming method*	*Objective functions for reactors*
	SLO-2	*Problems based on analytical optimization methods*	*Problems based on conjugate gradient method*	*Problems based on cubic and quadratic interpolation method*	*Graphical solution for integer linear programming*	*Objective functions for reactors*
S-7	SLO-1	*Problems based on analytical optimization methods*	*Newton's method*	*Problems based on cubic and quadratic interpolation method*	*Geometric programming method – unconstrained minimization*	*Process simulators and optimization codes*

	SLO-2	*Problems based on analytical optimization methods*	*Problem solving based on newton's method*	*Problems based on cubic and quadratic interpolation method*	*Geometric programming method – unconstrained minimization*	*Process simulators and optimization codes*
S-8	SLO-1	*Classification of models and mathematical forms of models*	*Quasi – newton method*	*Fibonacci method*	*Dynamic programming method*	*Optimization using equation-based process simulators*
	SLO-2	*Classification of models and mathematical forms of models*	*Lagrange multiplier method*	*Fibonacci method*	*Dynamic programming method*	*Optimization using equation-based process simulators*
S-9	SLO-1	*Selecting functions to fit empirical data*	*Problems based on lagrange multiplier method*	*Golden section method*	*Quadratic programming method*	*Optimization using modular-based simulators*
	SLO-2	*Fitting models by least squares*	*Problems based on lagrange multiplier method*	*Golden section method*	*Quadratic programming method*	*Optimization using modular-based simulators*

Learning Resources	1. Thomas F. Edgar, David M. Himmelblau, Leon S. Lasdon, "Optimization of Chemical Processes", 2nd edition, McGraw-Hill Higher Education, 2001. 2. Singiresu S. Rao, "Engineering Optimization: Theory and Practice", 4th edition, John Wiley & Sons, Inc., 2009.

Learning Assessment

	Bloom's Level of Thinking	Continuous Learning Assessment (50% weightage)								Final Examination (50% weightage)	
		CLA – 1 (10%)		CLA – 2 (15%)		CLA – 3 (15%)		CLA – 4 (10%)#			
		Theory	Practice	Theory	Practice	Theory	Practice	Theory	Practice	Theory	Practice
Level 1	Remember Understand	40 %	-	30 %	-	30 %	-	30 %	-	30%	-
Level 2	Apply Analyze	40 %	-	40 %	-	40 %	-	40 %	-	40%	-
Level 3	Evaluate Create	20 %	-	30 %	-	30 %	-	30 %	-	30%	-
	Total	100 %		100 %		100 %		100 %		100 %	

CA – 4 can be from any combination of these: Assignments, Seminars, Tech Talks, Mini-Projects, Case-Studies, Self-Study, MOOCs, Certifications, Conf. Paper etc.,

Course Designers

Experts from Industry	Experts from Higher Technical Institutions	Internal Experts
1. Mr. A. Subramaniam, PESCO Beam Environmental Solutions Pvt. Ltd.,	*1. Dr. Lima Rose Miranda, Anna University, email: limamiranda2007@gmail.com*	*1. Dr. M. Magesh Kumar SRM Inst. of Science & Technology, mageshkm@srmist.edu.in*
2. Mr. S. T. Kalaimani, CPCL, Chennai	*2. Dr. T. R. Sundararaman, Rajalakshmi Engineering College*	*2. Dr. S. Vishali SRM Inst. of Science & Technology, vishalis@srmist.edu.in*

Course Code	18CHE367T	Course Name	EQUILIBRIUM STAGE OPERATIONS	Course Category	E	Professional elective	L	T	P	C
							3	0	0	3

Pre-requisite Courses	18CHC303T	Co-requisite Courses	Nil	Progressive Courses	Nil
Course Offering Department	Chemical Engineering	Data Book / Codes/Standards	Nil		

Course Learning Rationale (CLR):	*The purpose of learning this course is to*
CLR-1 :	*Understand fundamental concepts of equilibrium-governed separation processes*
CLR-2 :	*Understand the cascade configurations in chemical process systems*
CLR-3 :	*Acquire knowledge of concepts involved in absorption and distillation*
CLR-4 :	*Acquire knowledge of liquid-liquid extraction and solid-liquid extraction operations*
CLR-5 :	*Understand principles of adsorption and its applications*
CLR-6:	*Understand the concepts underlying equilibrium stage operations in chemical engineering*

Course Learning Outcomes (CLO):	*At the end of this course, learners will be able to:*	Learning 1 Level of Thinking (loom)	Learning 2 Expected Proficiency %)	Learning 3 Expected Attainment (%)	PLO 1 Engineering Knowledge	PLO 2 Problem Analysis	PLO 3 Design & Development	PLO 4 Analysis, Design, Research	PLO 5 Modern Tool Usage	PLO 6 Society & Culture	PLO 7 Environment & Sustainability	PLO 8 Ethics	PLO 9 Individual & Team Work	PLO 10 Communication	PLO 11 Project Mgt. & Finance	PLO 12 Life Long Learning	PLO 13 PSO - 1	PLO 14 PSO - 2	PLO 15 PSO –3
CLO-1 :	*Explain various equilibrium governed separation processes*	2	80	75	H			M									H		
CLO-2 :	*Analyze cascade configurations for multicomponent separations*	2	75	70	H			M									H		
CLO-3 :	*Perform calculations for absorption and distillation columns*	2	75	75	H	M		M									H	M	
CLO-4 :	*Perform calculations for extraction systems and compare various configurations*	2	80	75	H	H	L	M									H	M	
CLO-5 :	*Perform adsorption bed related calculations*	2	75	70	H		H	M									H	M	
CLO-6:	*Understand and perform calculations in equilibrium stage operations*	2	75	70	H	M	M	M									H	M	

Duration (hour)		9	9	9	9	9
S-1	SLO-1	*Overview of different separation processes*	*Typical cascade configurations*	*Equilibrium in a gas-liquid system*	*Liquid-liquid extraction*	*Adsorption, isotherms*
	SLO-2	*Overview of separation processes*	*Hybrid systems*	*Equilibrium in a gas-liquid system*	*Liquid-liquid extraction*	*Isotherms*
S-2	SLO-1	*Characteristics of separation processes*	*General approach to analysis of equilibrium governed operations*	*Stage calculations for absorption and stripping*	*Solvent selection*	*Equilibrium considerations in adsorption*
	SLO-2	*Types of separating agents*	*General approach to analysis of equilibrium governed operations*	*Examples*	*Solvent selection*	*Equilibrium considerations in adsorption*
S-3	SLO-1	*Separation factors*	*General approach to analysis of equilibrium governed operations*	*Batch distillation-binary and multicomponent mixtures*	*Ternary phase diagrams*	*Kinetic and transport considerations*
	SLO-2	*Practice session for separation factors based problems*	*Examples*	*Batch distillation-binary and multicomponent mixtures*	*Problem solving*	*Kinetic and transport considerations*
S-4	SLO-1	*Sequence of separations*	*Mass transfer in stage-wise contact of two phases*	*Continuous multistage distillation of binary mixtures*	*Single stage*	*Adsorption in a fixed bed*
	SLO-2	*Examples*	*Mass transfer in stage-wise contact of two phases*	*Examples*	*Problem solving*	*Adsorption in a fixed bed*
S-5	SLO-1	*Heuristics for separation schemes*	*Mass transfer in stage-wise contact of two phases*	*Multiple feed and product withdrawal*	*Multistage single section cascades*	*Design calculations of fixed bed adsorption*
	SLO-2	*Examples*	*Examples*	*Problem solving*	*Multistage single section cascades*	*Design calculations of fixed bed adsorption*
S-6	SLO-1	*Review of thermodynamics principles, phase equilibrium*	*Stage Calculations for cocurrent, cascades*	*Multicomponent distillation*	*Design calculations*	*Design calculations of fixed bed adsorption*
	SLO-2	*Ideal and non-ideal solutions, activity coefficients*	*Problem solving*	*Key components*	*Problem solving*	*Design calculations of fixed bed adsorption*
S-7	SLO-1	*Simple equilibrium processes*	*Crosscurrent cascades*	*Approximate Methods- fenske-underwood – gilliland method*	*Solid-liquid extraction*	*Problem solving*
	SLO-2	*Single equilibrium stage*	*Crosscurrent cascades*	*Problem solving*	*Solid-liquid extraction*	*Problem solving*
S-8	SLO-1	*Checking phase condition of a mixture*	*Countercurrent Cascades*	*Enhanced distillation- extractive distillation*	*Rate of solid-liquid extraction*	*Ion-exchange*
	SLO-2	*Examples*	*Problem solving*	*Azeotropic distillation, reactive distillation*	*Rate of solid-liquid extraction*	*Ion-exchange*
S-9	SLO-1	*Flash calculations*	*Kremser equation*	*Residue-curve maps*	*Supercritical fluid extraction*	*Chromatography*
	SLO-2	Binary and multicomponent systems flash equations	Problem solving	Residue-curve maps	Supercritical fluid extraction	Chromatography

Learning Resources	1. *Principles of Mass Transfer and Separation Processes, PHI Learning Pvt. Ltd. 2007* 2. *J. D. Seader, Ernest J. Henley, D. Keith Roper, Separation process principles : chemical and biochemical operations, 3rd edn, 2011*

Learning Assessment											
	Bloom's Level of Thinking	Continuous Learning Assessment (50% weightage)								Final Examination (50% weightage)	
		CLA – 1 (10%)		CLA – 2 (15%)		CLA – 3 (15%)		CLA – 4 (10%)#			
		Theory	Practice	Theory	Practice	Theory	Practice	Theory	Practice	Theory	Practice
Level 1	Remember Understand	40 %	-	30 %	-	30 %	-	30 %	-	30%	-
Level 2	Apply Analyze	40 %	-	40 %	-	40 %	-	40 %	-	40%	-
Level 3	Evaluate Create	20 %	-	30 %	-	30 %	-	30 %	-	30%	-
	Total	100 %		100 %		100 %		100 %		100 %	

CA – 4 can be from any combination of these: Assignments, Seminars, Tech Talks, Mini-Projects, Case-Studies, Self-Study, MOOCs, Certifications, Conf. Paper etc.,

Course Designers		
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2. *Mr. S. T. Kalaimani, CPCL, Chennai*	2. *Dr. T. R. Sundararaman, Rajalakshmi Engineering College*	2. *Dr. K. Suresh SRM Inst. of Science & Technology, sureshk@srmist.edu.in*

Course Code	18CHE368T	Course Name	COMPUTATIONAL FLUID DYNAMICS	Course Category	E	Professional Elective	L	T	P	C
							3	0	0	3

Pre-requisite Courses	18CHC205T 18CHC207T	Co-requisite Courses	Nil	Progressive Courses	Nil
Course Offering Department	Chemical Engineering	Data Book / Codes/Standards		Nil	

Course Learning Rationale (CLR):	The purpose of learning this course is to:
CLR-1 :	*Discretize the conservation law equations*
CLR-2 :	*Solve the conservation equations by numerical techniques*
CLR-3 :	*Understand fundamentals underlying Computational fluid dynamic simulations*
CLR-4 :	*Understand the flow and temperature field in engineering problems*
CLR-5 :	*Learn to assess the quality of numerical results*
CLR-6 :	*Acquire knowledge to solve computational fluid dynamics related problems*

Course Learning Outcomes (CLO):	At the end of this course, learners will be able to:	Learning 1: Level of Thinking (loom)	Learning 2: Expected Proficiency %)	Learning 3: Expected Attainment (%)	PLO 1: Engineering Knowledge	PLO 2: Problem Analysis	PLO 3: Design & Development	PLO 4: Analysis, Design, Research	PLO 5: Modern Tool Usage	PLO 6: Society & Culture	PLO 7: Environment & Sustainability	PLO 8: Ethics	PLO 9: Individual & Team Work	PLO 10: Communication	PLO 11: Project Mgt. & Finance	PLO 12: Life Long Learning	PLO 13: PSO - 1	PLO 14: PSO - 2	PLO 15: PSO –3
CLO-1 :	*Appreciate role and importance of CFD and learn underlying fundamental principles*	2	80	75	H				L										
CLO-2 :	*Understand CFD solution methodologies, sources of error*	2	75	70	H	M			L										
CLO-3 :	*Apply discretization using Finite difference method approach*	2	75	75	H			L										H	
CLO-4 :	*Apply discretization using Finite volume method approach*	2	80	75	H			L									H		
CLO-5 :	*Apply discretization using Finite difference element approach, TDMA*	2	75	70	H			L											M
CLO-6 :	*Apply computational knowledge in solving transport processes related problems in chemical engineering*	2	75	70	H	M	L	L	L								H	H	M

Duration (hour)		9	9	9	9	9
S-1	SLO-1	*Introduction to CFD*	*CFD solution procedure*	*Types of PDEs*	*Finite volume method introduction*	*Finite element method introduction*
	SLO-2	*Applications*	*CFD solution procedure*	*Examples*		
S-2	SLO-1	*CFD solution strategies*	*Physical and computational domains*	*Solution using discretization scheme*	*General representation form of conservation equation*	*Concept of weighted residual approach*
	SLO-2	*CFD solution strategies*	*Physical and computational domains*	*Examples*	*Physical meaning*	*Concept of weighted residual approach*
S-3	SLO-1	*Vector and calculus review for fluid dynamics*	*Boundary conditions*	*Finite difference methods*	*Finite volume method procedure of discretization*	*FEM method of discretization*
	SLO-2	*Derivation and physical meaning of substantial derivative*	*Boundary conditions examples*	*Forward, backward and central difference schemes*	*Finite volume method procedure of discretization*	*FEM method of discretization*
S-4	SLO-1	*Introduction to tensors*	*Types of mesh*	*Converting derivatives to algebraic equations*	*Implementation of boundary conditions-temperature and heat flux*	*FEM application for 1D steady state heat conduction*
	SLO-2	*Problem solving*	*mesh quality parameters*	*Converting derivatives to algebraic equations*	*Examples*	*Problem solving*
S-5	SLO-1	*Types of models*	*Solver settings*	*Converting mixed derivatives to algebraic equations*	*1-D steady state heat conduction with source*	*Implementation of boundary conditions*
	SLO-2	*Types of models*	*Convergence*	*Graphical representation*	*Examples*	*Problem solving*
S-6	SLO-1	*Continuity equation derivation based on different models*	*Types of error*	*General approach to difference equations for uniform grid*	*FVM: 1-D steady state diffusion equation problem without source*	*Solution of system of linear algebraic equations*
	SLO-2	*Derivation*	*Types of error*	*Examples*	*FVM*	*Solution of system of linear algebraic equations*
S-7	SLO-1	*Problem solving*	*Sources of error*	*Polynomial approach for finite difference equations*	*1-D convection and diffusion*	*Tridiagonal matrix algorithm*
	SLO-2	*Problem solving*	*Sources of error*	*Illustrative examples*	*Examples*	*Tridiagonal matrix algorithm*
S-8	SLO-1	*Momentum balance*	*Post processing*	*Implementation of boundary conditions*	*Problem solving*	*Problem solving*
	SLO-2	*Momentum balance*	*Post processing*	*Merits and limitations of FDM*	*Problem solving*	*Problem solving*
S-9	SLO-1	*Navier Stokes equation*	*Examples of CFD solutions*	*Problem solving*	*Problem solving*	*Problem solving*
	SLO-2	*Navier Stokes equation*	*Problem solving*	*Problem solving*	*Problem solving*	*Problem solving*

Learning Resources	1. *H. K. Versteeg and W. Malalasekera, An introduction to computational fluid dynamics – The finite volume method, Longman Group Ltd 1995.* 2. *J.H. Ferziger and M. Peric, Computational Methods for Fluid Dynamics, Springer, 2002.* 3. *Tu, Jiyuan, Guan-Heng Yeoh, and Chaoqun Liu. Computational fluid dynamics: a practical approach. Butterworth-Heinemann, 2018.*

Learning Assessment											
	Bloom's Level of Thinking	Continuous Learning Assessment (50% weightage)								Final Examination (50% weightage)	
		CLA – 1 (10%)		CLA – 2 (15%)		CLA – 3 (15%)		CLA – 4 (10%)#			
		Theory	Practice	Theory	Practice	Theory	Practice	Theory	Practice	Theory	Practice
Level 1	Remember Understand	40 %	-	30 %	-	30 %	-	30 %	-	30%	-
Level 2	Apply Analyze	40 %	-	40 %	-	40 %	-	40 %	-	40%	-
Level 3	Evaluate Create	20 %	-	30 %	-	30 %	-	30 %	-	30%	-
	Total	100 %		100 %		100 %		100 %		100 %	

CA – 4 can be from any combination of these: Assignments, Seminars, Tech Talks, Mini-Projects, Case-Studies, Self-Study, MOOCs, Certifications, Conf. Paper etc.,

Course Designers		
Experts from Industry	Experts from Higher Technical Institutions	Internal Experts
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2. *Mr. S. T. Kalaimani, CPCL, Chennai*	2. *Dr. T. R. Sundararaman, Rajalakshmi Engineering College*	2. *Dr. K. Suresh SRM Inst. of Science & Technology, sureshk@srmist.edu.in*

Course Code	18CHE369T	Course Name	BIOCHEMICAL PROCESS DESIGN	Course Category	E	Professional Elective	L	T	P	C
							3	0	0	3

Pre-requisite Courses	Nil	Co-requisite Courses	Nil	Progressive Courses	Nil
Course Offering Department	Chemical Engineering	Data Book / Codes/Standards	Nil		

Course Learning Rationale (CLR):	*The purpose of learning this course is to:*
CLR-1 :	*Understand the basic configuration, accessories and types of bioreactor*
CLR-2 :	*Understand the scale-up criteria for bioreactors*
CLR-3:	*Learn the different control requirements of a bioreactor*
CLR-4 :	*Understand the different methods of product recovery and purification*
CLR-5 :	*Understand the process of synthesis of various bioproducts*
CLR-6 :	*Understand the operation of bioreactors*

Course Learning Outcomes (CLO):	*At the end of this course, learners will be able to:*	Learning 1: Level of Thinking (Bloom)	Learning 2: Expected Proficiency (%)	Learning 3: Expected Attainment (%)	PLO 1: Engineering Knowledge	PLO 2: Problem Analysis	PLO 3: Design & Development	PLO 4: Analysis, Design, Research	PLO 5: Modern Tool Usage	PLO 6: Society & Culture	PLO 7: Environment & Sustainability	PLO 8: Ethics	PLO 9: Individual & Team Work	PLO 10: Communication	PLO 11: Project Mgt. & Finance	PLO 12: Life Long Learning	PLO 13: PSO - 1	PLO 14: PSO - 2	PLO 15: PSO –3
CLO- 1 :	*Select the required bioreactor for a given process*	*3*	*80*	*75*	*M*	*L*	*L*	*L*			*M*						*M*		*M*
CLO-2 :	*Formulate the scale-up of bioreactor in industrial processes*	*3*	*75*	*70*	*M*	*M*	*M*	*M*									*M*		*M*
CLO-3 :	*Comprehend the different types of instruments and controllers used in bioprocess industries*	*2*	*75*	*70*	*M*		*M*	*L*	*M*		*M*						*M*		
CLO-4 :	*Analyze the various stages of product recovery*	*4*	*80*	*75*	*H*	*M*	*M*	*M*	*M*		*M*						*M*	*H*	*M*
CLO-5 :	*Appreciate the industrial scale synthesis of various bioproducts*	*3*	*75*	*70*	*H*	*H*	*H*	*H*	*M*		*H*						*M*	*M*	*M*
CLO-6 :	*Apply the knowledge of reactor design for novel products/processes*	*3*	*75*	*70*	*M*	*M*	*M*	*M*	*M*		*M*						*M*	*M*	*M*

Duration (hour)		9	9	9	9	9
S-1	SLO-1	*Introduction to Bioreactors*	*Biochemical reactor scale-up*	*Instrumentation control of bioreactors*	*Product recovery operation*	*Industrial bioprocess technology*
	SLO-2	*Basic principle of bioreactor*	*Transport phenomena in Bioprocess systems*	*Measurement of physical and chemical parameters in bioreactors*	*Separation of biomolecules*	*Aerobic processes*
S-2	SLO-1	*Components of bioreactor*	*Gas-liquid mass transfer*	*Bioreactor sensor s for temperature control*	*Cell disruption for release of products*	*Production of citric acid*
	SLO-2	*Classification and configuration of bioreactors*	*Determination of oxygen transfer rates*	*Principles of dissolved oxygen measurement and control*	*Cell disruption for release of products*	*Production of penicillin*
S-3	SLO-1	*Analysis of batch bioreactors*	*Measurement of* k_La	*Principles of pH control*	*Mechanical methods of cell disruption*	*Anaerobic bioprocesses*
	SLO-2	*Analysis of batch bioreactors*	*Measurement of* k_La	*Principles of redox measurement and control*	*Enzymatic methods of cell disruption*	*Anaerobic bioprocesses*
S-4	SLO-1	*Analysis of continuous flow bioreactors*	*Key dimensionless groups*	*On-line sensors*	*Chemical methods of cell disruption*	*Production of ethanol*
	SLO-2	*Analysis of continuous flow bioreactors*	*Correlations for mass transfer co-efficients and interfacial area*	*Off-line analytical methods*	*Cells and solid particle separation*	*Production of lactic acid*
S-5	SLO-1	*Analysis of fed-batch bioreactors*	*Overall* k_La *estimates and power requirement for sparged and agitated vessels*	*Measurement of medium properties*	*Filtration*	*Acetone-butanol production*
	SLO-2	*Design of novel biochemical reactors*	*Overall* k_La *estimates and power requirement for sparged and agitated vessels*	*Analysis of cell population composition*	*Filtration*	*Production of biopolymers*
S-6	SLO-1	*Operation of novel biochemical reactors*	*Heat transfer*	*Prevention of foam*	*Centrifugation*	*Production of Xanthan gum*
	SLO-2	*Air-lift loop reactors*	*Heat transfer correlations*	*Determination of biomass*	*Centrifugation*	*Production of Xanthan gum*
S-7	SLO-1	*Fluidized bed biochemical reactors*	*Scaling of mass transfer equipment*	*Application of biosensors*	*Product isolation*	*Production of PHB*
	SLO-2	*Immobilized enzyme reactors*	*Scaling of mass transfer equipment*	*Application of biosensors*	*Product isolation*	*Production of PHB*
S-8	SLO-1	*Design of immobilized enzyme reactors*	*Regime analysis of Biochemical reactor processes*	*Design and operation strategies for batch operation*	*Adsorption*	*Production of single cell protein*
	SLO-2	*Packed bed reactors*	*Regime analysis of Biochemical reactor processes*	*Design and operation strategies for batch operation*	*Liquid-liquid extraction*	*Production of single cell protein*
S-9	SLO-1	*Fluidized bed reactors*	*Scale-up criteria for bioreactors based on oxygen transfer and power consumption*	*Continuous process control*	*Product purification- Chromatography*	*Production of vinegar*
	SLO-2	*Membrane reactors*	*Scale-up criteria for bioreactors based on oxygen transfer and power consumption*	*Continuous process control*	*Product purification- Chromatography*	*Production of vinegar*

Learning Resources	1. Bailey, J.E. and Ollis, D.F. *"Biochemical Engineering Fundamentals"*, 2nd edition, McGraw– Hill, 1988. 2. Peter F. Stanbury, Allan Whitaker, *"Principles of Fermentation Technology"*, 2nd edition, Butterworth – Heinemann (an imprint of Elsevier), 1995. 3. Shuler, M.L. and Kargi, F. *"Bioprocess Engineering: Basic Concepts"*, 2nd edition, PHI, 2002.

Learning Assessment											
	Bloom's Level of Thinking	Continuous Learning Assessment (50% weightage)								Final Examination (50% weightage)	
		CLA – 1 (10%)		CLA – 2 (15%)		CLA – 3 (15%)		CLA – 4 (10%)#			
		Theory	Practice	Theory	Practice	Theory	Practice	Theory	Practice	Theory	Practice
Level 1	Remember Understand	40 %	-	30 %	-	30 %	-	30 %	-	30%	-
Level 2	Apply Analyze	40 %	-	40 %	-	40 %	-	40 %	-	40%	-
Level 3	Evaluate Create	20 %	-	30 %	-	30 %	-	30 %	-	30%	-
	Total	100 %		100 %		100 %		100 %		100 %	

CA – 4 can be from any combination of these: Assignments, Seminars, Tech Talks, Mini-Projects, Case-Studies, Self-Study, MOOCs, Certifications, Conf. Paper etc.,

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Course Code	18CHE370T	Course Name	MICROCHEMICAL SYSTEMS	Course Category	E	Professional Elective	L	T	P	C
							3	0	0	3

Pre-requisite Courses	18CHC205T	Co-requisite Courses	NIL	Progressive Courses	NIL
Course Offering Department	Chemical Engineering	Data Book / Codes/Standards	NIL		

Course Learning Rationale (CLR):	*The purpose of learning this course is to*
CLR-1 :	*Concept of lab-on-a-chip and its significance and relevance*
CLR-2 :	*Fundamental transport processes relevant to micro scale devices*
CLR-3 :	*Acquire knowledge of various microfabrication methods and relevant material science*
CLR-4 :	*Get a basic knowledge of design, simulation, and experimental methods at microscale*
CLR-5 :	*Get exposure to wide range of applications of microchemical systems*
CLR-6 :	*Get basic understanding of engineering principles related to microchemical systems*

		Learning			Program Learning Outcomes (PLO)														
		1	2	3	1	2	3	4	5	6	7	8	9	10	11	12	13	14	15
Course Learning Outcomes (CLO):	*At the end of this course, learners will be able to:*	Level of Thinking (loom)	Expected Proficiency (%)	Expected Attainment (%)	Engineering Knowledge	Problem Analysis	Design & Development	Analysis, Design, Research	Modern Tool Usage	Society & Culture	Environment & Sustainability	Ethics	Individual & Team Work	Communication	Project Mgt. & Finance	Life Long Learning	PSO - 1	PSO - 2	PSO –3
CLO-1 :	*Understand lab on chip concept and importance*	*2*	*80*	*75*	*H*		*L*	*M*	*H*									*M*	
CLO-2 :	*Understand principles of engineering applicable at microscale*	*2*	*75*	*70*	*H*		*M*										*H*		
CLO-3 :	*Understand various methods of fabrication and materials for designing microdevices*	*2*	*75*	*75*	*H*		*H*	*M*										*M*	
CLO-4 :	*Understand fundamentals of design, simulation and experimental approaches for microscale systems*	*2*	*80*	*75*	*H*	*M*	*H*											*M*	
CLO-5 :	*Appreciate wide variety of applications possible with microchemical systems*	*2*	*75*	*70*	*M*		*M*	*M*	*H*										*H*
CLO-6 :	*Understand principles of microchemical systems*	*2*	*75*	*70*	*H*	*M*	*M*	*M*	*H*								*H*	*M*	*H*

Duration (hour)		9	9	9	9	9
S-1	SLO-1	*Concept of lab-on-a-chip and microfluidics*	*Principles in microfluidics*	*Microfabrication techniques*	*Concepts and approach from design to realization*	*Miniaturized chemical systems*
	SLO-2	*Concept of lab-on-a-chip and microfluidics*	*Principles in microfluidics*	*Microfabrication techniques*	*Concepts and approach from design to realization*	*Miniaturized chemical systems*
S-2	SLO-1	*Origins and motivation*	*Navier-stokes equation at microscale*	*Conventional methods*	*Tools for design*	*Microreactors*
	SLO-2	*Origins and motivation*	*Navier-stokes equation at microscale*	*Origins*	*Tools for design*	*Microreactors examples*
S-3	SLO-1	*Advantages, limitations, interdisciplinary approach*	*Multiphase flows*	*Photolithography*	*Tools for modeling and simulation*	*Process intensification principles*
	SLO-2	*Advantages, limitations, interdisciplinary approach*	*Multiphase flows*	*Photolithography*	*Tools for modeling and simulation*	*Process intensification examples*
S-4	SLO-1	*Range of applications- basic sciences*	*Capillary action*	*Micromachining*	*Examples of design and simulation*	*Point-of-care devices: principles*
	SLO-2	*Range of applications- basic sciences*	*Capillary action*	*Micromachining*	*Examples of design and simulation*	*Point-of-care devices: examples*
S-5	SLO-1	*Range of applications- applied areas of science and engineering*	*Mixing at microscale and*	*Etching*	*Experimental methods at microscale*	*Sensors*
	SLO-2	*Range of applications- applied areas of science and engineering*	*Mixing at microscale and*	*Etching*	*Experimental methods at microscale*	*Sensors for environmental quality monitoring*
S-6	SLO-1	*Scale out approach*	*Enhancing mixing*	*Soft lithography fundamentals*	*Experimental methods: components pumps*	*Biomedical diagnostics principles*
	SLO-2	*Scale out approach*	*Enhancing mixing*	*Soft lithography fundamentals*	*Experimental methods: valves*	*Biomedical diagnostics examples*
S-7	SLO-1	*Commercialized technologies*	*Separations at microscale*	*Soft lithography applications*	*Measurements at microscale, pressure, flow rate,*	*Energy generation devices*
	SLO-2	*Commercialized technologies*	*Separations at microscale*	*Soft lithography applications*	*Measurements at microscale, pressure, flow rate,*	*Micro fuel cells*
S-8	SLO-1	*Challenges*	*Heat transfer in microchannels,*	*Alternative fabrication strategies*	*Temperature measurements*	*Integrated systems principles*
	SLO-2	*Challenges*	*Heat transfer in microchannels,*	*Unconventional fabrication*	*Temperature measurements*	*Integrated systems examples*
S-9	SLO-1	*Opportunities*	*Numerical problems*	*Materials in fabrication: traditional*	*Analytical techniques*	*Biomimetics*
	SLO-2	*Opportunities*	*Examples*	*Materials in fabrication: emerging*	*Analytical techniques examples*	*Biomimetics*

Learning Resources	1. *Kirby, B.J., Micro- and Nanoscale Fluid Mechanics: Transport in Microfluidic Devices, Cambridge University Press, 2010.* 2. *Nguyen, N. T., Werely, S. T., Fundamentals and applications of Microfluidics, Artech house Inc., 2002* 3. *Madou, M. J., Fundamentals of Microfabrication, CRC press, 2002.*

Learning Assessment

	Bloom's Level of Thinking	Continuous Learning Assessment (50% weightage)								Final Examination (50% weightage)	
		CLA – 1 (10%)		CLA – 2 (15%)		CLA – 3 (15%)		CLA – 4 (10%)#			
		Theory	Practice	Theory	Practice	Theory	Practice	Theory	Practice	Theory	Practice
Level 1	Remember Understand	40 %	-	30 %	-	30 %	-	30 %	-	30%	-
Level 2	Apply Analyze	40 %	-	40 %	-	40 %	-	40 %	-	40%	-
Level 3	Evaluate Create	20 %	-	30 %	-	30 %	-	30 %	-	30%	-
	Total	100 %		100 %		100 %		100 %		100 %	

CA – 4 can be from any combination of these: Assignments, Seminars, Tech Talks, Mini-Projects, Case-Studies, Self-Study, MOOCs, Certifications, Conf. Paper etc.,

Course Designers

Experts from Industry	Experts from Higher Technical Institutions	Internal Experts
1. Mr. A. Subramaniam, PESCO Beam Environmental Solutions Pvt. Ltd.,	*1. Dr. Lima Rose Miranda, Anna University, email: limamiranda2007@gmail.com*	*1. Dr. Ashish Kapoor SRM Inst. of Science & Technology, ashishko@srmist.edu.in*
2. Mr. S. T. Kalaimani, CPCL, Chennai	*2. Dr. T. R. Sundararaman, Rajalakshmi Engineering College*	

Course Code	18CHE371T	Course Name	ELECTROCHEMICAL ENGINEERING	Course Category	E	Professional Elective	L	T	P	C
							3	0	0	3

Pre-requisite Courses	NIL	Co-requisite Courses	NIL	Progressive Courses	NIL
Course Offering Department	Chemical Engineering	Data Book / Codes/Standards	NIL		

Course Learning Rationale (CLR):	*The purpose of learning this course is to:*	Learning			Program Learning Outcomes (PLO)														
CLR-1 :	*Understand the concept of electrochemistry*	1	2	3	1	2	3	4	5	6	7	8	9	10	11	12	13	14	15
CLR-2 :	*Acquire knowledge on electrochemical processes*																		
CLR-3 :	*Understand the concepts of corrosion and its types*																		
CLR-4 :	*Application of electrochemical concepts on environmental issues*																		
CLR-5 :	*Use of different electrodes and reactors in electrochemical reactor design*																		
CLR -6:	*Expose to the importance of electrochemical process on chemical industries*																		
Course Learning Outcomes (CLO):	*At the end of this course, learners will be able to:*	Level of Thinking (loom)	Expected Proficiency %)	Expected Attainment (%)	Engineering Knowledge	Problem Analysis	Design & Development	Analysis, Design, Research	Modern Tool Usage	Society & Culture	Environment & Sustainability	Ethics	Individual & Team Work	Communication	Project Mgt. & Finance	Life Long Learning	PSO - 1	PSO - 2	PSO –3
CLO-1 :	*Derive the relation between emf and rate of reaction*	*2*	*80*	*70*	*M*	*L*	*L*	*L*			*M*		*M*			*M*	*L*	*L*	*L*
CLO-2 :	*Analyze the mass transfer operations in electrochemical process*	*2*	*80*	*70*	*H*	*H*	*H*	*M*			*M*		*H*			*M*	*L*	*M*	*L*
CLO-3 :	*Relate the corrosion phenomenon with electrochemical reactions*	*2*	*75*	*65*	*M*	*L*	*M*	*M*			*H*		*M*			*H*	*L*	*M*	*M*
CLO-4 :	*Able to use electrochemical energy for environmental issues*	*3*	*80*	*75*	*H*	*H*	*H*	*M*			*H*		*H*			*H*	*M*	*L*	*M*
CLO-5 :	*Ability to design the electrochemical reactor*	*3*	*80*	*70*	*H*	*H*	*H*	*H*			*H*		*H*			*H*	*M*	*H*	*H*
CLO-6:	*Design electrochemical process for industrial concerns*	*3*	*70*	*60*	*H*	*H*	*M*	*L*			*H*		*M*			*M*	*L*	*M*	*M*

Duration (hour)		9	9	9	9	9
S-1	SLO-1	*Course introduction*	*Mass transfer in electrochemical systems:*	*Derivation of potential current relations of activities controlled and diffusion controlled corrosion process.*	*Electro deposition*	*Electrodes used in different electrochemical industries*
	SLO-2	*Review basics of electrochemistry*	*Mass transfer in electrochemical systems:*	*Derivation of potential current relations of activities controlled and diffusion controlled corrosion process.*	*Electro deposition*	*Electrodes used in different electrochemical industries*
S-2	SLO-1	*Faraday's law, nernst potential*	*Diffusion controlled electrochemical reaction*	*Potential-ph diagram*	*Electro refining*	*Metals-graphite –lead dioxide –titanium substrate insoluble electrodes*
	SLO-2	*Faraday's law, nernst potential*	*Diffusion controlled electrochemical reaction*	*Potential-ph diagram*	*Electro refining*	*Metals-graphite –lead dioxide –titanium substrate insoluble electrodes*
S-3	SLO-1	*Galvanic cells*	*Importance of convention*	*Forms of corrosion*	*Electroforming*	*Iron oxide –semi conducting type etc.*
	SLO-2	*Galvanic cells*	*Importance of convention*			
S-4	SLO-1	*Polarography*	*Importance of the concept of limiting current*	*Definition, factors and control methods of various forms of corrosion*	*Electro polishing*	*Metal finishing-cell design.*
	SLO-2	*Polarography*	*Importance of the concept of limiting current*	*Definition, factors and control methods of various forms of corrosion*	*Electro polishing*	*Metal finishing-cell design*
S-5	SLO-1	*Electrical double layer*	*Over potential*	*Corrosion control measures industrial boiler water corrosion control*	*Anodizing*	*Types of electrochemical reactors*
	SLO-2	*Electrical double layer*	*Over potential*	*Corrosion control measures industrial boiler water corrosion control*	*Anodizing*	*Types of electrochemical reactors*
S-6	SLO-1	*Role of electrical double layer in electrochemical processes*	*Primary-secondary current distribution*	*Protective coatings*	*Selective solar coatings*	*Batch cell, fluidized bed electrochemical reactor*
	SLO-2	*Role of electrical double layer in electrochemical processes*	*Primary-secondary current distribution*	*Protective coatings*	*Selective solar coatings*	*Batch cell, fluidized bed electrochemical reactor*
S-7	SLO-1	*Electro capillary curve*	*rotating disc electrode*	*Vapor phase inhibitors*	*Primary and secondary batteries*	*filter press cell, Swiss roll cell*

	SLO-2	*Electro capillary curve*	*rotating disc electrode*	*Vapor phase inhibitors*	*Primary and secondary batteries*	*filter press cell, Swiss roll cell*
S-8	SLO-1	*Helmholtz layer*	*Corrosion*	*cathodic protection*	*types of batteries*	*plug flow cell, design equation,*
	SLO-2	*Helmholtz layer*	*Corrosion*	*cathodic protection*	*types of batteries*	*plug flow cell, design equation,*
S-9	SLO-1	*Guoy, Steven's layer, fields at the interface*	*Introduction to corrosion, series and corrosion theories*	*sacrificial anodes –Paint removers*	*Fuel cells*	*Figures of merits of different type of electro chemical reactors.*
	SLO-2	*Guoy, Steven's layer, fields at the interface*	*Introduction to corrosion, series and corrosion theories*	*sacrificial anodes –Paint removers*	*Fuel cells*	*Figures of merits of different type of electro chemical reactors.*

Learning Resources	1. *Picket, "Electrochemical Engineering ", Prentice Hall. 1977.* 2. *Newman, J. S., "Electrochemical systems ", Prentice Hall, 1973.*	3. *Barak, M. and Stevenge, U. K., " Electrochemical Power Sources – Primary and Secondary Batteries" 1980* 4. *Mantell, C. "Electrochemical Engineering ", McGraw Hill, 1972.*

Learning Assessment

	Bloom's Level of Thinking	Continuous Learning Assessment (50% weightage)								Final Examination (50% weightage)	
		CLA – 1 (10%)		CLA – 2 (15%)		CLA – 3 (15%)		CLA – 4 (10%)#			
		Theory	Practice	Theory	Practice	Theory	Practice	Theory	Practice	Theory	Practice
Level 1	Remember Understand	40 %	-	30 %	-	30 %	-	30 %	-	30%	-
Level 2	Apply Analyze	40 %	-	40 %	-	40 %	-	40 %	-	40%	-
Level 3	Evaluate Create	20 %	-	30 %	-	30 %	-	30 %	-	30%	-
	Total	100 %		100 %		100 %		100 %		100 %	

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Experts from Industry	Experts from Higher Technical Institutions	Internal Experts
1. *1. Mr. A. Subramaniam, PESCO Beam Environmental Solutions Pvt. Ltd.,*	1. *Dr. Lima Rose Miranda, Anna University, email: limamiranda2007@gmail.com*	1. *Dr. S. Sam David SRM Inst. Of Science and Technology samdavid@srmist.edu.in*
2. *2. Mr. S. T. Kalaimani, CPCL, Chennai*	2. *Dr. T. R. Sundararaman, Rajalakshmi Engineering College*	2. *Dr. K. Deepa SRM Inst. Of Science and Technology*

Course Code	18CHE372T	Course Name	PETROCHEMICAL TECHNOLOGY	Course Category	E	Professional Elective	L	T	P	C
							3	0	0	3

Pre-requisite Courses	NIL	Co-requisite Courses	NIL	Progressive Courses	NIL
Course Offering Department	Chemical Engineering	Data Book / Codes/Standards	NIL		

Course Learning Rationale (CLR):	*The purpose of learning this course is to:*
CLR-1 :	*Expose to the importance petrochemical products and feedstock*
CLR-2 :	*Application of different resource for basic petrochemical synthesis process*
CLR-3 :	*Learn the various second generation petrochemical synthesis process*
CLR-4 :	*Understand the process flow diagram of third generation petrochemical process*
CLR-5 :	*Study process flow diagram for polymers production and application*
CLR-6:	*Learn process flow for Agrochemicals and Pharmaceuticals products*

Course Learning Outcomes (CLO):	*At the end of this course, learners will be able to:*	Learning 1: Level of Thinking (loom)	Learning 2: Expected Proficiency %)	Learning 3: Expected Attainment (%)	PLO 1: Engineering Knowledge	PLO 2: Problem Analysis	PLO 3: Design & Development	PLO 4: Analysis, Design, Research	PLO 5: Modern Tool Usage	PLO 6: Society & Culture	PLO 7: Environment & Sustainability	PLO 8: Ethics	PLO 9: Individual & Team Work	PLO 10: Communication	PLO 11: Project Mgt. & Finance	PLO 12: Life Long Learning	PLO 13: PSO - 1	PLO 14: PSO - 2	PLO 15: PSO –3
CLO-1 :	*Analysis the importance of petrochemicals and growth potential of petrochemical industry*	*5*	*85*	*80*	*L*	*L*	*L*	*L*			*H*					*L*	*H*	*H*	*H*
CLO-2 :	*Develop processes for manufacture of basic petrochemicals from hydrocarbon feedstock*	*2*	*85*	*80*	*H*	*L*	*H*	*M*			*M*					*L*	*H*	*L*	*L*
CLO-3 :	*Familiarize to draw flow diagrams of intermediate petrochemicals production processes*	*2*	*80*	*75*	*H*	*L*	*H*	*M*			*M*					*L*	*M*	*M*	*M*
CLO-4 :	*Ability to draw flow diagram for plastic and resin production process*	*2*	*90*	*85*	*H*	*L*	*H*	*M*			*M*					*L*	*M*	*H*	*M*
CLO-5 :	*Familiarize to drawprocess flow diagram for rubber and fibers production process*	*3*	*85*	*80*	*H*	*L*	*H*	*M*			*M*					*L*	*M*	*H*	*M*
CLO-6:	*Design and analysis the production process for agrochemicals and pharmaceuticals products*	*3*	*90*	*85*	*H*	*L*	*H*	*M*			*M*					*L*	*M*	*M*	*H*

Duration (hour)		9	9	9	9	9
S-1	SLO-1	*Definition of petrochemicals*	*Selection of raw material and process for acetylene synthesis*	*Feed stock and process for acrylonitrile synthesis*	*Classification of industrial important polymers*	*Importance of agrochemicals*
	SLO-2	*History of petrochemical industry*	*Process flow for manufacture of acetylene*	*Process flow for manufacture of acrylonitrile*	*Plastics and its classification*	*Classification of agrochemicals*
S-2	SLO-1	*Overview of petrochemical products*	*Feed stock and process for and process for Ethylene synthesis*	*Selection of raw material and process for ethylene derivative synthesis*	*Selection of raw material and process for polyethylene synthesis*	*Selection of raw material and process for DDT synthesis*
	SLO-2	*Importance of petrochemical*	*Process flow for manufacture of ethylene*	*Process flow for production of ethylene oxide*	*Process diagram for polyethylene production*	*Process flow for production of DDT*
S-3	SLO-1	*Structure of petrochemical industry*	*Application of C1 and C2 petrochemical*	*Industrial application of acrylonitrile*	*Industrial application of polyethylene*	*Feed stock and selection process for parathion synthesis*
	SLO-2	*Feedstock selection for petrochemical*	*Selection of raw material and process for propylene synthesis*	*Selection of raw material and process for propylene oxide synthesis*	*Selection of raw material and process for PVC production*	*Process flow for manufacture of parathion*
S-4	SLO-1	*Petrochemicals from petroleum fractions feedstock*	*Process flow for manufacture of propylene*	*Process flow for manufacture of propylene oxide*	*Process block diagram for PVC production*	*Process flow for manufacture of propylene oxide*
	SLO-2	*Petrochemical industry in india*	*Feed stock and process for butadiene synthesis*	*Raw material and process selection for ethylene chloride synthesis*	*Definition of elastomer and types*	*Importance of detergents*
S-5	SLO-1	*Growth potential of petrochemical in India*	*Process flow for manufacture of butadiene*	*Draw flow diagram for manufacture of ethylene chloride*	*Feed stock and process for synthetic rubber synthesis*	*Classification of detergents*
	SLO-2	*Petrochemical socio-economic Linkage*	*Application of C3 and C4 petrochemical*	*Selection of raw material and process for vinyl acetate synthesis*	*Process flow for manufacture of synthetic rubber*	*Feed stock and process for -anionicdetergents synthesis*
S-6	SLO-1	*Source of petrochemicals*	*Industrial important basic aromatics compounds*	*Manufacture of vinyl acetate*	*Industrial important fibers polymers*	*Block diagram for manufacture of anionicdetergents*
	SLO-2	*Classification of petrochemicals*	*Preparation of raw materials and process for aromatic compound synthesis*	*Feed stock and process for vinyl chloride synthesis*	*Raw material and process condition for nylon synthesis*	*Selection of raw material and process for cationic detergents synthesis*

S-7	SLO-1	*Various petrochemical building block*	*Process flow diagram for manufacture of BTX*	*Process flow for manufacture of vinyl chloride*	*Manufacture of nylon*	*Manufacture of cationic detergents*
	SLO-2	*Petrochemical manufacturing involves building blocks processes*	*Application of BTX petrochemicals*	*Industrial application of ethylene and propylene derivative*	*Industrial application of nylon fibers*	*Raw material and process for non-ionic detergents synthesis*
S-8	SLO-1	*Various basic petrochemicals*	*Industrial important Alcohols*	*Feed stock and process for phenol synthesis*	*Feed stock for polyesters synthesis*	*Process flow for manufacture of non-ionic detergents*
	SLO-2	*Intermediate petrochemical products*	*Process flow for manufacture of methanol*	*Process flow for manufacture of phenol*	*Process flow for manufacture of polyesters*	*Classification of carbon black*
S-9	SLO-1	*Major polymer petrochemical products*	*Process flow for manufacture of ethanol*	*Selection of raw material and process for styrene synthesis*	*Synthetic resins- process for phenol formaldehyde synthesis*	*Various methods of carbon black production*
	SLO-2	*Various uses of petrochemical products*	*Application of methanol and ethanol*	*Process flow for manufacture of styrene*	*Block diagram for manufacture of phenol formaldehyde*	*Application carbon black*

Learning Resources	1. *Bhaskara Rao. B.K, "Petrochemicals", Khanna Publishers, New Delhi.* 2. *Gopala Rao. M. and Marshall Sittig, "Dryden's Outlines of Chemical Technology", 3rd Edn., East-West Press, New Delhi, 2008.* 3. *Steiner H. "Introduction to Petroleum Chemicals", Pergammon Press, 1992.*

SLO – Session Learning Outcome

Learning Assessment

	Bloom's Level of Thinking	Continuous Learning Assessment (50% weightage)								Final Examination (50% weightage)	
		CLA – 1 (10%)		CLA – 2 (15%)		CLA – 3 (15%)		CLA – 4 (10%)#			
		Theory	Practice	Theory	Practice	Theory	Practice	Theory	Practice	Theory	Practice
Level 1	Remember Understand	40 %	-	30 %	-	30 %	-	30 %	-	30%	-
Level 2	Apply Analyze	40 %	-	40 %	-	40 %	-	40 %	-	40%	-
Level 3	Evaluate Create	20 %	-	30 %	-	30 %	-	30 %	-	30%	-
	Total	100 %		100 %		100 %		100 %		100 %	

CA – 4 can be from any combination of these: Assignments, Seminars, Tech Talks, Mini-Projects, Case-Studies, Self-Study, MOOCs, Certifications, Conf. Paper etc.,

Course Designers

Experts from Industry	Experts from Higher Technical Institutions	Internal Experts
1. *Mr. A. Subramaniam, PESCO Beam Environmental Solutions Pvt. Ltd.,*	1. *Dr. Lima Rose Miranda, Anna University, email: limamiranda2007@gmail.com*	1. *Dr.K.Tamilarasan SRM Inst. of Science & Technology, tamilarasan.k@srmuniv.ac.in*
2. *Mr. S. T. Kalaimani, CPCL, Chennai*	2. *Dr. T. R. Sundararaman, Rajalakshmi Engineering College*	

Course Code	18CHE373T	Course Name	FOOD TECHNOLOGY	Course Category	E	Professional Elective	L	T	P	C
							3	0	0	3

Pre-requisite Courses	NIL	Co-requisite Courses	NIL	Progressive Courses	NIL
Course Offering Department	Chemical Engineering	Data Book / Codes/Standards	NIL		

Course Learning Rationale (CLR):	The purpose of learning this course is to:
CLR-1 :	*Familiarize general aspects of food industry ,role of chemical engineers in food industry and constituents of food*
CLR-2 :	*Study the unit operations used in food processing*
CLR-3 :	*Know about the food deterioration, preservation and packing method*
CLR-4 :	*Learn the different food products*
CLR-5 :	*Learn about the packing methods and waste disposal*
CLR-6 :	*Production Processing and Preservation of food*

Course Learning Outcomes (CLO):	At the end of this course, learners will be able to:	Learning 1 Level of Thinking (loom)	Learning 2 Expected Proficiency %)	Learning 3 Expected Attainment (%)	PLO 1 Engineering Knowledge	PLO 2 Problem Analysis	PLO 3 Design & Development	PLO 4 Analysis, Design, Research	PLO 5 Modern Tool Usage	PLO 6 Society & Culture	PLO 7 Environment & Sustainability	PLO 8 Ethics	PLO 9 Individual & Team Work	PLO 10 Communication	PLO 11 Project Mgt. & Finance	PLO 12 Life Long Learning	PLO 13 PSO - 1	PLO 14 PSO - 2	PLO 15 PSO –3
CLO-1 :	*Know about the general aspects of food industry ,role of chemical engineers in food industry and constituents of food*	1	80	70	L	M	L	M		L	H	H	L	M			H	L	L
CLO-2 :	*Acquire a knowledge about the different types unit operations used in food processing industry*	1	80	75	M	M	M	M		L	M	M		M			H	M	H
CLO-3 :	*Control the food deterioration by the way of preservation and packing method*	1	80	75	H	H	M	M	M	M	H	M	H	M			H	H	H
CLO-4 :	*Understand the technology involved in different food products*	2	80	70	M	M	M	L		M	H	M	H	M			H	M	H
CLO-5 :	*Apply the knowledge gained to provide suitable packing methods to improve the shelf life of the product and able dispose the waste in properway.*	1	80	75	H	M	M	L	M	M	H	H	M	M			H	H	H
CLO-6 :	*Able to produce process and preserve food products*	1	70	70	H	M	M	M	M	M	H	H	M	M			H	H	M

Duration (hour)		9	9	9	9	9
S-1	SLO-1	*INTRODUCTION Characteristics of food industry and role of Engineers*	*UNIT OPERATION IN FOOD PROCESSING Material handling; Heat exchanging*	*DETERIORATION AND PRESERVATION Deteriorative factors and their control*	*FOOD PRODUCTS Bakery, confectionary and chocolate products*	*PACKING METHODS AND WASTE DISPOSAL Principles of food packaging-*
S-2	SLO-1	*Constituents of food- Carbohydrates, Proteins*	*Heating, Cooling*	*Kinetics of chemical reactions in foods*	*Bakery, confectionary and chocolate products*	*Requirements of effective food packaging,*
S-3	SLO-1	*Constituents of food- Carbohydrates, Proteins*	*Heating, Cooling*	*Preservation by heat and cold*	*Soft and alcoholic beverages*	*Types of containers,*
S-4	SLO-1	*Fats and Oils and additional food constituents*	*Evaporation, Drying*	*Preservation by heat and cold*	*Soft and alcoholic beverages*	*Food packaging materials and forms,*
S-5	SLO-1	*Nutritive aspects of food constituents*	*Evaporation, Drying*	*Dehydration, concentration*	*Dairy products*	*Food packaging materials and forms*
S-6	SLO-1	*Nutritive aspects of food constituents*	*Forming, Packaging, Controlling*	*Dehydration, concentration*	*Dairy products*	*Package testing, Packages with special features.*
S-7	SLO-1	*Food additives*	*Forming, Packaging, Controlling*	*drying*	*Meat, Poultry and fish products*	*Package testing, Packages with special features.*
S-8	SLO-1	*Quality factors in foods and Quality standards*	*Overlapping unit operations*	*Irradiation, Microwave heating*	*Cereal, grains, pulses*	*Factory Hygiene*
S-9	SLO-1	*Quality factors in foods and Quality standards*	*Energy conservation and new processes*	*Irradiation, Microwave heating*	*vegetables, fruits, and spices*	*Wastewater disposal and pollution control in food industry*

Learning Resources	
	1. Potter. JH, Hotchkiss NN, "Food Science", 5th edn., The CBS Publishing Co, Delhi, 2007. *2. Toldeo. RT, "The Fundamentals of Food Engineering", The CBS Publishing Co, Delhi, 2000.* *3. Sivasankar.,B, "Food Processing and Preservation", Prentice-Hall of India, New Delhi, 2002.* *4. "Desrosier, NW., "The Technology of Food Preservation," The CBS Publishers & Distributors, 1998.*

Learning Assessment											
	Bloom's Level of Thinking	Continuous Learning Assessment (50% weightage)								Final Examination (50% weightage)	
		CLA – 1 (10%)		CLA – 2 (15%)		CLA – 3 (15%)		CLA – 4 (10%)#			
		Theory	Practice	Theory	Practice	Theory	Practice	Theory	Practice	Theory	Practice
Level 1	Remember Understand	40 %	-	30 %	-	30 %	-	30 %	-	30%	-
Level 2	Apply Analyze	40 %	-	40 %	-	40 %	-	40 %	-	40%	-
Level 3	Evaluate Create	20 %	-	30 %	-	30 %	-	30 %	-	30%	-
	Total	100 %		100 %		100 %		100 %		100 %	

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Experts from Industry	Experts from Higher Technical Institutions	Internal Experts
1. *Mr. A. Subramaniam, PESCO Beam Environmental Solutions Pvt. Ltd.,*	1. *Dr. Lima Rose Miranda, Anna University, email: limamiranda2007@gmail.com*	1. *Dr. B. Karunanithi, SRMIST karunanb@srmist.edu.in*
2. *Mr. S. T. Kalaimani, CPCL, Chennai*	2. *Dr. T. R. Sundararaman, Rajalakshmi Engineering College*	

Course Code	18CHE374T	Course Name	COMPUTATIONAL TECHNIQUES IN CHEMICAL ENGINEERING	Course Category	E	Professional Elective	L	T	P	C
							3	0	0	3

Pre-requisite Courses	NIL	Co-requisite Courses	NIL	Progressive Courses	NIL
Course Offering Department	Chemical Engineering	Data Book / Codes/Standards	NIL		

Course Learning Rationale (CLR):	*The purpose of learning this course is to:*
CLR-1 :	*Review the Numerical methods for solving the different type of equations.*
CLR-2 :	*Familiarize to solve the non-linear algebraic equation, linear simultaneous algebraic equation, Integration, Ordinary differential equation and partial differential equation using numerical methods.*
CLR-3 :	*Apply the conservation of mass and energy equation for simple chemical engineering systems.*
CLR-4 :	*Analyze the limitations and rate of convergence for different numerical methods.*
CLR-5 :	*Compare the different numerical methods with analytical solution.*
CLR-6:	*Familiarize to solve the mathematical model equation in chemical engineering system*

Course Learning Outcomes (CLO):	*At the end of this course, learners will be able to:*	Learning			Program Learning Outcomes (PLO)														
		1	2	3	1	2	3	4	5	6	7	8	9	10	11	12	13	14	15
		Level of Thinking (loom)	Expected Proficiency %)	Expected Attainment (%)	Engineering Knowledge	Problem Analysis	Design & Development	Analysis, Design, Research	Modern Tool Usage	Society & Culture	Environment & Sustainability	Ethics	Individual & Team Work	Communication	Project Mgt. & Finance	Life Long Learning	PSO - 1	PSO - 2	PSO –3
CLO-1 :	*Apply the root finding methods for solving the non-linear algebraic equations in thermodynamics and fluid mechanics.*	*3*	*80*	*70*	*H*	*H*	*L*	*M*											
CLO-2 :	*Analyze the numerical methods for solving the linear simultaneous algebraic equations in chemical reaction engineering and process heat transfer.*	*3*	*80*	*70*	*H*	*H*	*L*	*M*										*L*	
CLO-3 :	*Apply the numerical integration for solving the chemical engineering problems in chemical reaction engineering and mass transfer application.*	*3*	*75*	*70*	*H*	*H*	*L*	*H*										*L*	
CLO-4 :	*Apply the curve fitting methods to get the batch kinetics parameters using batch reactor data.*	*3*	*80*	*70*	*H*	*H*	*L*	*L*											
CLO-5 :	*Analyze the different numerical methods for solving the ordinary and partial differential equations in chemical Reaction Engineering, process heat transfer and mass transfer application*	*3*	*70*	*60*	*H*	*H*	*L*	*H*										*L*	
CLO-6:	*Solve any mathematical equations involved in engineering problems*				*H*	*H*	*H*	*H*										*L*	

Duration (hour)		9	9	9	9	9
S-1	SLO-1	*Review the root finding methods: Regula-Falsi and Newton Raphson method*	*Review the methods for solving the linear simultaneous algebraic equations*	*Review the methods for solving the Integration equations*	*Review the Taylor series, Euler's method with examples*	*Review the Finite Difference Method for solving the Partial Differential Equations*
S-2	SLO-1	*Review the phase equilibrium in ideal solutions*	*Review the material and energy balance concept without reaction*	*Rate of drying from batch drying data*	*Review the Runga-Kutta method with examples*	*Steady state one dimensional heat transfer problem*
S-3	SLO-1	*Boiling point of ideal solution using thermodynamics iteration method*	*Review of material balance with reaction*	*Determination of drying time from batch drying data using Trapezoidal multistage rule*	*Estimate the concentration of species in unsteady state of mixing tank*	*Unsteady steady state one dimensional heat transfer problem*
S-4	SLO-1	*Boiling point of ideal solution using Newton Raphson method*	*Continuous Stirred Tank reactor with multiple reaction using Gauss-Siedel method*	*Determine the volume of single reactor using Simpson's rule*	*Solve the ODE in batch reactor using Euler's method*	*Steady state two-dimensional heat transfer problem*
S-5	SLO-1	*Dew point of ideal solution using Newton Raphson method and plot the T-x-y diagram*	*Cascade Continuous Stirred Tank Reactors with single reaction using Gauss Elimination method*	*Determine the volume of cascade flow reactors using Trapezoidal Multistage method*	*Solve the ODE in Continuous stirred tank reactor with multiple reaction*	*Convective Diffusion problems*
S-8	SLO-1	*Review the flash vaporization algorithm*	*Review of single and multiple stage liquid – liquid extraction*	*Recap the integral methods to estimate the chemical kinetic parameter (order and rate constant) using batch kinetic data*	*Solve the ODE in heat conduction problems using R-K method*	*Convective Diffusion problem*
	SLO-2	*Flash vaporization calculation using Newton Raphson method*	*Estimate the composition of extract in each stage using Gauss Elimination method*	*Differential method to estimate the chemical kinetic parameters*	*Solve the ODE in Continuous stirred tank without reaction using Euler's method*	*One dimensional steady state mass transfer*
S-9	SLO-1	*Recap the equation of state and density of gas mixture*	*Review of single and multi-stage evaporators*	*Determine the order and rate constant using polynomial curve fitting combined with Least Square method.*	*Concentration profile along the reactor length in isothermal plug flow reactor using Euler's method*	*Stability analysis of finite difference schemes to PDE*
	SLO-2	*Estimate the molar volume of liquid and vapor using Newton Raphson method*	*Estimate the area of multi-stage evaporator using explicit method.*	*Curve fitting in heat conduction problems*	*Temperature profile in plug flow reactor*	*Unsteady state heat transfer problem.*

Learning Resources	1. *Steven C. Chapra and Raymond P. Canale, Numerical Methods for Engineers, sixth Edn., McGraw Hill* 2. *Ismail Tosun, Modeling in Transport Phenomena – A Conceptual Approach, 2ndEdn., Elsevier Publications 2007* 3. *Y.V.C. Rao, Chemical Engineering Thermodynamics, Universities press, 1997.*	4. *H. K. Versteeg and W. Malalasekera, An introduction to computational fluid dynamics – The finite volume method, Longman Group Ltd 1995.* 5. *H. Scott Fogler, Elements of Chemical Reaction Engineering, 4th Edition, Prentice Hall International Series*

Learning Assessment

	Bloom's Level of Thinking	Continuous Learning Assessment (50% weightage)								Final Examination (50% weightage)	
		CLA – 1 (10%)		CLA – 2 (15%)		CLA – 3 (15%)		CLA – 4 (10%)#			
		Theory	Practice	Theory	Practice	Theory	Practice	Theory	Practice	Theory	Practice
Level 1	Remember Understand	40 %	-	30 %	-	30 %	-	30 %	-	30%	-
Level 2	Apply Analyze	40 %	-	40 %	-	40 %	-	40 %	-	40%	-
Level 3	Evaluate Create	20 %	-	30 %	-	30 %	-	30 %	-	30%	-
	Total	100 %		100 %		100 %		100 %		100 %	

CA – 4 can be from any combination of these: Assignments, Seminars, Tech Talks, Mini-Projects, Case-Studies, Self-Study, MOOCs, Certifications, Conf. Paper etc.,

Course Designers

Experts from Industry	Experts from Higher Technical Institutions	Internal Experts
1. *Mr. A. Subramaniam, PESCO Beam Environmental Solutions Pvt. Ltd.,*	1. *Dr. Lima Rose Miranda, Anna University, email: limamiranda2007@gmail.com*	1. *Dr. K. Sureshn SRM Inst. of Science & Technology, sureshk@srmist.edu.in*
2. *Mr. S. T. Kalaimani, CPCL, Chennai*	2. *Dr. T. R. Sundararaman, Rajalakshmi Engineering College*	2. *Dr. Ashish Kapoor SRM Inst. of Science & Technology, ashishko@srmist.edu.in*

Course Code	18CHE375T	Course Name	INTRODUCTION TO PROCESS PLANT SIMULATION	Course Category	E	Professional Elective	L	T	P	C
							3	0	0	3

Pre-requisite Courses	Nil	Co-requisite Courses	Nil	Progressive Courses	Nil
Course Offering Department	Chemical Engineering	Data Book / Codes/Standards	Nil		

Course Learning Rationale (CLR):	*The purpose of learning this course is to:*
CLR-1 :	*Overview of mathematical modeling of various chemical engineering systems*
CLR-2 :	*Understand the modular approaches in process plant simulation*
CLR-3 :	*Understand the various tearing algorithms in process plant simulation*
CLR-4 :	*learnt the convergence promotion methods involved in process simulation*
CLR-5 :	*Evaluate the individual equipment simulation using commercial software*
CLR-6:	*Hand-on-training for plant simulation using commercial software*

Course Learning Outcomes (CLO):	*At the end of this course, learners will be able to:*	Learning 1 Level of Thinking (loom)	2 Expected Proficiency %)	3 Expected Attainment (%)	PLO 1 Engineering Knowledge	2 Problem Analysis	3 Design & Development	4 Analysis, Design, Research	5 Modern Tool Usage	6 Society & Culture	7 Environment & Sustainability	8 Ethics	9 Individual & Team Work	10 Communication	11 Project Mgt. & Finance	12 Life Long Learning	13 PSO - 1	14 PSO - 2	15 PSO –3
CLO-1 :	*Propose the mathematical model equation for chemical engineering equipment*	1	80	70	H	H	H		H								H	L	
CLO-2 :	*Solve the model equations using sequential modular approaches*	2	80	70	H	H	L		H								H	H	L
CLO-3 :	*Solve the model equations using equation solving approach*	2	70	65	H	H	L		H								H	H	
CLO-4 :	*Apply the convergence promotion for minimize the total time required for simulation*	2	80	70	H	H	L		H								H	H	
CLO-5 :	*Perform the process plant simulation using commercial software*	2	70	65	H	H	H	L	H						M		M	L	
CLO-6:	*Process plant simulation using commercial software*	2	75	65	H	H	H	M									H	M	L

Duration (hour)		9	9	9	9	9
S-1	SLO-1	*Introduction to process synthesis and analysis*	*Modular approaches – Analysis Vs Design mode*	*Decomposition of Networks*	*Convergence promotion scheme and Newton's method*	*Cascade simulations*
S-2	SLO-1	*Process plant simulation*	*Sequential modular approaches*	*Tearing Algorithms in decomposition of networks*	*Direct substitution*	*Steady state simulation: Ammonia synthesis reactor simulation*
S-3	SLO-1	*Modeling Aspects*	*Simultaneous modular approaches*	*Digraphs and signal flow graph*	*Wegstein's method*	*Simulation results and discussion*
S-4	SLO-1	*Classification of Mathematical Modeling.*	*Tearing a system of equations*	*BM Algorithm*	*Dominant Eigen value method*	*Steady state simulation of thermal cracking operation*
S-5	SLO-1	*Artificial Neural Networks*	*Equation Solving approach*	*BTA and K & S Algorithms*	*Quasi-Newton methods*	*Simulation results and discussion*
S-6	SLO-1	*steady state single and two stage solvent extraction*	*Precedence – ordering of equation sets*	*M&H Algorithms*	*Criterion for acceleration*	*Design of Shell-and -Tube Heat Exchanger*
S-7	SLO-1	*Unsteady-state mass balance in a mixing tank*	*Disjointing, PTM*	*Related problems*	*Introduction to application of flow sheeting software*	*Simulation results and discussion*
S-8	SLO-1	*Unsteady state steam heating of a liquid*	*The SWS and Rudd-Algorithm*	*Comparison of various Tearing Algorithms*	*Steady state simulations for single equipment*	*Steady state simulation of pyrolysis of Biomass*
S-9	SLO-1	*Degree of freedom for equipment*	*Direct methods and iterative methods*	*Linear and non-linear equations.*	*Dynamics simulations for single equipment*	*Simulation results and discussion*
	SLO-2	*Degree of freedom for process flow sheet.*				

Learning Resources	
	1. *B.V. Babu, Process Plant Simulation, Oxford University Press, India 2004* 2. *Robin Smith, Chemical Process Design and Integration, 2nd Edition, Wiley, 2016* 3. *Richard Turton, Analysis, Synthesis and Design of Chemical Processes, pearson Education International, 2009.*

Learning Assessment											
	Bloom's Level of Thinking	Continuous Learning Assessment (50% weightage)								Final Examination (50% weightage)	
		CLA – 1 (10%)		CLA – 2 (15%)		CLA – 3 (15%)		CLA – 4 (10%)#			
		Theory	Practice	Theory	Practice	Theory	Practice	Theory	Practice	Theory	Practice
Level 1	Remember Understand	40 %	-	30 %	-	30 %	-	30 %	-	30%	-
Level 2	Apply Analyze	40 %	-	40 %	-	40 %	-	40 %	-	40%	-
Level 3	Evaluate Create	20 %	-	30 %	-	30 %	-	30 %	-	30%	-
	Total	100 %		100 %		100 %		100 %		100 %	

CA – 4 can be from any combination of these: Assignments, Seminars, Tech Talks, Mini-Projects, Case-Studies, Self-Study, MOOCs, Certifications, Conf. Paper etc.,

Course Designers		
Experts from Industry	Experts from Higher Technical Institutions	Internal Experts
1. *Mr. A. Subramaniam, PESCO Beam Environmental Solutions Pvt. Ltd.,*	1. *Dr. Lima Rose Miranda, Anna University, email: limamiranda2007@gmail.com*	1. *Dr. K. Suresh SRM Inst. of Science & Technology, sureshk@srmist.edu.in*
2. *Mr. S. T. Kalaimani, CPCL, Chennai*	2. *Dr. T. R. Sundararaman, Rajalakshmi Engineering College*	

ACADEMIC CURRICULA

Professional Elective Courses

CIVIL ENGINEERING

Regulations - 2018

SRM INSTITUTE OF SCIENCE AND TECHNOLOGY

(Deemed to be University u/s 3 of UGC Act, 1956)

Kattankulathur, Kancheepuram, Tamil Nadu, India

Course Code	18CEE301T	Course Name	FOUNDATION ENGINEERING AND DESIGN	Course Category	E	Professional Elective	L	T	P	C
							3	0	0	3

Pre-requisite Courses	Nil	Co-requisite Courses	Nil	Progressive Courses	Nil
Course Offering Department	CIVIL ENGINEERING	Data Book / Codes/Standards	Nil		

Course Learning Rationale (CLR):	The purpose of learning this course is to:
CLR-1 :	*Understanding the essential steps involved in a Geotechnical Investigation*
CLR-2 :	*Analyze the principle types of foundation and the factors governing the choice of the most suitable type of foundation.*
CLR-3 :	*Get exposed to determination of bearing capacity of shallow foundation*
CLR-4 :	*Analyze the cause and remedial measures for settlement and slope failure*
CLR-5 :	*Get an insight into the load carrying capacity of pile foundation in the field condition*
CLR-6 :	*Understand and analyse the concept of earth pressure*

Course Learning Outcomes (CLO):	At the end of this course, learners will be able to:	Learning 1	2	3	Program Learning Outcomes (PLO) 1	2	3	4	5	6	7	8	9	10	11	12	13	14	15
		Level of Thinking (Bloom)	Expected Proficiency (%)	Expected Attainment (%)	Engineering Knowledge	Problem Analysis	Design & Development	Analysis, Design, Research	Modern Tool Usage	Society & Culture	Environment & Sustainability	Ethics	Individual & Team Work	Communication	Project Mgt. & Finance	Life Long Learning	PSO - 1	PSO - 2	PSO – 3
CLO-1 :	*Identify the soil characteristics through geotechnical investigation*	2	85	80	H	H	-	-	-	-	-	-	-	-	-	-	H	-	-
CLO-2 :	*Proper type of foundation is chosen depending upon the soil condition*	2	85	75	H	H	-	-	-	-	-	-	-	-	-	-	H	-	-
CLO-3 :	*Compute g the bearing capacity of shallow foundation*	2	80	75	H	H	-	H-	-	-	-	-	-	-	-	-	H	-	-
CLO-4 :	*Utilize the proper measures for reducing the settlement and slope failure*	2	85	80	H	H	-		-	-	-	-	-	-	-	-	H	-	-
CLO-5 :	*Utilize the proper type of pile in the field*	2	85	75	H	H	-	H	-	-	-	-	-	-	-	-	H	-	-
CLO-6 :	*Estimate of earth pressure for different soil condition*	2	80	75	H	H	-	-	-	-	-	-	-	-	-	-	H	-	-

Duration (hour)		9	9	9	9	9
S-1	SLO-1	*Site investigation, soil Exploration*	*Definition: Foundation, purpose of foundation.*	*Combined footing - types*	*Deep foundation – Necessity. Pile Foundations classification*	*Lateral Earth Pressures Theories-Introduction:*
	SLO-2	*Planning and stages in site investigation*	*Definition: Shallow Foundation – classification. Ultimate, gross, net, safe bearing capacity. safe and allowable bearing pressure*	*Combined footing - types*	*Pile Foundations – classification*	*applications of earth pressure theories*
S-2	SLO-1	*Soil exploration – Methods – direct, semi-direct and indirect method*	*Bearing capacity failure - modes of shear failures – general, local and punching shear failure*	*Method of proportioning – Rectangular footing*	*Load carrying capacity of pile – Methods*	*Different types of earth pressure at rest, active and passive pressure*
	SLO-2	*Direct method – test pit, trenches*	*Factors affecting bearing capacity*	*Method of proportioning – Rectangular footing*	*Dynamic method – ENR, and Hiley's - Problems*	*Different types of earth pressure at rest, active and passive pressure*
S-3	SLO-1	*Indirect methods. Geophysical methods- Seismic Refraction Method*	*Bearing capacity determinations – Methods.*	*Method of proportioning – Trapezoidal footing*	*Static method – all type of soils - problems*	*Rankine's Earth Pressure Theory, active earth pressure and passive earth pressure for horizontal backfill for cohesion-less soil*
	SLO-2	*Geophysical methods- Electrical Resistivity Method*	*Terzaghi theory – Assumption.*	*Method of proportioning – Trapezoidal footing*	*Static method – all type of soils - problems*	*Rankine's Earth Pressure Theory, active earth pressure and passive earth pressure for horizontal backfill for cohesion-less soil*
S-4	SLO-1	*Indirect method – SPT*	*Bearing capacity – Strip and Square foundation*	*Combined footing - problems*	*Static method – all type of soils - problems*	*Rankine's Earth Pressure Theory, active earth pressure and passive earth pressure for horizontal backfill for cohesion-less soil-Problems*
	SLO-2	*Indirect method – SPT*	*Bearing capacity – Circular and Rectangular foundation*	*Combined footing - problems*	*Static method – all type of soils - problems*	*Rankine's Earth Pressure Theory, active earth pressure and passive earth pressure for horizontal backfill for cohesion-less soil-Problems*
S-5	SLO-1	*Indirect method – DCPT*	*Bearing capacity – effect of water table*	*Settlement – total and differential settlement.*	*Pile load capacity – penetration test results*	*Rankine's Earth Pressure Theory, active earth pressure and passive earth pressure for horizontal backfill for cohesive soils.*

	SLO-2	*Indirect method –SCPT*	*Bearing capacity – effect of water table*	*Settlement – total and differential settlement.*	*Pile load capacity – penetration test results*	*Rankine's Earth Pressure Theory, active earth pressure and passive earth pressure for horizontal backfill for cohesive soils*
S6	SLO-1	*Semi direct method Borings – auger*	*Bearing capacity - problems*	*Causes and methods to minimize the total settlement*	*Pile group – efficiency - problems*	*Rankine's Earth Pressure Theory, active earth pressure and passive earth pressure for horizontal backfill for cohesive soils-Problems*
	SLO-2	*Semi direct method Borings –shell and auger*	*Bearing capacity - problems*	*Causes and methods to minimize the total settlement*	*Pile group – efficiency - problems*	*Rankine's Earth Pressure Theory, active earth pressure and passive earth pressure for horizontal backfill for cohesive soils-Problems*
S-7	SLO-1	*Semi direct method Borings – wash boring and rotary drilling*	*Bearing capacity - problems*	*Causes and methods to minimize the differential settlement*	*Pile group – efficiency - problems*	*Earth pressure theories – Graphical method*
	SLO-2	*Semi direct method Borings – percussion method*	*Bearing capacity - problems*	*Causes and methods to minimize the differential settlement*	*Pile group – efficiency - problems*	*Earth pressure theories – Graphical method*
S-8	SLO-1	*Number and deposition of trail pits and borings*	*Hansen and IS code method*	*Slopes – types – Causes of slope failure*	*Pile load test : Types - Load carrying capacity of pile, under-reamed pile and pile group*	*Rebhann's Construction for Active Pressure*
	SLO-2	*Bore log details*	*Bearing capacity from Penetration test results*	*Methods to minimize the slope failure*	*load test as per BIS – estimation of load carrying capacity*	*Rebhann's Construction for Active Pressure*
S-9	SLO-1	*Soil Sample ; UDS*	*Bearing capacity : Plate load test as per BIS ,*	*Slope stability – methods - Swedish Method of Slice for a Cohesive-frictional Soil*	*Problems in pile load test.*	*Culmann'sgraphical solutions for active and passive case*
	SLO-2	*Soil Sample ; DS*	*limitations and estimation of settlements - Performance of foundation*	*Slope stability – methods - Swedish Method of Slice for a Cohesive-frictional Soil*	*Negative skin friction*	*Culmann'sgraphical solutions for active and passive case*

Learning Resources	1. *Joseph.E Bowles, "Foundation Analysis and Design", Mc Graw Hill Publishing co., 2001.* 2. *Murthy .V.N.S, "Textbook of Soil Mechanics and Foundation Engineering", CBS Publishersand Distributors, New Delhi, 2009.* 3. *Arora .K.R. "Soil Mechanics and Foundation Engineering", Standard Publishers and Distributors, New Delhi, 2011.* 4. *Varghese, P.C., "Foundation Engineering", PHI Learning New Delhi. 2011*	5. *Punmia.B.C., "Soil Mechanics and Foundations", Laxmi publications Pvt Ltd., 2000.* 6. *Das .B.M, "Principles of Foundation Engineering", (Fifth Edition), Thomson Books, 2010.* 7. *NPTEL Course – Advanced Foundation Engineering : https://nptel.ac.in/courses/105105039/* 8. *NPTEL Course – Foundation Engineering : https://nptel.ac.in/courses/105101083/*

Learning Assessment

	Bloom's Level of Thinking	Continuous Learning Assessment (50% weightage)								Final Examination (50% weightage)	
		CLA – 1 (10%)		CLA – 2 (15%)		CLA – 3 (15%)		CLA – 4 (10%)#			
		Theory	Practice	Theory	Practice	Theory	Practice	Theory	Practice	Theory	Practice
Level 1	Remember Understand	*50%*	-	*40%*	-	*40%*	-	*45%*	-	*70%*	-
Level 2	Apply Analyze	*50%*	-	*60%*	-	*60%*	-	*55%*	-	*30%*	-
Level 3	Evaluate Create	-	-	-	-	-	-	-	-	-	-
	Total	100 %		100 %		100 %		100 %		100 %	

CLA – 4: Assignments and / or Field visits

Course Designers		
Experts from Industry	Experts from Higher Technical Institutions	Internal Experts
Dr. P.Selvanambi, Divisional Engineer (Highways), sundariselvam@yahoo.com	*Dr.M.Muttharam, Anna University, muttharam@annauniv.edu*	*Dr. P.T. Ravichandran, SRMIST*
Mr.Lenin K.R., Head –GEOTECH, SECON Private Limited, Bangalore, lenin.kr@secon.in	*Dr.V.Murugaiyan, Pondichery Engineering College, vmurugaiyan@pec.edu*	*Ms. S. Mary Rebekah Sharmila, SRMIST.*

Course Code	18CEE302T	Course Name	GEOTECHNICAL DESIGN	Course Category	E	Professional Elective	L	T	P	C
							3	0	0	3

Pre-requisite Courses	Nil	Co-requisite Courses	Nil	Progressive Courses	Nil
Course Offering Department	CIVIL ENGINEERING	Data Book / Codes/Standards	Nil		

Course Learning Rationale (CLR):	*The purpose of learning this course is to:*
CLR-1 :	*Understand the essential steps involved in a Geotechnical Investigation*
CLR-2 :	*Understand the concept of consolidation and the estimation of preconsolidation pressure*
CLR-3 :	*Analyze the stress strain behavior of different types of soil*
CLR-4 :	*Compute of the ultimate load carrying capacity of shallow foundation under different field condition*
CLR-5 :	*Estimate of pile load capacity and settlement of single and group of piles*
CLR-6 :	*Utilize the ultimate loads of shallow and pile foundation in the civil engineering field*

Course Learning Outcomes (CLO):	*At the end of this course, learners will be able to:*	Learning 1: Level of Thinking (Bloom)	Learning 2: Expected Proficiency (%)	Learning 3: Expected Attainment (%)	PLO 1: Engineering Knowledge	PLO 2: Problem Analysis	PLO 3: Design & Development	PLO 4: Analysis, Design, Research	PLO 5: Modern Tool Usage	PLO 6: Society & Culture	PLO 7: Environment & Sustainability	PLO 8: Ethics	PLO 9: Individual & Team Work	PLO 10: Communication	PLO 11: Project Mgt. & Finance	PLO 12: Life Long Learning	PLO 13: PSO - 1	PLO 14: PSO - 2	PLO 15: PSO – 3
CLO-1 :	*Analyze the soil properties based on geotechnical investigation*	2	85	80	H	H	-	-	-	-	-	-	-	-	-	-	H	-	-
CLO-2 :	*Utilize the preconsolidation pressure for determining the rate of consolidation*	2	85	75	H	H	-	-	-	-	-	-	-	-	-	-	H	-	-
CLO-3 :	*Utilize the stress strain behavior of soil in the field*	2	80	75	H	H	-	M	-	-	-	-	-	-	-	-	H	-	-
CLO-4 :	*Identify the application of ultimate loads of shallow foundation in the field*	2	85	80	H	H	-	-	-	-	-	-	-	-	-	-	H	-	-
CLO-5 :	*Identify the application of ultimate loads of pile foundation in the field*	2	85	75	H	H	-	M	-	-	-	-	-	-	-	-	H	-	-
CLO-6 :	*Apply of shallow and deep foundation in the field*	2	80	75	H	H	-	-	-	-	-	-	-	-	-	-	H	-	-

Duration (hour)		9	9	9	9	9
S-1	SLO-1	*Planning of subsurface investigation*	*Terzaghi's theory of one dimensional consolidation*	*Stress and strain behavior of soil*	*Bearing capacity and settlement analysis of shallow foundations: Modes of failure*	*Pile foundation: Functions*
	SLO-2	*Purpose and scope*	*Terzaghi's theory of one dimensional consolidation*	*Stress and strain behavior of soil*	*Bearing capacity and settlement analysis of shallow foundations: Modes of failure*	*Pile foundation: Functions*
S-2	SLO-1	*Influence of soil conditions on exploratory program*	*Derivation of Terzaghi's equation (solution in detail need not be covered)*	*Triaxial test -drained and un-drained behavior of sand*	*Failure criteria, Prandtl Reissner Method, Assumptions - Estimation of ultimate loads,*	*Types of pile foundations*
	SLO-2	*Type of foundation on exploratory program*	*Derivation of Terzaghi's equation (solution in detail need not be covered)*	*Triaxial test -drained and un-drained behavior of sand*	*Failure criteria, Prandtl Reissner Method, Assumptions - Estimation of ultimate loads,*	*Types of pile foundations*
S-3	SLO-1	*Subsurface soundings –Static methods*	*Estimation of Cc and Cv from laboratory tests*	*Triaxial test -drained and un-drained behavior of clays*	*Terzaghi solution, Assumptions - Estimation of ultimate loads*	*Pile load tests, Use of load tests*
	SLO-2	*Subsurface soundings –Static methods*	*Estimation of Cc and Cv from laboratory tests*	*Triaxial test -drained and un-drained behavior of clays*	*Terzaghi solution, Assumptions - Estimation of ultimate loads*	*Pile load tests, Use of load tests*
S-4	SLO-1	*Subsurface soundings – Dynamic methods*	*Estimation of Cc and Cv from laboratory tests*	*Failure criteria in soils –only Mohr – Coulomb's criteria*	*Estimation of ultimate loads- Effect of shape,*	*Methods of estimation of pile load capacity- Static and dynamic*
	SLO-2	*Subsurface soundings – Dynamic methods*	*Estimation of Cc and Cv from laboratory tests*	*Failure criteria in soils –only Mohr – Coulomb's criteria*	*Estimation of ultimate loads- Effect of shape,*	*Methods of estimation of pile load capacity- Static and dynamic*
S-5	SLO-1	*Planning of subsurface investigations*	*Estimation of Pc by various methods*	*Ideal, plastic and real soil behavior*	*Estimation of ultimate loads- embedment of footing*	*Estimation of single pile capacity by static*
	SLO-2	*Planning of subsurface investigations*	*Estimation of Pc by various methods*	*Ideal, plastic and real soil behavior*	*Estimation of ultimate loads- embedment of footing*	*Estimation of single pile capacity by static*
S6	SLO-1	*Planning of subsurface investigations*	*Field consolidation curves*	*Shear strength of sand and clays*	*Estimation of ultimate loads- eccentricity in loading*	*Estimation of single pile by dynamic methods*
	SLO-2	*Planning of subsurface investigations*	*Field consolidation curves*	*Shear strength of sand and clays*	*Estimation of ultimate loads- eccentricity in loading*	*Estimation of single pile by dynamic methods*
S-7	SLO-1	*Type and sequence of operations*	*Quasi pre-consolidation*	*Estimation of stresses: Boussinesq's theory*	*Compressibility (including critical rigidity index), Choice of factor of safety, Settlement of foundations on sand –*	*Group capacity of piles*

					Schmertmann method	
	SLO-2	*Type and sequence of operations*	*Quasi pre-consolidation*	*Estimation of stresses: Boussinesq's theory*	*Compressibility (including critical rigidity index), Choice of factor of safety, Settlement of foundations on sand – Schmertmann method*	*Group capacity of piles*
S-8	SLO-1	*Lateral extent and depth of exploration*	*Quasi Secondary consolidation*	*Estimation of stresses: Westergard's theory*	*Foundations on collapsing and swelling soils, non-uniform soils, compressible soils and on rock*	*Separation of skin friction and end bearing capacity*
	SLO-2	*Lateral extent and depth of exploration*	*Quasi Secondary consolidation*	*Estimation of stresses: Westergard's theory*	*Foundations on collapsing and swelling soils, non-uniform soils, compressible soils and on rock*	*Separation of skin friction and end bearing capacity*
S-9	SLO-1	*Interpretation of field and laboratory data*	*Practical applications*	*Estimation of stresses: Newmark's charts*	*Design of isolated and combined footings*	*Settlement of single and group of piles.*
	SLO-2	*Interpretation of field and laboratory data*	*Practical applications*	*Estimation of stresses: Newmark's charts*	*Design of isolated and combined footings*	*Settlement of single and group of piles.*

Learning Resources	1. *Joseph.E Bowles, "Foundation Analysis and Design", Mc Graw Hill Publishing co., 2001.* 2. *Murthy .V.N.S, "Textbook of Soil Mechanics and Foundation Engineering", CBS Publishersand Distributors, New Delhi, 2009.* 3. *Arora .K.R. "Soil Mechanics and Foundation Engineering", Standard Publishers and Distributors, New Delhi, 2011.*	4. *Varghese, P.C., "Foundation Engineering", PHI Learning New Delhi. 2011* 5. *Punmia.B.C., "Soil Mechanics and Foundations", Laxmi publications Pvt Ltd., 2000.* 6. *Das .B.M, "Principles of Foundation Engineering", (Fifth Edition), Thomson Books, 2010.* 7. *NPTEL Course – Foundation Design : https://nptel.ac.in/courses/105104162/*

Learning Assessment											
	Bloom's Level of Thinking	Continuous Learning Assessment (50% weightage)								Final Examination (50% weightage)	
		CLA – 1 (10%)		CLA – 2 (15%)		CLA – 3 (15%)		CLA – 4 (10%)#			
		Theory	Practice	Theory	Practice	Theory	Practice	Theory	Practice	Theory	Practice
Level 1	Remember Understand	*50%*	-	*40%*	-	*40%*	-	*45%*	-	*70%*	-
Level 2	Apply Analyze	*50%*	-	*60%*	-	*60%*	-	*55%*	-	*30%*	-
Level 3	Evaluate Create	-	-	-	-	-	-	-	-	-	-
	Total	100 %		100 %		100 %		100 %		100 %	

CLA – 4 : Assignments and / or Field visits

Course Designers		
Experts from Industry	Experts from Higher Technical Institutions	Internal Experts
Dr. P.Selvanambi, Divisional Engineer (Highways), sundariselvam@yahoo.com	*Dr.M.Muttharam, Anna University, muttharam@annauniv.edu*	*Dr. P.T. Ravichandran, SRMIST*
Mr.Lenin K.R., Head –GEOTECH, SECON Private Limited, Bangalore, lenin.kr@secon.in	*Dr.V.Murugaiyan, Pondichery Engineering College, vmurugaiyan@pec.edu*	*Ms.S. Mary Rebekah Sharmila, SRMIST.*

Course Code	18CEE303T	Course Name	GROUND IMPROVEMENT TECHNIQUES	Course Category	E	Professional Elective	L	T	P	C
							3	0	0	3

Pre-requisite Courses	Nil	Co-requisite Courses	Nil	Progressive Courses	Nil
Course Offering Department	CIVIL ENGINEERING	Data Book / Codes/Standards	Nil		

Course Learning Rationale (CLR):	*The purpose of learning this course is to:*
CLR-1 :	*Understand the need for ground improvement*
CLR-2 :	*Understand the techniques adopted for ground improvement with respect to hydraulic modification*
CLR-3 :	*Identify conceptual and practical understanding of in-situ soil densification techniques*
CLR-4 :	*Familiarize with soil chemical modification techniques and acquaintance with emerging technologies*
CLR-5 :	*Understand the mechanism and concept related to soil modification by reinforcements*
CLR-6 :	*Recommend and design cost effective ground improvement techniques for difficult practical soil conditions*

Course Learning Outcomes (CLO):	*At the end of this course, learners will be able to:*	Learning 1: Level of Thinking (Bloom)	Learning 2: Expected Proficiency (%)	Learning 3: Expected Attainment (%)	PLO 1: Engineering Knowledge	PLO 2: Problem Analysis	PLO 3: Design & Development	PLO 4: Analysis, Design, Research	PLO 5: Modern Tool Usage	PLO 6: Society & Culture	PLO 7: Environment & Sustainability	PLO 8: Ethics	PLO 9: Individual & Team Work	PLO 10: Communication	PLO 11: Project Mgt. & Finance	PLO 12: Life Long Learning	PLO 13: PSO - 1	PLO 14: PSO - 2	PLO 15: PSO – 3
CLO-1 :	*Gain a thorough knowledge on the role of ground improvement techniques in the infrastructure development*	2	85	80	H	L	-	-	-	-	-	-	-	-	-	-	H	-	-
CLO-2 :	*Recommend hydraulic modification techniques for related problems*	2	85	75	H	M	-	-	-	-	-	-	-	-	-	-	H	-	-
CLO-3 :	*Apply densification techniques for loose sand deposits and alternative techniques for soft clay deposits*	2	80	75	H	M	-	-	-	-	-	-	-	-	-	-	H	-	-
CLO-4 :	*Recommend additives and frame soil chemical modification schemes for stabilizing problematic soil*	2	85	80	H	M	-	-	-	-	-	-	-	-	-	-	H	-	-
CLO-5 :	*Design geotechnical structures using reinforcements like reinforced earth retaining walls, slopes, foundations etc.,.*	3	85	75	H	H	-	M	-	-	-	-	-	-	-	-	H	-	-
CLO-6 :	*Recommend design efficient and economic alternatives using ground improvement techniques for problematic and difficult sites*	3	80	75	H	H	-	-	-	-	-	-	-	-	-	-	H	-	-

Duration (hour)		9	9	9	9	9
S-1	SLO-1	*Introduction-Ground improvement techniques*	*Hydraulic modification-concept and principle*	*In-situ densification of cohesionless soil*	*Grouting -introduction*	*Soil reinforcement concepts*
	SLO-2	*Role of ground improvement techniques in foundation engineering*	*Dewatering -objectives -types*	*Various Methods and mechanism involved*	*Necessity types of grout-suspension-solution grouts*	*Principle and mechanism*
S-2	SLO-1	*Objectives and scope of ground improvement techniques*	*Dewatering Techniques -well points system*	*Consolidation of cohesive soil-types*	*Functions of grouting-permeation*	*Reinforced earth retaining structures-various applicability in geotechnical engineering*
	SLO-2	*Classification of techniques adopted*	*Installation -mechanism and suitability of soil*	*Properties and behaviour*	*Functions-Compaction-hydro fracture*	*Embankments -slopes etc..*
S-3	SLO-1	*Hydraulic-Mechanical-Chemical-Reinforcement*	*Dewatering methods-Ditches*	*Vibrofloatation techniques*	*Grouting equipment and methods*	*Types of reinforcing materials*
	SLO-2	*Choice of method of ground improvement techniques*	*Dewatering methods-Sumps*	*Dry feed method-wet feed method*	*Grouting with soil, bentonite*	*Natural and manmade materials*
S-4	SLO-1	*Geotechnical problems in Lateritic soil*	*Dewatering methods -Vacuum method.*	*Sand compaction piles*	*Grouting with cement mixes*	*Geosynthetics-types*
	SLO-2	*Properties and behavior and techniques adopted*	*Dewatering methods-Electroosmotic method*	*Installation techniques*	*Mechanism and concept*	*Geotextile-geogrids-geonets*
S-5	SLO-1	*Geotechnical problems in Alluvial soil*	*Seepage analysis of 2-dimensional flow-concepts*	*Deep compaction -dynamic compaction -blasting technique*	*Grout injection methods*	*Functions of geosynthetics*
	SLO-2	*Properties and behavior and techniques adopted*	*Theory and problems*	*Concepts and factors influencing*	*grout monitoring schemes*	*Filtration, drainage*
S6	SLO-1	*Geotechnical problems in Black Cotton soil*	*Seepage analysis-fully penetrated slot*	*Stone columns -installation*	*Civil engineering application of grouting techniques*	*Geosynthetics-Reinforcement*
	SLO-2	*Properties and behavior and techniques adopted*	*Theory and problems*	*Mechanism*	*Some of the field studies*	*Separation function -Geotechnical field application*

S-7	SLO-1	Selection of suitable ground improvement techniques based on soil condition	Preloading-concept	Design criteria	Stabilization -concept	Geomembranes-containments
	SLO-2	Some field conditions for practical applicability	Field applicability	Stone column- soil criteria-field application	Stabilization of expansive soil	Barriers- field application
S-8	SLO-1	Use of Piezometers	Vertical drains-sand drains	Lime columns-applicability	Lime stabilization-concept-suitability criteria	Current practices-geosynthetics
	SLO-2	Field applications	Installation and mechanism	Soil criteria-mechanism involved	Mechanism involved	Field application reinforcement
S-9	SLO-1	Use of inclinometers	Prefabricated vertical drains	Field application	Cement stabilization -concept-suitability criteria	Geosynthetics in field applications
	SLO-2	Field applications	Installation and mechanism	Installation -mechanism	Mechanism involved	Introduction of ground anchors

Learning Resources	1. *Purushothama Raj. P, "Ground Improvement Techniques", Lakshmi Publications, 2ndEdition, 2016.* 2. *Manfired R. Hausmann, Engineering Principles of Ground Modification, McGraw-Hill Pub, Co., 1990.* 3. *Koerner, R.M. "Construction and Geotechnical Methods in Foundation Engineering", McGraw Hill, 1994.*	4. *Nihar Ranjan Patra, "Ground Improvement Techniques", Vikas Publishing House, FirstEdition, 2012.* 5. *Mittal.S, "An Introduction to Ground Improvement Engineering", Medtech Publisher, First Edition, 2013.* 6. *NPTEL Course - Advanced Techniques in Geotechnical and Foundation Engineering : https://nptel.ac.in/courses/105106144/* 7. *NPTEL Course - Ground Improvement Techniques : https://nptel.ac.in/courses/105108075/*

Learning Assessment											
	Bloom's Level of Thinking	Continuous Learning Assessment (50% weightage)								Final Examination (50% weightage)	
		CLA – 1 (10%)		CLA – 2 (15%)		CLA – 3 (15%)		CLA – 4 (10%)#			
		Theory	Practice	Theory	Practice	Theory	Practice	Theory	Practice	Theory	Practice
Level 1	Remember Understand	*40%*	-	*30%*	-	*30%*	-	*30%*	-	*30%*	-
Level 2	Apply Analyze	*40%*	-	*40%*	-	*40%*	-	*40%*	-	*40%*	-
Level 3	Evaluate Create	20%	-	30%	-	30%	-	30%	-	30%	-
	Total	100 %		100 %		100 %		100 %		100 %	

CLA – 4 can be from any combination of these: Assignments, Seminars, Tech Talks, Mini-Projects, Case-Studies, Self-Study, MOOCs, Certifications, Conf. Paper etc.,

Course Designers		
Experts from Industry	Experts from Higher Technical Institutions	Internal Experts
Dr. P.Selvanambi, Divisional Engineer (Highways), sundariselvam@yahoo.com	*Dr.M. Muttharam, Anna University, muttharam@annauniv.edu*	*Dr. P.T. Ravichandran, SRMIST*
Mr. K.R. Lenin Head –GEOTECH, SECON Private Limited, Bangalore, lenin.kr@secon.in	*Dr.V. Murugaiyan, Pondichery Engineering College, vmurugaiyan@pec.edu*	*Dr. S. Bhuvaneshwari, SRMIST*

Course Code	18CEE305J	Course Name	CONCRETE TECHNOLOGY	Course Category	E	Professional Elective	L	T	P	C
							2	0	2	3

Pre-requisite Courses	Nil	Co-requisite Courses	Nil	Progressive Courses	Nil
Course Offering Department	Civil Engineering	Data Book / Codes/Standards	IS 10262: 2019 and IS 456: 2000		

Course Learning Rationale (CLR):	*The purpose of learning this course is to:*
CLR-1 :	*Understand and test the properties of materials constitutes concrete*
CLR-2 :	*Understand about chemical and mineral admixtures used in concrete. Also understand and test fresh concrete properties*
CLR-3 :	*Know and understand the properties of concrete in hardened state*
CLR-4 :	*Know and understand the durability properties of concrete and special concrete*
CLR-5 :	*Understand the importance of concrete mix design*
CLR-6 :	*Understand the process involved in manufacture of concrete*

Course Learning Outcomes (CLO):	*At the end of this course, learners will be able to:*	Learning			Program Learning Outcomes (PLO)														
		1	2	3	1	2	3	4	5	6	7	8	9	10	11	12	13	14	15
		Level of Thinking (Bloom)	Expected Proficiency (%)	Expected Attainment (%)	Engineering Knowledge	Problem Analysis	Design & Development	Analysis, Design, Research	Modern Tool Usage	Society & Culture	Environment & Sustainability	Ethics	Individual & Team Work	Communication	Project Mgt. & Finance	Life Long Learning	PSO - 1	PSO - 2	PSO - 3
CLO-1 :	*Test and study the properties of cement, aggregates and water*	3	80	75	H	M	-	-	-	-	-	-	-	-	-	-	L	H	M
CLO-2 :	*Know the effects of admixtures in concrete and test the fresh concrete properties*	3	85	75	H	M	-	-	-	-	-	-	-	-	-	-	L	H	M
CLO-3 :	*Test the hardened concrete properties*	3	75	75	H	M	-	-	-	-	-	-	-	-	-	-	L	H	M
CLO-4 :	*Understand the importance of durability of concrete and properties of special concrete*	3	90	80	H	L	-	-	-	-	-	-	-	-	-	-	L	H	M
CLO-5 :	*Design the concrete mix without and with admixtures*	3	85	75	H	H	H	-	-	-	-	-	-	-	-	-	M	H	M
CLO-6 :	*Know the various stages of manufacture of concrete*	3	80	75	H	L	-	-	-	-	-	-	-	-	-	-	L	H	M

Duration (hour)		9	9	9	9	9
S-1	SLO-1	*CONCRETE CONSTITUENTS MATERIALS Overview. Cement, brought up, invention, chemical composition, oxide composition, limits and role.*	*ADMIXTURES Overview –Chemical and mineral admixtures – additive – plasticizers – definition – situation need high workability – effects of plasticizer in concrete.*	*HARDENED CONCRETE Test – purpose – density - compressive strength test.*	*DURABILITY OF CONCRETE Definition - significance – permeability – reasons for permeability in actual structures.*	*CONCRETE MIX DESIGN Definition – Principle of mix design – Factors choice of mix proportion – Properties of concrete related to mix design.*
	SLO-2	*Hydration - Bogue's compound – types of cement.*	*Super plasticizers – effects in – fresh and hardened concrete.*	*Factors affects strength of concrete. Failure of compression specimen.*	*Joints in concrete – classifications.*	*Physical properties of materials required for mix design.*
S-2	SLO-1	*Properties of cement - Tests on cement – field.*	*Accelerators – accelerating plasticizer.*	*Flexural strength – central point load.*	*Concrete subjected to high temperature.*	*Nominal and design mix – variables in mix design.*
	SLO-2	*Laboratory tests – fineness – specific gravity – procedures.*	*Retarders – use – materials. Water proofers.*	*Flexural strength –third point load.*	*Freezing and thawing.*	*Objective of mix design – List of methods of mix design. Basic steps — Information required for mix design.*
S-3	SLO-1	*Determination of fineness of cement and normal consistency of cement practically in lab.*	*Determination of soundness of cement (Demo only) practically in lab.*	*Determination of crushing strength of coarse aggregate practically in lab.*	*Determination of flakiness and elongation index of coarse aggregate practically in lab.*	*Determination of flexural strength of concrete practically in lab.*
	SLO-2					
S-4	SLO-1	*Consistency - setting time of cement – initial and final setting time.*	*Fly ash – characteristics – use – classification –effects in fresh and hardened concrete.*	*Indirect tension test.*	*Sulphate attack – methods to control.*	*Indian standard method of mix design - Step by step mix design procedure.*
	SLO-2	*Soundness and strength of cement.*	*Silica fume – characteristics – effects in fresh and hardened concrete.*	*Stress – strain curve.*	*Acid attack – concrete in sea water.*	*Mix design example : Without admixture*
S-5	SLO-1	*Aggregates – classification – source - size – shape – texture.*	*GGBS - effects in fresh and hardened concrete – uses.*	*Modulus of elasticity –determination.*	*Carbonation - factors.*	*Mix design examples: With chemical admixture and mineral admixture*
	SLO-2	*Properties of aggregates and tests: Crushing – 10% fines – impact.*	*Metakaolin – application – advantages – uses.*	*Different elastic moduli.*	*Chloride attack – limits of chloride.*	

S-6	SLO-1	*Determination of initial setting time of cement and final setting time (Demo only) - practically in lab.*	*Determination of fineness modulus of coarse aggregate practically in lab.*	*Determination of impact resistance of coarse aggregate practically in lab.*	*Compressive strength of bricks and concrete cubes practically in lab.*	*Determination of split tensile strength of concrete practically in lab.*
	SLO-2					
S-7	SLO-1	*Abrasion – bulk density – specific gravity Absorption and moisture content – bulking.*	*FRESH CONCRETE Workability –factors – tests.*	*Impact resistance test – Impact energy.*	*Effects of some materials on durability.*	*MANUFACUTRE OF CONCRETE Process – various stages of manufacture of concrete.*
	SLO-2	*Soundness – flakiness index – elongation index.*	*Slump and compaction factor tests.*	*Impact energy calculation*	*Surface treatments of concrete – materials used.*	*Batching – mixing*
S-8	SLO-1	*Grading – sieve analysis – fineness modulus.*	*Segregation – types – conditions – remedies.*	*Shrinkage – classifications – factors affect.*	*Concrete permeability test - Rapid chloride penetration test.*	*Transporting – Methods adopted for transportation of concrete.*
	SLO-2	*Water – quality – quantity.*	*Bleeding – effects – test.*	*Creep – definition – measurement of creep – factors affect.*	*Introduction to special concretes.*	*Placing – compacting - curing – finishing.*
S-9	SLO-1	*Determination of specific gravity of cement, fine and coarse aggregate practically in lab*	*Determination of bulking of sand practically in lab.*	*Determination of abrasion resistance of coarse aggregate practically in lab.*	*Workability of concrete – slump – compaction factor test practically in lab.*	*Determination of impact strength of concrete practically in lab.*
	SLO-2					

Learning Resources	1. *Neville, A.M. Properties of Concrete, Fifth Edition, Pearson, 2011.* 2. *Shetty, M.S. Concrete Technology, Theory and Practice, S. Chand & Company, New Delhi, 2013.* 3. *A.R. Santhakumar, Concrete Technology, 2009 Edition, Oxford University Press*	4. *Kumar Mehta Paulo,P and Monteiro, J.M. Concrete Microstructure, Properties and Materials, Fourth Edition, McGraw Hill Education, 2006, copy right ©2014.* 5. *NPTEL Course: Concrete Technology: https://nptel.ac.in/courses/105102012/* 6. *Laboratory Manual - SRMIST*

Learning Assessment

	Bloom's Level of Thinking	Continuous Learning Assessment (50% weightage)								Final Examination (50% weightage)	
		CLA – 1 (10%)		CLA – 2 (15%)		CLA – 3 (15%)		CLA – 4 (10%)#			
		Theory	Practice	Theory	Practice	Theory	Practice	Theory	Practice	Theory	Practice
Level 1	Remember Understand	*20 %*	*20 %*	*15 %*	*15 %*	*15 %*	*15 %*	*15 %*	*15 %*	*15 %*	*15 %*
Level 2	Apply Analyze	*20 %*	*20 %*	*20 %*	*20 %*	*20 %*	*20 %*	*20 %*	*20 %*	*20 %*	*20 %*
Level 3	Evaluate Create	*10 %*	*10 %*	*15 %*	*15 %*	*15 %*	*15 %*	*15 %*	*15 %*	*15 %*	*15 %*
	Total	100 %		100 %		100 %		100 %		100 %	

CLA – 4 can be from any combination of these: Assignments, Seminars, Tech Talks, Mini-Projects, Case-Studies, Self-Study, MOOCs, Certifications, Conf. Paper etc.,

Course Designers		
Experts from Industry	Experts from Higher Technical Institutions	Internal Experts
1. Er. G.Hariharanath, GA Consultants, Chennai, gac1996@hotmail.com	*1. Dr. R. Santhakumar, Professor, Centre for Rulal Department, NITTTR*	*1. Dr. K. Gunasekaran, SRMIST*
2. Er. AGV. Desigan, Design Group Engineering Consultancy Pvt Ltd. Chennai, desigan.agv@gmail.com	*2. Dr. P. Jayabalan, NIT, Trichy, pjeya@nitt.edu*	*2. Dr. P. R. KannanRajkumar, SRMIST*

Course Code	18CEE306T	Course Name	PRESTRESSED CONCRETE STRUCTURES	Course Category	E	Professional Elective	L	T	P	C
							3	0	0	3

Pre-requisite Courses	Nil	Co-requisite Courses	Nil	Progressive Courses	Nil
Course Offering Department	Civil Engineering	Data Book / Codes/Standards	IS 1343: 2012		

Course Learning Rationale (CLR):	*The purpose of learning this course is to:*	Learning			Program Learning Outcomes (PLO)														
		1	2	3	1	2	3	4	5	6	7	8	9	10	11	12	13	14	15
CLR-1 :	*Know and utilize the concepts of prestress concrete to analyseprestress concrete sections*	Level of Thinking (Bloom)	Expected Proficiency (%)	Expected Attainment (%)	Engineering Knowledge	Problem Analysis	Design & Development	Analysis, Design, Research	Modern Tool Usage	Society & Culture	Environment & Sustainability	Ethics	Individual & Team Work	Communication	Project Mgt. & Finance	Life Long Learning	PSO - 1	PSO - 2	PSO - 3
CLR-2 :	*Know and understand the different losses of prestress and anchorage zone stress to design*																		
CLR-3 :	*Understand flexural failure types and to analyze and also to design flexural and tension members*																		
CLR-4 :	*Understand shear strength analyze and also to design for shear. Also to analyze due to torsion*																		
CLR-5 :	*Know the design concept of prestressed concrete one way and two way slab*																		
CLR-6 :	*Know the design concept of prestressed concrete flat slab*																		
Course Learning Outcomes (CLO):	*At the end of this course, learners will be able to:*																		
CLO-1 :	*Analyze the prestress concrete sections using different concepts*	3	80	75	H	H	-	H	-	-	-	-	-	-	-	-	H	-	M
CLO-2 :	*Analyze the different losses of prestress and anchorage zone stress to design*	3	85	75	H	H	-	H	-	-	-	-	-	-	-	-	H	-	M
CLO-3 :	*Analyze and design of prestressed concrete flexural and tension members*	3	75	75	H	H	-	H	-	-	-	-	-	-	-	-	H	-	M
CLO-4 :	*Analyze and design of prestressed concrete for shear and also analyze due to torsion*	3	90	80	H	H	-	H	-	-	-	-	-	-	-	-	H	-	M
CLO-5 :	*Design the prestressed concrete one way and two way slab*	3	85	75	H	H	-	H	-	-	-	-	-	-	-	-	H	-	M
CLO-6 :	*Design the prestressed concrete flat slab*	3	80	75	H	H	-	H	-	-	-	-	-	-	-	-	H	-	M

Duration (hour)		9	9	9	9	9
S-1	SLO-1	*PRESTRESSED CONCRETE Introduction - Basic concept – Principle of prestressing – Materials.*	*LOSSES OF PRESTRESS Nature of losses of prestress – types of losses of prestress in – pre and post tensioning.*	*FLEXURAL STRENGTH ANALYSIS Flexural failure - control parameters.*	*SHEAR STRENGTH ANALYSIS Shear and principal stresses – maximum and minimum principal stresses.*	*PRESTRESSED CONCRETE SLAB Slabs types –cross section of floor panels.*
	SLO-2	*Forms of steel – systems of prestressing*		*Types of flexural failure.*	*Eliminate diagonal tension cracks - improvement of shear resistance.*	
S-2	SLO-1	*Types of prestressing – uses of prestressed concrete.*	*Loss due to elastic deformation*	*Indian code provisions – moment of resistance – bonded tendons only.*	*Example without and with axial prestress*	*Design of one-way slab*
	SLO-2	*Materials – concrete strength limitation – requirements of steel for prestressed concrete.*	*Example*	*Rectangular section*		
S-3	SLO-1	*Analysis – basic assumptions.*	*Loss due to shrinkage and creep of concrete*	*Examples*	*Example with curved cable and vertical cable.*	*Example*
	SLO-2	*Concentric and eccentric tendons – resultant stresses – at transfer – at service. Concepts of prestressing – rectangle – symmetrical I-section only.*	*Example*			
S-4	SLO-1	*Stress concept*	*Loss due to relaxation of steel – friction – anchorage slip.*	*T – Sections. Neutral axis – within the flange – outside the flange.*	*DESIGN FOR SHEAR Types of shear cracks – sections uncracked in flexure – sections cracked in flexure.*	*Example*
	SLO-2		*Example*	*Examples*	*Design of shear reinforcement*	
S-5	SLO-1	*Stress concept – examples*	*ANCHORAGE ZONE STRESSES Anchorage zone – nature of stresses – objective.*	*DESIGN FOR FLEXURE Stress conditions - minimum section modulus – critical combinations – four fundamental conditions – at transfer – at service loads.*	*Examples*	*Design of two-way slab*

	SLO-2		Stress distribution in end block – single and double anchor plates – ideal stress distribution.	Minimum prestressing force – maximum eccentricity.		
S-6	SLO-1	Stress concept - examples	Effect of transverse tensile stress	Examples	Examples	Example
	SLO-2		Analysis of anchorage zone stress – methods (names only)			
S-7	SLO-1	Strength concept - examples	Indian standard method of analysis of anchorage zone stresses	Examples	TORSION ANALYSIS Shear stress due to torsion - circular – rectangle – T –section and box section.	Design of simple flat slab
	SLO-2					
S-8	SLO-1	Load balancing concept – cable profile – reaction – equivalent loads.	Examples	DESIGN OF TENSION MEMBER Determination of area of concrete	Examples	Example
	SLO-2			Load factor – cracking and collapse		
S-9	SLO-1	Load balancing concept – examples.	Design of anchorage zone.	Example	Examples	Example
	SLO-2		Example			

Learning Resources	1. Krishnaraju .R, "Prestressed Concrete", Tata McGraw-Hill Education, Edition: 2018, NewDelhi. 2. Pandit .G.S, Gupta .S.P, "Prestressed Concrete", CBS Publishers & Distributors, 2008 3. S. Ramamrutham, "Prestressed Concrete", DhanpatRai Publishing Company, Fifth Edition, Reprint 2016	4. Lin T.Y, Design of, "Prestressed Concrete Structures", Asia Publishing House, Bombay 1995. 5. IS: 1343-2012 "IS Code of Practice for Prestressed Concrete", BIS, New Delhi, 2012. 6. NPTEL Course: Prestressed Concrete Structures: https://nptel.ac.in/courses/105106117/

Learning Assessment

	Bloom's Level of Thinking	Continuous Learning Assessment (50% weightage)								Final Examination (50% weightage)	
		CLA – 1 (10%)		CLA – 2 (15%)		CLA – 3 (15%)		CLA – 4 (10%)#			
		Theory	Practice	Theory	Practice	Theory	Practice	Theory	Practice	Theory	Practice
Level 1	Remember / Understand	40 %	-	30 %	-	30 %	-	30 %	-	30%	-
Level 2	Apply / Analyze	40 %	-	40 %	-	40 %	-	40 %	-	40%	-
Level 3	Evaluate / Create	20 %	-	30 %	-	30 %	-	30 %	-	30%	-
	Total	100 %		100 %		100 %		100 %		100 %	

CLA – 4 can be from any combination of these: Assignments, Seminars, Tech Talks, Mini-Projects, Case-Studies, Self-Study, MOOCs, Certifications, Conf. Paper etc.,

Course Designers

Experts from Industry	Experts from Higher Technical Institutions	Internal Experts
1. Er. G.Hariharanath, GA Consultants, Chennai, gac1996@hotmail.com	1. Dr. R. Santhakumar, Professor, Centre for Rulal Department, NITTTR	1. Dr. K. Gunasekaran, SRMIST
2. Er. AGV. Desigan, Design Group Engineering Consultancy Pvt Ltd. Chennai, desigan.agv@gmail.com	2. Dr. P. Jayabalan, NIT, Trichy, pjeya@nitt.edu	2. Dr. P. R. Kannan Rajkumar, SRMIST

Course Code	18CEE307T	Course Name	DESIGN OF EARTHQUAKE RESISTANT STRUCTURES	Course Category	E	Professional Elective	L	T	P	C
							3	0	0	3

Pre-requisite Courses	Nil	Co-requisite Courses	Nil	Progressive Courses	Nil
Course Offering Department	Civil Engineering	Data Book / Codes/Standards	IS 1893 (Part 1):2016, IS 13920 : 2016		

Course Learning Rationale (CLR):	*The purpose of learning this course is to:*
CLR-1 :	*Understand the principles of structural dynamics with regard to Single Degree Of Freedom (SDOF) system.*
CLR-2 :	*Extension of understanding of SDOF system to Multi Degree Of Freedom System (MDOF) with emphasis on two degree of freedom system.*
CLR-3 :	*Understand the fundamentals of earthquake forces.*
CLR-4 :	*Apply structural dynamics principles to the analysis of structures subjected to earthquake forces.*
CLR-5 :	*Design earthquake resistant moment resistant frames / shear walls with emphasis on ductile detailing.*
CLR-6 :	*Understand the modern concepts in the design of earthquake resistant structures using isolation techniques.*

Course Learning Outcomes (CLO):	*At the end of this course, learners will be able to:*	Learning 1: Level of Thinking (Bloom)	Learning 2: Expected Proficiency (%)	Learning 3: Expected Attainment (%)	PLO 1: Engineering Knowledge	PLO 2: Problem Analysis	PLO 3: Design & Development	PLO 4: Analysis, Design, Research	PLO 5: Modern Tool Usage	PLO 6: Society & Culture	PLO 7: Environment & Sustainability	PLO 8: Ethics	PLO 9: Individual & Team Work	PLO 10: Communication	PLO 11: Project Mgt. & Finance	PLO 12: Life Long Learning	PLO 13: PSO - 1	PLO 14: PSO - 2	PLO 15: PSO - 3
CLO-1 :	*Analyze single degree moment resistant frame for free and forced vibrations*	3	80	80	H	H	-	H	-	-	-	-	-	-	-	-	H	-	-
CLO-2 :	*Analyze two degree moment resistant frame for free vibrations using modal superposition method*	3	75	75	H	H	-	H	-	-	-	-	-	-	-	-	H	-	-
CLO-3 :	*Calculate base shear using equivalent static method as per IS 1893*	3	90	85	H	H	H	H	-	-	-	-	-	-	-	L	H	-	-
CLO-4 :	*Calculate base shear using response spectrum method as per IS 1893*	3	85	80	H	H	H	H	-	-	-	-	-	-	-	L	H	-	-
CLO-5 :	*Apply the provisions of IS13920 to structures*	3	90	80	H	M	M	M	-	-	L	-	-	-	-	L	H	-	-
CLO-6 :	*Suggest isolation systems for earthquake resistance*	3	75	75	H	L	L	L	-	-	L	-	-	-	-	-	M	-	-

Duration (hour)		9	9	9	9	9
S-1	SLO-1	*SINGLE DEGREE OF FREEDOM SYSTEM (SDOF)* *Introduction to Systems with single degree of freedom*	*MULTI-DEGREE OF FREEDOM SYSTEM (MDOF)* *Introduction to Systems with two degrees of freedom*	*DESIGN SEISMIC FORCES AS PER IS 1893-2016* *Basis of earthquakes – epicenter*	*DUCTILE DESIGN FOR EARTHQUAKE RESISTANCE USING IS 13920-2016* *Definition of ductility – member and structural*	*BASE ISOLATION* *Introduction to base isolation*
	SLO-2	*Definition of free vibration – mass, stiffness,*	*Introduction to Systems with multi degrees of freedom (MDOF)*	*Magnitude of earthquake – measurement – Richter's scale*	*Response reduction factor and ductility*	*Passive base isolation – introduction*
S-2	SLO-1	*Damped and undamped vibration*	*Moment resistant frames as MDOF– two degree freedom system*	*Intensity of earthquake – different scales*	*General specification for ductility*	*Base isolation for a building*
	SLO-2	*Fundamental / Natural frequency and time period – problem solving*	*Shear building and lumped mass*	*Configurations of buildings to resist earthquake*	*Ductile requirements of beams – general*	*Purpose of base isolation*
S-3	SLO-1	*Forced vibration –Harmonic loading*	*Calculation of column stiffness – effect of orientation of column on stiffness*	*Vertical and in-plan mass irregularities*	*Ductile requirements of beams – Longitudinal reinforcement*	*Principles of base isolation*
	SLO-2	*Derivation of equation of motion for free and forced vibration*	*Computation of diagonal mass matrix*	*Vertical and in-plan stiffness irregularities – calculation of eccentricities in plan*	*Ductile requirements of beams – Transverse reinforcement*	*Basic requirements of base isolation system*
S-4	SLO-1	*Solution of equation of motion for free vibration*	*Computation of stiffness matrix*	*Storey drift and storey shear*	*Ductile requirements of columns – geometry*	*Type of Base Isolation Systems – Elastomeric rubber bearings – Roller and ball bearings,*
	SLO-2	*Solution of equation of motion for forced vibration – harmonic loading*	*Forming acceleration and velocity vectors*	*Response spectrum*	*Relative strength of columns and beams at a joint*	
S-5	SLO-1	*Problem solving for finding the response for undamped free vibration*	*Equation of motion of undamped two degree lumped mass free vibration of moment resistant frame*	*Seismic zone factor, Importance factor,*	*Transverse reinforcement in column*	*Type of Base Isolation Systems – springs – sliding bearing*
	SLO-2	*Problem solving for finding the response for damped free vibration*	*Solution of equation of motion of undamped two degree freedom system for free vibration*	*Response reduction factor*	*Ductile detailing for shear walls – introduction*	*Modeliing base isolation in SAP – introduction*

S-6	SLO-1	*Problem solving for finding the response for undamped forced vibration*	*Eigen value problem and modal superposition method*	*Percentage of imposed loads , seismic weight of floors- Load combinations*	*General requirements*	*Input requirements for SAP*
	SLO-2	*Problem solving for finding the response for damped forced vibration*	*Determining modal frequencies and time periods*	*Introduction to Equivalent Static Method (ESM) and its limitations*	*Design for shear force*	*Input requirements for ETABS*
S-7	SLO-1	*Magnification factor*	*Uncoupled equations in SDOF and finding modal response*	*Computation of base shear for single & double storey moment resistant plane frame using ESM*	*Design for axial force*	*Modeling for base isolation in STAAD.Pro*
	SLO-2	*Application to determine the forces transferred to base from machine foundation*	*Undamped equation of motion for two degree moment resistant frame with lateral harmonic loading at the DOF*	*Introduction to Response Spectrum Method(RSM) and applicability*	*Design for bending moment*	*Input requirements for STAAD.Pro*
S-8	SLO-1	*Machine isolation*	*Modal superposition method to form uncoupled SDOF equations including modal load vector.*	*Computation of base shear for single storey and double storey moment resistant plane frame using RSM*	*Opening in walls – introduction*	*Introduction to active base isolation*
	SLO-2	*Determination of damping required to minimize forces transferred to foundation*	*Determination of response of the structure at discrete time intervals.*	*Introduction to DBE (Design Based Earthquake) and MCE(Maximum Considered Earthquake)*	*Detailing around the openings*	*Underlying principles of active base isolation*
S-9	SLO-1	*Definition of ground motion due to earthquake*	*Superposition of modal responses*	*Performance based design – Capacity and demand spectra as per ATC40*	*Ductile construction joints*	*Schematic diagram of a typical active base isolation system*
	SLO-2	*Equivalent model for considering ground motion in moment resistant fame*	*Square Root of Sum of Squares (SRSS) method.*	*Principles of pushover analysis and pushover curve*	*Ductile design of gravity columns in buildings*	*Comparison between passive and active base isolation*

Learning Resources	1. *Anil K.Chopra, "Dynamics of structures" (Theory and Applications to Earthquake Engineering), 5th Edition, Pearson, 2016* 2. *Short course on "Seismic design of reinforced concrete buildings", CEP, IIT, Kanpur, 2005.*	3. *IS 1893: 2016, (Part I) "Criteria for Earthquake Resistant Design of Structures - Part 1: General Provisions and Buildings", BIS, 2016.* 4. *IS 13920: 2016,"Ductile design and detailing of reinforced concrete structures subjected to seismic forces - Code of practice", BIS, 2016.*

Learning Assessment											
	Bloom's Level of Thinking	Continuous Learning Assessment (50% weightage)								Final Examination (50% weightage)	
		CLA – 1 (10%)		CLA – 2 (15%)		CLA – 3 (15%)		CLA – 4 (10%)#			
		Theory	Practice	Theory	Practice	Theory	Practice	Theory	Practice	Theory	Practice
Level 1	Remember Understand	*40 %*	-	*40 %*	-	*40 %*	-	*10 %*	-	*40%*	-
Level 2	Apply Analyze	*40 %*	-	*40 %*	-	*40 %*	-	*70 %*	-	*55%*	-
Level 3	Evaluate Create	*20 %*	-	*20 %*	-	*20 %*	-	*20 %*	-	*5%*	-
	Total	100 %		100 %		100 %		100 %		100 %	

CLA – 4 can be from any combination of these: Assignments, Seminars, Tech Talks, Mini-Projects, Case-Studies, Self-Study, MOOCs, Certifications, Conf. Paper etc.,

Course Designers		
Experts from Industry	Experts from Higher Technical Institutions	Internal Experts
1. Er. S. Dhanabal, General Manager, NLY, Neyveli, dhans1960@yahoo.co.in	*1. Dr. R. Santhakumar, Professor, Centre for Rulal Department, NITTTR*	*Prof. G. Augustine Maniraj Pandian, SRMIST*
2. Er. AGV. Desigan, Design Group Engineering Consultancy Pvt Ltd. Chennai, desigan.agv@gmail.com	*2. Dr. P. Jayabalan, NIT, Trichy, pjeya@nitt.edu*	*Dr. K.S. Satyanarayanan, SRMIST*

Course Code	18CEE308T	Course Name	DESIGN OF STEEL-CONCRETE COMPOSITE STRUCTURES	Course Category	E	Professional Elective	L	T	P	C
							3	0	0	3

Pre-requisite Courses	Nil	Co-requisite Courses	Nil	Progressive Courses	Nil
Course Offering Department	Civil Engineering	Data Book/Codes/Standards	IS 456 :2000, IS 800: 2007, IS 11384, Steel Tables		

Course Learning Rationale (CLR):	*The purpose of learning this course is to:*
CLR-1 :	*Understand the concept of steel-concrete composite member design and to get introduced to the relevant IS codes*
CLR-2 :	*Create insights to the concepts of Limit state method of design*
CLR-3 :	*Utilize the concepts in performing design of steel-concrete composite beams and columns*
CLR-4 :	*Utilize the concepts in performing design of steel-concrete composite connections*
CLR-5 :	*Understand the behaviour of composite girder bridges*
CLR-6 :	*Create insights to the seismic behaviour of composite structures*

		Learning			Program Learning Outcomes (PLO)														
		1	2	3	1	2	3	4	5	6	7	8	9	10	11	12	13	14	15
Course Learning Outcomes (CLO):	*At the end of this course, learners will be able to:*	Level of Thinking (Bloom)	Expected Proficiency (%)	Expected Attainment (%)	Engineering Knowledge	Problem Analysis	Design & Development	Analysis, Design, Research	Modern Tool Usage	Society & Culture	Environment & Sustainability	Ethics	Individual & Team Work	Communication	Project Mgt. & Finance	Life Long Learning	PSO - 1	PSO - 2	PSO – 3
CLO-1 :	*Identify the effect of external loads on steel-concrete composite members and the factors influencing their behaviour and to get familiarity with the relevant IS codes*	*2*	*85*	*80*	*H*	*-*	*-*	*M*	*-*	*-*	*-*	*-*	*-*	*-*	*-*	*H*	*H*	*M*	*-*
CLO-2 :	*Analyze the behavior of steel-concrete composite sections under flexure, shear and compression*	*2*	*85*	*80*	*H*	*H*	*-*	*M*	*-*	*-*	*-*	*-*	*-*	*-*	*-*	*H*	*H*	*M*	*-*
CLO-3 :	*Apply Limit state method of design to steel-concrete composite beams and columns*	*2*	*80*	*75*	*H*	*H*	*H*	*H*	*-*	*-*	*-*	*-*	*-*	*-*	*-*	*H*	*H*	*M*	*-*
CLO-4 :	*Apply Limit state method of design to steel-concrete composite connections*	*2*	*80*	*75*	*H*	*H*	*-*	*M*	*-*	*-*	*-*	*-*	*-*	*-*	*-*	*H*	*H*	*M*	*-*
CLO-5 :	*Analyze the behavior of steel-concrete composite girder bridges*	*2*	*80*	*75*	*H*	*-*	*-*	*M*	*-*	*-*	*-*	*-*	*-*	*-*	*-*	*H*	*H*	*M*	*-*
CLO-6 :	*Analyze the seismic behaviour of composite structures*	*2*	*85*	*80*	*H*	*H*	*H*	*H*	*-*	*-*	*-*	*-*	*-*	*-*	*-*	*H*	*H*	*M*	*-*

Duration (hour)		9	9	9	9	9
S-1	SLO-1	*INTRODUCTION Introduction to Steel - Concrete Composite Construction-Advantages-Limitations*	*Design Example 1*	*Design Example 3*	*Design Example 1*	*SEISMIC BEHAVIOUR OF STEEL-CONCRETE COMPOSITE STRUCTURES Introduction*
	SLO-2	*Materials to be used-Structural advantages-Factors deciding selection of materials*	*Design Example 1*	*DESIGN OF CONNECTIONS Introduction*	*Design Example 1*	*Basic concepts*
S-2	SLO-1	*Introduction to steel - concrete composite codes/standards*	*Design Example 2*	*Types of Connections*	*Design Example 2*	*General design criteria*
	SLO-2	*Limitations of using BIS codes-Introduction to Eurocode 4*	*Design Example 2*	*Choice of Connections in Composite structures*	*Design Example 2*	*General design criteria*
S-3	SLO-1	*Theory of composite structures*	*Design Example 2*	*Behaviour of Connections in Composite structures*	*DESIGN OF STEEL-CONCRETE COMPOSITE GIRDER BRIDGES Introduction*	*Code provisions*
	SLO-2	*Behaviour of composite beams*	*Design Example 2*	*Basic concepts*	*Behaviour of girder bridges*	*Seismic behaviour of composite beams*
S-4	SLO-1	*Behaviour of composite beams*	*Design of Composite Columns*	*Code provisions*	*Behaviour of girder bridges*	*Seismic behaviour of composite beams*
	SLO-2	*Behaviour of composite columns*	*Design Procedure*	*Design procedure*	*Design concepts*	*Seismic behaviour of composite slabs*
S-5	SLO-1	*Behaviour of composite columns*	*Relevant BIS code provisions*	*Design Example 1*	*Design concepts*	*Seismic behaviour of composite slabs*
	SLO-2	*Limit state method of design of steel-concrete composite sections under flexure-code provisions*	*Choice of cross-sections*	*Design Example 1*	*Materials to be used-Types of cross-sections*	*Seismic behaviour of composite columns*
S-6	SLO-1	*Limit state method of design of steel-concrete composite sections under shear- code provisions*	*Design Example 1*	*Design Example 2*	*Basic design considerations*	*Seismic behaviour of composite columns*
	SLO-2	*Limit state method of design of steel-concrete composite sections under compression- code provisions*	*Design Example 1*	*Design Example 2*	*Basic design considerations*	*Seismic behaviour of composite connections*

S-7	SLO-1	*DESIGN OF STEEL-CONCRETE COMPOSITE MEMBERS* *Design of Composite beams*	*Design Example 1*	*Design Example 3*	*Failure types*	*Seismic behaviour of composite connections*
	SLO-2	*Design Procedure*	*Design Example 2*	*Design Example 3*	*Failure types*	*Seismic behaviour of composite frames*
S-8	SLO-1	*Relevant BIS code provisions*	*Design Example 2*	*Design of Shear Connections*	*Relevant code provisions*	*Seismic behaviour of composite frames*
	SLO-2	*Choice of cross-sections*	*Design Example 2*	*Basic concepts*	*Mandatory checks*	*Seismic behaviour of composite frames*
S-9	SLO-1	*Design Example 1*	*Design Example 3*	*Code provisions*	*Comparison with conventional bridge types*	*Design methods*
	SLO-2	*Design Example 1*	*Design Example 3*	*Design procedure*	*Comparison with conventional bridge types*	*Design methods*

Learning Resources	1. *"Teaching Resource Material for Structural Steel Design", Volume 2/3 jointly prepared by 1. I.I.T., MS 2. Anna University 3. SERC, MS 4. "Institute for Steel Development and growth", Calcutta.* 2. *Owens .G.W, & Knowels.P. "Steel Designs Manual", (sixth Edition) Steel Concrete Institute (UK) Oxford Black; well Scientific Publications, 2003.*	3. *Johnson.R.P, "Composite Structures of Steel and Concrete". Vol-I, # Oxford Black; well Scientific Publications (Third Edition) U.K. 2004.* 4. *Subramanian.N, Design of Reinforced Concrete Structures, Oxford University Press New Delhi, 2013* 5. *Subramanian.N, Design of Steel structures-Limit state method, Oxford University Press New Delhi, 2016*

	Bloom's Level of Thinking	Continuous Learning Assessment (50% weightage)								Final Examination (50% weightage)	
		CLA – 1 (10%)		CLA – 2 (15%)		CLA – 3(15%)		CLA – 4 (10%)			
		Theory	Practice	Theory	Practice	Theory	Practice	Theory	Practice	Theory	Practice
Level 1	Remember Understand	*30%*	-	*30%*	-	*30%*	-	*30%*	-	*30%*	-
Level 2	Apply Analyze	*50%*	-	*50%*	-	*50%*	-	*50%*	-	*60%*	-
Level 3	Evaluate Create	*20%*	-	*20%*	-	*20%*	-	*20%*	-	*10%*	-
	Total	100 %		100 %		100 %		100 %		100 %	

CLA – 4 can be from any combination of these: Assignments, Mini-Projects

Course Designers		
Experts from Industry	Experts from Higher Technical Institutions	Internal Experts
1. Er. G.Hariharanath, GA Consultants, Chennai, gac1996@hotmail.com	*1. Dr. R. Santhakumar, Professor, Centre for Rulal Department, NITTTR*	*Prof.G.Augustine Maniraj Pandian, SRMIST*
2. Er. AGV. Desigan, Design Group Engineering Consultancy Pvt Ltd. Chennai, desigan.agv@gmail.com	*2. Dr. P. Jayabalan, NIT, Trichy, pjeya@nitt.edu*	*Prof. N.Umamaheswari, SRMIST*

Course Code	18CEE310T	Course Name	SOLID AND HAZARDOUS WASTE MANAGEMENT	Course Category	E	Professional Elective	L	T	P	C
							3	0	0	3

Pre-requisite Courses	Nil	Co-requisite Courses	Nil	Progressive Courses	Nil
Course Offering Department	CIVIL ENGINEERING	Data Book / Codes/Standards	Nil		

Course Learning Rationale (CLR):	*The purpose of learning this course is to:*
CLR-1 :	*Create insights to the various sources and classification of solid and hazardous waste*
CLR-2 :	*Address concepts related to waste characteristics and source reduction*
CLR-3 :	*Create insights to the storage, collection and transport of waste*
CLR-4 :	*Address concepts related to waste processing technologies*
CLR-5 :	*Address concepts related to waste disposal*
CLR-6 :	*Role of Government and NGO's in sustaining the waste management*

Course Learning Outcomes (CLO):	*At the end of this course, learners will be able to:*	Learning 1: Level of Thinking (Bloom)	2: Expected Proficiency (%)	3: Expected Attainment (%)	PLO 1: Engineering Knowledge	2: Problem Analysis	3: Design & Development	4: Analysis, Design, Research	5: Modern Tool Usage	6: Society & Culture	7: Environment & Sustainability	8: Ethics	9: Individual & Team Work	10: Communication	11: Project Mgt. & Finance	12: Life Long Learning	13: PSO - 1	14: PSO - 2	15: PSO – 3
CLO-1 :	*Understand the various sources of solid and hazardous waste*	2	85	80	H	H	M	L	-	L	H	-	-	-	-	L	M	-	-
CLO-2 :	*Able to identify the options for Reduction, reuse and recycling of waste*	2	85	75	H	H	H	H	-	-	H	-	-	-	-	-	M	-	-
CLO-3 :	*Knowledge of collection and transport of solid and hazardous waste*	2	80	75	H	H	M	M	-	L	H	-	-	-	-	L	M	-	-
CLO-4 :	*Able to know about various waste processing techniques*	2	85	75	H	H	H	H	-	-	H	-	-	-	-	-	M	-	-
CLO-5 :	*Understand the waste disposal methods and management*	2	85	80	H	H	M	M	L	L	M	-	-	-	-	L	M	-	-
CLO-6 :	*Knowledge of basic solid and hazardous waste legislations*	2	80	75	H	H	M	-	-	L	M	-	-	-	-	-	M	-	-

Duration (hour)		9	9	9	9	9
S-1	SLO-1	*Sources, classification and regulatory framework: Sources of solid waste*	*Waste characterization and source reduction: Waste generation rates*	*Storage, collection and transport of waste: Handling of waste at source*	*Waste processing technologies: Objectives of waste processing*	*Waste disposal : Waste disposal options for solid and hazardous waste*
	SLO-2	*Types of solid waste*	*Waste generation variation*	*Segregation of waste at source*	*material separation technologies in solid waste*	*Disposal in landfills*
S-2	SLO-1	*Hazardous Waste - Identification*	*sampling and characterization*	*Storage of municipal solid waste*	*Physical Processing Equipment*	*Landfill Classification*
	SLO-2	*Hazardous Waste -Classification*	*factors affecting waste generation rate and Composition*	*On-site storage methods*	*material processing technologies*	*Landfill types*
S-3	SLO-1	*Need for solid waste management*	*Physical properties of solid waste*	*Effect of storage*	*chemical conversion technologies*	*Landfill methods*
	SLO-2	*Need for hazardous waste management*	*Chemical properties of solid waste*	*Materials used for containers*	*biological conversion technologies methods of Composting*	*Site selection*
S-4	SLO-1	*Elements of integrated waste management*	*Biological properties of solid waste*	*Collection of municipal solid waste-Methods*	*biological conversion technologies methods of Composting*	*Design and operation of sanitary landfills*
	SLO-2	*roles of stakeholder's*	*Hazardous Characteristics*	*Collection vehicles – Manpower – Collection routes*	*Factors of Composting*	*Landfill liners*
S-5	SLO-1	*Role of public and NGO's*	*TCLP tests*	*Analysis of Collection systems*	*Thermal conversion technologies-energy recovery*	*Secure landfills*
	SLO-2	*Tutorial 1: Case Study: Status of Waste Generation in Bangalore*	*Tutorial 3 : Practices in household waste management*	*Solving problems using Tutorial Sheet 7*	*Thermal conversion technologies- energy recovery*	*Landfill bioreactors*
S-6	SLO-1	*Public health and environmental impacts*	*Tutorial 4: Source Reduction and Recycling.*	*Need for transfer and transport*	*Incineration*	*Leachate management*
	SLO-2	*Salient features of Indian legislations on management and handling of municipal solid waste*	*Source reduction of waste*	*Transfer stations*	*Hazardous Waste Treatment*	*Landfill gas management*

S-7	SLO-1	*Hazardous waste*	*Waste exchange*	*Hazardous Waste-Storage and collection*	*Physical and chemical treatment*	*Landfill closure*
	SLO-2	*Biomedical waste*	*Extended producer responsibility*	*Hazardous Waste-Storage and collection*	*Thermal treatment*	*Environmental monitoring*
S-8	SLO-1	*Lead acid batteries*	*Recycling*	*Hazardous Waste -Transfer and transport*	*Biological treatment*	*Rehabilitation of open dumps*
	SLO-2	*Electronic waste*	*Reuse*	*Hazardous Waste -Transfer and transport*	*Pollution Prevention and Waste Minimization*	*Landfill remediation*
S-9	SLO-1	*Plastics and fly ash*	*Solving problems using Tutorial Sheet 5*	*Hazardous waste manifests*	*Hazardous Wastes Management in India*	*Solving problems using Tutorial Sheet 9*
	SLO-2	*Tutorial 2: Mention the public awareness program*	*Solving problems using Tutorial Sheet 6*	*Hazardous waste transport*	*Solving problems using Tutorial Sheet 8*	*Solving problems using Tutorial Sheet 10*

Learning Resources	1. *George Tchobanoglous, Hilary Theisen and Samuel A, Vigil, "Integrated Solid Waste Management, Mc-Graw Hill International edition, New York, 1993.* 2. *Michael D. LaGrega, Philip L Buckingham, Jeffrey C. E vans and Environmental Resources Management, Hazardous waste Management, Mc-Graw Hill International edition, New York, 2001.*	3. *CPHEEO, "Manual on Municipal Solid waste management, Central Public Health and Environmental Engineering Organisation, Government of India, New Delhi, 2000.* 4. *NPTEL Course-Municipal solid waste management : https://nptel.ac.in/courses/120108005/* 5. *NPTEL Course-Solid and Hazardous waste management : https://nptel.ac.in/courses/105106056/*

Learning Assessment

	Bloom's Level of Thinking	Continuous Learning Assessment (50% weightage)								Final Examination (50% weightage)	
		CLA – 1 (10%)		CLA – 2 (15%)		CLA – 3 (15%)		CLA – 4 (10%)			
		Theory	Practice	Theory	Practice	Theory	Practice	Theory	Practice	Theory	Practice
Level 1	Remember Understand	*60%*	-	*60%*	-	*60%*	-	*60%*	-	*60%*	-
Level 2	Apply Analyze	*40%*	-	*40%*	-	*40%*	-	*40%*	-	*40%*	-
Level 3	Evaluate Create	-	-	-	-	-	-	-	-	-	-
	Total	100 %		100 %		100 %		100 %		100 %	

CLA – 4 can be from any combination of these: Assignments, Seminars, Tech Talks, Mini-Projects, Case-Studies, Self-Study, MOOCs, Certifications, and Conference Paper etc.

Course Designers

Experts from Industry	Experts from Higher Technical Institutions	Internal Experts
1. Dr. Rajkumar Samuel, Hubert Enviro-Care Systems, Chennai, rajkumar@hecs.in	*1. Dr. E. S. M Suresh, NITTTR Taramani Chennai, esmsuresh@gmail.com*	*Mr. D. Justus Reymond, Asst.Prof, SRMIST*
2. Mr. A. Abdul Rasheed, CMWSS Board, juruterarasheed@gmail.com	*2. Dr. G. Dhinagaran, Asst. Professor, CES, Anna University, twinsdina@gmail.com*	*Mr. S. Dhanasekar, Asst.Prof, SRMIST*

Course Code	18CEE311T	Course Name	AIR AND NOISE POLLUTION AND CONTROL	Course Category	E	Professional Elective	L	T	P	C
							3	0	0	3

Pre-requisite Courses	Nil	Co-requisite Courses	Nil	Progressive Courses	Nil
Course Offering Department	CIVIL ENGINEERING	Data Book / Codes/Standards	Nil		

Course Learning Rationale (CLR):	*The purpose of learning this course is to:*
CLR-1 :	*Create insights to the various sources ofair quality*
CLR-2 :	*Address concepts related to modeling of atmospheric pollutants*
CLR-3 :	*Create insights to the air and noise pollution monitoring techniques*
CLR-4 :	*Address concepts related to reduce air pollution*
CLR-5 :	*Address concepts related to reduce noise pollution*
CLR-6 :	*Role of Government and NGO's in sustaining the air pollution at the source*

		Learning			Program Learning Outcomes (PLO)														
		1	2	3	1	2	3	4	5	6	7	8	9	10	11	12	13	14	15
Course Learning Outcomes (CLO):	*At the end of this course, learners will be able to:*	Level of Thinking (Bloom)	Expected Proficiency (%)	Expected Attainment (%)	Engineering Knowledge	Problem Analysis	Design & Development	Analysis, Design, Research	Modern Tool Usage	Society & Culture	Environment & Sustainability	Ethics	Individual & Team Work	Communication	Project Mgt. & Finance	Life Long Learning	PSO - 1	PSO - 2	PSO – 3
CLO-1 :	*Understand the various sources of air and noise pollution*	2	85	80	H	H	M	L	-	L	H	-	-	-	-	L	M	-	-
CLO-2 :	*Able to analyze air quality parameters*	2	85	75	H	H	H	H	-	-	H	-	-	-	-	-	M	-	-
CLO-3 :	*Knowledge of atmospheric transport models for air pollutants*	2	80	75	H	H	M	M	-	L	H	-	-	-	-	L	M	-	-
CLO-4 :	*Able to identify techniques to reduce noise pollution*	2	85	75	H	H	H	H	-	-	H	-	-	-	-	-	M	-	-
CLO-5 :	*Apply the concept of reducing air and noise pollution*	2	85	80	H	H	M	M	L	L	M	-	-	-	-	L	M	-	-
CLO-6 :	*Knowledge of basic environmental legislations related to air and noise pollution*	2	80	75	H	H	M	-	-	L	M	-	-	-	-	-	M	-	-

Duration (hour)		9	9	9	9	9
S-1	SLO-1	*Introduction*	*Sources, classification and effects*	*Sampling and Meteorology*	*Air Pollution Control Measures*	*Noise pollutionand its control*
	SLO-2	*Air pollutants, Sources, classification,*	*Ambient air quality and emission standards*	*Ambient air sampling*	*Basics of pollution control*	*Basics of acoustics and specification of sound;*
S-2	SLO-1	*Monitoring techniques for air and noise pollution*	*Air pollution indices.*	*pollution measurement methods,*	*Control equipments –*	*sound power, sound intensity and sound pressure levels;*
	SLO-2	*Combustion Processes and pollutant emission,*	*Natural sources*	*principles and instruments*	*Particulate control methods*	*plane, point and line sources, multiple sources;*
S-3	SLO-1	*Air Act, legislation and regulations*	*Type of air pollutants*	*Monitoring stations in India*	*settling chambers,*	*outdoor and indoor noise propagation;*
	SLO-2	*Air quality management in India.*	*Effects on Health, vegetation-*	*temperature lapse rate and stability*	*cyclone separation,*	*psychoacoustics and noise criteria,*
S-4	SLO-1	*Greenhouse effect.*	*-materials and atmosphere*	*Adiabatic lapse rate*	*Wet collectors*	*effects of noise on health, annoyance rating schemes;*
	SLO-2	*Urban heat island*	*Reactions of pollutants in the atmosphere and their effects*	*Wind Rose, Inversion*	*fabric filters*	*special noise environments*
S-5	SLO-1	*Major contributions of air pollutant*	*-Smoke, smog and ozone*	*Wind velocity and turbulence*	*electrostatic precipitators*	*Infrasound, ultrasound, impulsive sound and sonic boom;*
	SLO-2	*Noise -What is Noise?*	*Layerdisturbance,*	*Plume behavior*	*Removal of gaseous pollutants by adsorption, absorption,*	
S-6	SLO-1	*Noise pollution,*	*Ambient noise quality and emission standards*	*Carbon emission*	*Biological air pollution control technologies,*	*noise standards and limit values;*
	SLO-2	*Sources, classification,*	*Noise pollution indices.*	*Noise sampling and Noise level meter*	*Indoor air quality*	*Occupational noise standard*
S-7	SLO-1	*Monitoring techniques for noise pollution*	*Manmade sources*	*Pollution measurement methods,*	*control principles*	*Noise instrumentation and monitoring procedure.*
	SLO-2	*Noise Act, legislation and regulations*	*Types of noise pollutant*	*Principles and instruments*	*Alternative*	*Noise indices.*
S-8	SLO-1	*Noise quality management in India.*	*Effects on Human Health and*	*Occupational noise monitoring*	*Case studies on Air pollution -1*	*Noise control methods*
	SLO-2	*Noise management in other countries*	*O0occupational exposure*	*Monitoring-case studies*	*Case studies on Air pollution -1*	*Case studies on Air pollution– 2*
S-9	SLO-1	*Solving problems using Tutorial Sheet 1*	*Solving problems using Tutorial Sheet 3*	*Tutorial hour-1*	*Tutorial hour-3*	*Case studies on noise pollution*
	SLO-2	*Solving problems using Tutorial Sheet 2*	*Solving problems using Tutorial Sheet 4*	*Tutorial hour-2*	*Tutorial hour-4*	*Case studies on noise pollution*

Learning Resources	1. *C. S. Rao, "Environmental Pollution Control Engineering", Wiley Eastern Limited, 2000.* 2. *M. N. Rao, H. V. N. Rao, Air pollution, Tata McGraw Hill Pvt Ltd, New Delhi, 1993* 3. *Dr. Y. Anjaneyulu, "Air Pollution and Control Technologies", Allied publishers Pvt. Ltd., 2002.* 4. *Noel De Nevers, "Air pollution control Engineering", McGraw Hill International Edition* 5. *Peterson and E.Gross Jr., "Hand Book of Noise Measurement", 5 th Edition, 1963*	6. *Mukherjee, "Environmental Pollution and Health Hazards", causes and effects, 1986* 7. *Antony Milne, "Noise Pollution: Impact and Counter Measures", David & Charles PLC, 1979.* 8. *Kenneth wark, Cecil F.Warner, "Air Pollution its Origin and Control", Harper and Row Publishers* 9. *NPTEL Online Course - Noise Management and Control : https://swayam.gov.in/nd1_noc19_me72/*

Learning Assessment											
	Bloom's Level of Thinking	Continuous Learning Assessment (50% weightage)								Final Examination (50% weightage)	
		CLA – 1 (10%)		CLA – 2 (15%)		CLA – 3 (15%)		CLA – 4 (10%)#			
		Theory	Practice	Theory	Practice	Theory	Practice	Theory	Practice	Theory	Practice
Level 1	Remember Understand	*60%*	-	*60%*	-	*60%*	-	*60%*	-	*60%*	-
Level 2	Apply Analyze	*40%*	-	*40%*	-	*40%*	-	*40%*	-	*40%*	-
Level 3	Evaluate Create	-	-	-	-	-	-	-	-	-	-
	Total	100 %		100 %		100 %		100 %		100 %	

CLA – 4 can be from any combination of these: Assignments, Seminars, Tech Talks, Mini-Projects, Case-Studies, Self-Study, MOOCs, Certifications, and Conf. Paper etc.

Course Designers		
Experts from Industry	Experts from Higher Technical Institutions	Internal Experts
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Dr.Rajkumar Director Hubert Envirocare Systems, Chennai rajkumar@hecs.in	*Dr. E.S.M Suresh Professor & Head Department of Civil Engineering NITTTR, Chennaiesmsuresh@gmail.com*	*Mr. S.Ramesh, Assist. Prof & Mr.K.C. Vinuprakash, Assist. Prof. SRMIST*

Course Code	18CEE312T	Course Name	ENVIRONMENTAL IMPACT ASSESSMENT AND LIFE CYCLE ANALYSIS	Course Category	E	Professional Elective	L	T	P	C
							3	0	0	3

Pre-requisite Courses	Nil	Co-requisite Courses	Nil	Progressive Courses	Nil
Course Offering Department	CIVIL ENGINEERING	Data Book / Codes/Standards	Nil		

Course Learning Rationale (CLR):	*The purpose of learning this course is to:*
CLR-1 :	*Know the interrelationship between various activities and their impact on environment*
CLR-2 :	*Understand how to conduct an environmental impact assessment*
CLR-3 :	*Learn principles and methods of environmental analysis*
CLR-4 :	*review and comment on an environmental impact statement, environmental assessment and environmental regulations*
CLR-5 :	*Understand role of standards and how government, NGOs, and the private sector can affect their evolution*
CLR-6 :	*Explain the concept of life cycle assessment (LCA) as an environmental management tool and its potential for identifying all the environmental impacts throughout the entire life cycle of a product*

Course Learning Outcomes (CLO):	*At the end of this course, learners will be able to:*	Learning 1 Level of Thinking (Bloom)	2 Expected Proficiency (%)	3 Expected Attainment (%)	PLO 1 Engineering Knowledge	2 Problem Analysis	3 Design & Development	4 Analysis, Design, Research	5 Modern Tool Usage	6 Society & Culture	7 Environment & Sustainability	8 Ethics	9 Individual & Team Work	10 Communication	11 Project Mgt. & Finance	12 Life Long Learning	13 PSO - 1	14 PSO - 2	15 PSO – 3
CLO-1 :	*Explainkey concepts in environmental impact assessment & Management*	3	85	80	H	-	-	-	-	-	H	H	-	-	-	-	M	-	-
CLO-2 :	*Understand the importance of various rules & regulation in EIA*	2	85	75	-	M	-	-	-	M	H	-	-	-	-	-	M	-	-
CLO-3 :	*Evaluate the Impact on various environments and role of stake holders in EIA*	2	80	75	H	M	-	M	-	M	M	-	-	-	-	-	M	-	-
CLO-4 :	*Explain the application of Life cycle analysis*	2	85	75	H	M	-	-	-	H	H	M	-	-	-	-	M	-	-
CLO-5 :	*Identify most suitable tool for assessment process and make suggestions for solutions*	2	85	80	H	H	-	M	M	-	M	M	-	-	-	-	M	-	-
CLO-6 :	*Participate in a group to evaluate a project using EIA & LCA using one or more management tools*	2	80	75	H	H	-	M	-	-	H	-	H	-	-	-	H	-	-

Duration (hour)		9	9	9	9	9
S-1	SLO-1	*Introduction* *Introduction, definitions and concepts of EIA, Ethics and environment, EIA for civil engineers*	*Evolution of EIA* *Evolution of EIA worldwide; Evolution of EIA in India; Forecasting Environmental Changes*	*Assessment Technique* *Components of the Environment: Water-Standards pertaining to water quality*	*Life Cycle Analysis* *Life cycle assessment and its purpose; Evolution of Life Cycle Assessment; Stages in LCA of a Product; A Code of Good Conduct for LCA*	*EIA Methodologies* *Initial Environmental Examination; Screening*
	SLO-2	*Discussion: Identify the Ethics that you breach in daily activities which affects the environment*	*Discussion: Introduction to importance of Rio Convention*	*Activity & Discussion using a Case Study*	*Discussion: Necessary for LCA*	*Case Study involving screening*
S-2	SLO-1	*Ecology and the environment ; Ecosystem and its characteristics*	*Types of EIA: Rapid; Comprehensive; Strategic; Sectoral; Regional Rationale and scope of each type*	*Components of the Environment: Air & Noise- Standards pertaining to Air & Noise quality*	*Procedures for LCA; Defining the goal and scope; Analyzing the inventory; Assessing environmental impact*	*Scoping Analysis of alternatives*
	SLO-2	*In continuation with previous class discussion in how the ecosystem in which you live gets affected your activities*	*Case Study*	*Activity & Discussion using a Case Study*	*Case Study using LCA*	*Case Study in EIA*
S-3	SLO-1	*Structure of Ecosystem; Biotic Components Abiotic components*	*EIA Regulations in India* *Overview of Indian laws – Constitutional Provisions (Water, Air, Forest, Hazardous etc)*	*Components of the Environment: Soil- Soil quality, Landuse Criteria*	*Carbon trading: Energy foot printing, Food foot printing and Carbon foot printing.*	*Mitigation- Definition, options for mitigation of impact on water, air and land, water, energy, flora and fauna*
	SLO-2	*Identify the impact of your activities on Biotic and abiotic components of your ecosystem& How their services gets affected*	*Discussion: Evolution of law with time*	*Activity & Discussion using a Case Study*	*Case Study On carbon footprint*	*Case study Employing mitigation measures*
S-4	SLO-1	*Food chains, Food webs and Tropic levels*	*EPA 1986*	*Components of the Environment: Biosphere (Macro, Micro)- Introduction to Hazard Exposure levels for biota*	*Environmental management: Principles, problems and strategies; Review of political, ecological and remedial actions.*	*Environmental Impact Statement- Document planning - collection and organization of relevant information*
	SLO-2	*Identify the impact of your activities on various trophic levels of your ecosystem*	*Discussion: Amendment of E(P) Rules, 1986 on time of 545 days for finalisation of Draft Notification (MOEFCC Website)*	*Activity & Discussion using a Case Study*	*Discussion With Activity: Why Environmental Management is important – using case study*	*Example: Case study with Documentation*
S-5	SLO-1	*Energy and energy flows; Elemental cycles,*	*EIA Notification 2006*	*Components of the Environment: Socio-economic*	*Environmental audit: Definitions,concepts, partial audit, compliance audit, methods & regulations.*	*ToR& Sectoral ToR*

	SLO-2	Choose a element cycle and how it affects the ecosystem	Case Study	Activity & Discussion using a Case Study	Discussion: Introduction to ISO 19011 (EMS Auditing)	Example of ToR for various environments
S-6	SLO-1	Concept of Succession;Role of succession in restoration and recovery of ecosystem	CPCB and State PCBs – roles and responsibilities	Components of the Environment: Cultural and Aesthetics	Local infrastructure development and environmental management: A system approach, Regional environmental management system Landuse Conversion plan development and implementation strategies	Environmental Assessment- Base line, Construction Phase, Post Construction/ Operational phase scenario
	SLO-2	Example: Restoration of an ecosystem (Mining area)	Discussion: Sethusamudram Project- Role of CPCB& SPCB and Central & State Governments	Activity & Discussion using a Case Study	Discussion: Problems faced in developmental projects- using case study	Case study on a project
S-7	SLO-1	Ecosystem disturbances and their causes; natural causes and anthropogenic causes	Structured Environmental Management Systems ISO 14001 - EMS	Role of Public Participation in EIA	Environmental management systems in local government. Certification body assessments of EMS Documentation for EMS	Impact Assessment Methodologies: Checklists- Simple, Descriptive, Scaling Checklist
	SLO-2	Discussion: How Do Species Replace One Another in Ecological Succession?	Case Study: (Whitelaw and Butterworth, ISO 14001: Environmental System Handbook, 1997)	Reference EIA Notification 2006	Discussion: Expert systems (Software/ Model) used for EMS	Case study involving Checklist methods
S-8	SLO-1	Ecosystem and Ecological Footprints	ISO 18001- OHSAS	Role of stakeholders	Sustainable development – Definitions, Charter and Global Conventions; Future scenarios.	Matrix- Simple, Interaction- Leopold Matrix, Stepped matrix
	SLO-2	Discussion: How Cultural Changes Have Increased Our Ecological Footprints?	Discussion: Accreditation Procedure for ISO 14001	Activity & Discussion using a Case Study, Role Play	Discussion on various important conventions	Case study involving Matrix methods Discussion: Aldo Leopold's Environmental Ethics
S-9	SLO-1	Discussion of basic concepts	Environmental Risk Assessment	Setting the baseline	Case Studies on EIA	Network Methods Decision Tree, Expert Systems
	SLO-2	Example: Case study (An Affected Area)	Discussion: risk screening/prioritization	Discussion-Describe the various aspects of the environmental components of your neighborhood	Case Studies on EIA	Case study involving Network methods Introduction to various Expert system (Software/ models widely used)

Learning Resources	1. .L. W. Canter, Environmental Impact Assessment, 2nd Ed., McGraw-Hill, 1997. 2. G. Burke, B. R. Singh and L. Theodore, Handbook of Environmental Management and Technology, 2nd Ed., John Wiley & Sons, 2000 3. R. Therivel, John Glasson, Andrew Chadwick, Introduction to Environmental Impact Assessment (Natural and Built Environment), Routledge, 2005. 4. K. Whitelaw and Butterworth, ISO 14001: Environmental System Handbook, 1997	5. H. Scott Matthews, Chris T. Hendrickson, and Deanna Matthews, Life Cycle Assessment: Quantitative Approaches for Decisions that Matter, 2014. Open access textbook, retrieved from https://www.lcatextbook.com/ 6. NPTEL Course - Environmental Management: https://nptel.ac.in/courses/120108004/16# 7. NPTEL Course - Environmental Impact Assessment : https://nptel.ac.in/syllabus/105103024/

Learning Assessment

	Bloom's Level of Thinking	Continuous Learning Assessment (50% weightage)								Final Examination (50% weightage)	
		CLA – 1 (10%)		CLA – 2 (15%)		CLA – 3 (15%)		CLA – 4 (10%)#			
		Theory	Practice	Theory	Practice	Theory	Practice	Theory	Practice	Theory	Practice
Level 1	Remember Understand	60%	-	60%	-	60%	-	60%	-	60%	-
Level 2	Apply Analyze	40%	-	40%	-	40%	-	40%	-	40%	-
Level 3	Evaluate Create	-	-	-	-	-	-	-	-	-	-
	Total	100 %		100 %		100 %		100 %		100 %	

CLA – 4 can be from any combination of these: Assignments, Seminars, Tech Talks, Mini-Projects, Case-Studies, Self-Study, MOOCs, Certifications, and Conf. Paper etc.

Course Designers

Experts from Industry	Experts from Higher Technical Institutions	Internal Experts
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Course Code	18CEE313T	Course Name	DESIGN OF HYDRAULIC STRUCTURES AND IRRIGATION ENGINEERING	Course Category	E	Professional Elective	L	T	P	C
							3	0	0	3

Pre-requisite Courses	Nil	Co-requisite Courses	Nil	Progressive Courses	Nil
Course Offering Department	CIVIL ENGINEERING	Data Book / Codes/Standards	Nil		

Course Learning Rationale (CLR):	*The purpose of learning this course is to:*
CLR-1 :	*Provide knowledge on irrigation and its types, and on water movement through soil*
CLR-2 :	*Expound on the design principles of gravity and earthen dams and associated structures*
CLR-3 :	*Introduce diversion structures and their design by applying failure concepts*
CLR-4 :	*Provide an understanding of canal structures*
CLR-5 :	*Address concepts on sediment movement*
CLR-6 :	*Introduce design concepts for various types of canals*

Course Learning Outcomes (CLO):	*At the end of this course, learners will be able to:*	Learning 1: Level of Thinking (Bloom)	Learning 2: Expected Proficiency (%)	Learning 3: Expected Attainment (%)	PLO 1: Engineering Knowledge	PLO 2: Problem Analysis	PLO 3: Design & Development	PLO 4: Analysis, Design, Research	PLO 5: Modern Tool Usage	PLO 6: Society & Culture	PLO 7: Environment & Sustainability	PLO 8: Ethics	PLO 9: Individual & Team Work	PLO 10: Communication	PLO 11: Project Mgt. & Finance	PLO 12: Life Long Learning	PLO 13: PSO - 1	PLO 14: PSO - 2	PLO 15: PSO – 3
CLO-1 :	*Acquire knowledge on soil–plant–water relationship*	2	85	80	H	H	-	-	-	-	-	-	-	-	-	-	H	-	-
CLO-2 :	*Complete a design for dams and spillways*	2	85	75	H	H	-	H	-	-	-	-	-	-	-	-	H	-	-
CLO-3 :	*Understand the types of diversion structures and design them by applying failure concepts*	2	85	75	H	H	-	H	-	-	-	-	-	-	-	-	H	-	-
CLO-4 :	*Identify the various canal structures and design them*	2	85	80	H	H	-	H	-	-	-	-	-	-	-	-	H	-	-
CLO-5 :	*Understand basic concepts of sediment movement*	2	80	75	H	H	-	-	-	-	-	-	-	-	-	-	H	-	-
CLO-6 :	*Design various types of canals considering efficiency and economy*	2	85	75	H	H	-	H	-	-	-	-	-	-	-	-	H	-	-

Duration (hour)		9	9	9	9	9
S-1	SLO-1	*Irrigation: Necessity and importance of irrigation*	*Lane's weighted creep theory*	*Earthen dams – types*	*Canal falls – necessity and location of falls*	*Computing the design capacity of an irrigation canal*
	SLO-2	*Methods of irrigation*	*Design of a vertical drop weir on Bligh's creep theory*	*Design of earthen dams*	*Types of canal falls*	*Shield's entrainment method*
S-2	SLO-1	*Methods of improving soil fertility*	*Design of a vertical drop weir on Bligh's creep theory*	*Design of earthen dams*	*Design of a trapezoidal notch fall*	*Design of non-scouring stable channels with protected side slopes in alluvium soil (Shield's entrainment method)*
	SLO-2	*Standards of quality for irrigation water*	*Khosla's method – flow nets*	*Seepage analysis in earthen dams*	*Design of a trapezoidal notch fall*	*Design of non-scouring stable channels with protected side slopes in alluvium soil (Shield's entrainment method)*
S-3	SLO-1	*Duty and delta – factors affecting duty*	*Khosla's method of independent variables for determination of pressures and exit gradient for seepage below a weir or a barrage*	*Seepage analysis in earthen dams*	*Design of simple vertical drop fall*	*Design of non-scouring channels with unprotected side slopes in alluvium soil*
	SLO-2	*Methods of improving duty*	*Design problem on Khosla's method of independent variables*	*Design for stability of earthen dams*	*Design of simple vertical drop fall*	*Design of non-scouring channels with unprotected side slopes in alluvium soil*
S-4	SLO-1	*Irrigation efficiencies*	*Design problem on Khosla's method of independent variables*	*Design for stability of earthen dams*	*Design of a Sarda fall*	*Design of most efficient channel section*
	SLO-2	*Problems in irrigation efficiencies*	*Complete design of weir/barrage using Khosla's theory*	*Spillways – types and design considerations*	*Design of a Sarda fall*	*Design of most efficient channel section*
S-5	SLO-1	*Estimation of consumptive use –Blaney Criddle method*	*Complete design of weir/barrage using Khosla's theory*	*Design of chute spillway*	*Cross drainage works – types*	*Design of stable channels – Kennedy's theory*
	SLO-2	*Pan evaporation method – Penman's method*	*Storage structures: Gravity dam – cross section of gravity dam*	*Design of chute spillway*	*Cross drainage works – selection of suitable type*	*Design of stable channels – Kennedy's theory*
S-6	SLO-1	*Classes and availability of soil water – soil moisture deficiency*	*Modes of failure of gravity dam*	*Design of ogee spillway*	*Design considerations for cross drainage works*	*Design of stable channels – Lacey's theory*

	SLO-2	*Depth of water stored in root zone*	*Criteria for structural stability of gravity dam*	*Design of ogee spillway*	*Design considerations for cross drainage works*	*Design of stable channels – Lacey's theory*
S-7	SLO-1	*Limiting soil moisture conditions*	*Design considerations for gravity dam*	*Energy dissipators*	*Design of cross drainage works*	*Balancing depth of canals*
	SLO-2	*Depth and frequency of irrigation*	*Design considerations for gravity dam*	*Design of stilling basin*	*Design of cross drainage works*	*Balancing depth of canals*
S-8	SLO-1	*Diversion structures: Weirs and barrages*	*Design of gravity dam*	*Canal structures: Canal regulators – head and cross regulator*	*Design of cross drainage works*	*Economic justification of canal lining for unlined canals*
	SLO-2	*Diversion head works and its components*	*Design of gravity dam*	*Functions – Alignment of the off-taking channel*	*Design of cross drainage works*	*Economic justification of canal lining for unlined canals*
S-9	SLO-1	*Failure of hydraulic structures – failure by piping and failure by direct uplift*	*Design of gravity dam*	*Design of cross regulator*	*Conveyance: Mechanics of sediment transport*	*Design of lined canals*
	SLO-2	*Bligh's creep theory*	*Design of gravity dam*	*Design of distributary head regulator*	*Computing the design capacity of an irrigation canal*	*Design of lined canals*

Learning Resources	1. *Santhosh Kumar Garg, "Irrigation Engineering and Hydraulic Structures",Khanna Publishers, 2000.* 2. *Punmia B.C. et al., "Irrigation and Water Power Engineering", Laxmi Publications Pvt. Ltd., New Delhi, 2009* 3. *AsawaG. L., "Irrigation and Water Resources Engineering", New Age International Publishers, New Delhi, 2005.*	4. *SharmaR.K., "Irrigation Engineering and Hydraulic Structures", Oxford and IBH Publishing Company, New Delhi, 2002* 5. *NPTEL – Irrigation and Drainage:https://nptel.ac.in/courses/126105010/* 6. *NPTEL – Water Resources Engineering: https://nptel.ac.in/downloads/105105110/*

Learning Assessment

	Bloom's Level of Thinking	Continuous Learning Assessment (50% weightage)								Final Examination (50% weightage)	
		CLA – 1 (10%)		CLA – 2 (15%)		CLA – 3 (15%)		CLA – 4 (10%)#			
		Theory	Practice	Theory	Practice	Theory	Practice	Theory	Practice	Theory	Practice
Level 1	Remember Understand	*40 %*	-	*30 %*	-	*30 %*	-	*30 %*	-	*30%*	-
Level 2	Apply Analyze	*40 %*	-	*40 %*	-	*40 %*	-	*40 %*	-	*40%*	-
Level 3	Evaluate Create	*20 %*	-	*30 %*	-	*30 %*	-	*30 %*	-	*30%*	-
	Total	100 %		100 %		100 %		100 %		100 %	

CLA – 4 can be from any combination of these: Assignments, MOOCs, Certifications, and Conf. Paper etc.

Course Designers		
Experts from Industry	Experts from Higher Technical Institutions	Internal Experts
1. Mr. Abdul Hakeem, National Remote Sensing Center, Hyderabad, abdulhakeem_k@nrsc.gov.in	*1. Dr. Rehana Shaik, IIIT, Hyderabad, rehana.s@iiit.ac.in*	*1. Dr. DeepthaThattai, SRMIST*
2. Dr. Sat Kumar Tomer, Satyukt Analytics Pvt Ltd., Bengaluru, sat@satyukt.com	*2. Dr. S. Saravanan, NIT Trichy, saravanans@nitt.edu*	*2. Dr. R. Sathyanathan, SRMIST*

Course Code	18CEE314T	Course Name	GROUND WATER ENGINEERING	Course Category	E	Professional Elective	L	T	P	C
							3	0	0	3

Pre-requisite Courses	Nil	Co-requisite Courses	Nil	Progressive Courses	Nil
Course Offering Department	CIVIL ENGINEERING	Data Book/Codes/Standards	Nil		

Course Learning Rationale (CLR):	The purpose of learning this course is to:
CLR-1 :	*Create insights into the occurrence and properties of groundwater*
CLR-2 :	*Address concepts related to movement of groundwater*
CLR-3 :	*Create insights on well hydraulics*
CLR-4 :	*Address concepts related to exploration and investigation of groundwater*
CLR-5 :	*Create insights into groundwater management and seawater intrusion*
CLR-6 :	*Understand the software applications in groundwater modeling*

Course Learning Outcomes (CLO):	At the end of this course, learners will be able to:	Learning 1: Level of Thinking (Bloom)	2: Expected Proficiency (%)	3: Expected Attainment (%)	PLO 1: Engineering Knowledge	2: Problem Analysis	3: Design & Development	4: Analysis, Design, Research	5: Modern Tool Usage	6: Society & Culture	7: Environment & Sustainability	8: Ethics	9: Individual & Team Work	10: Communication	11: Project Mgt. & Finance	12: Life Long Learning	13: PSO - 1	14: PSO - 2	15: PSO – 3
CLO-1 :	*Understand the various properties of groundwater*	2	85	80	H	M	L	L	-	L	H	-	-	-	-	L	M	-	-
CLO-2 :	*Understand the governing equations of groundwater movement*	2	85	75	H	H	H	H	-	-	H	-	-	-	-	-	M	-	-
CLO-3 :	*Acquire the knowledge on yield of the well and its hydraulics*	2	80	75	H	H	M	M	-	L	H	-	-	-	-	L	M	-	-
CLO-4 :	*Understand the concept of various methods of exploration*	2	85	75	H	L	M	M	-	-	H	-	-	-	-	-	M	-	-
CLO-5 :	*Understand the concept of seawater intrusion and conjunctive use*	2	85	80	H	M	H	H	-	M	M	-	-	-	-	L	M	-	-
CLO-6 :	*Acquire knowledge on groundwater modeling and models in use*	2	80	75	H	H	H	H	H	M	H	-	-	-	-	H	M	-	-

Duration (hour)		9	9	9	9	9
S-1	SLO-1	*Introduction to Groundwater: Global distribution of water, role of groundwater in hydrological cycle*	*Groundwater Movement Groundwater Movement- Governing Equation*	*Well Hydraulics Flow into a well*	*Subsurface Exploration Objective and Need for exploration Various methods*	*Groundwater Management and Modeling Groundwater quality and Contamination*
	SLO-2	*Various water bearing formations, subsurface water distribution*	*Darcy's Law*	*Steady radial flow into a well: Dupuit equation, Thiem's equation*	*Geophysical investigations*	*Groundwater quality standards*
S-2	SLO-1	*Aquifers and types of aquifers*	*Heterogeneity and anisotropy*	*Unsteady radial flow into a well: Theis equation*	*Surface geophysical techniques*	*Types and sources of groundwater contamination*
	SLO-2	*Aquifer properties: porosity, permeability, specific yield, storage coefficient and transmissivity, factors affecting permeability*	*Estimation of aquifer parameters*	*Jacob's correction for very thin aquifers with water table condition*	*Electrical resistivity method*	*Various quality parameters and its significance*
S-3	SLO-1	*Problems on aquifer properties*	*Problems on Darcy's law*	*Problems on Theis equation*	*Seismic refraction method*	*Attenuation of groundwater quality*
	SLO-2	*Problems on aquifer properties*	*Problems on aquifer parameter estimation*	*Problems on Jacob equation*	*Remote sensing in groundwater exploration*	*Potential evaluation of groundwater quality*
S-4	SLO-1	*Groundwater fluctuation*	*1D governing equation of flow through porous medium*	*Theis recovery, well hydraulics*	*Other surveying methods*	*Physical, chemical and biological method of analysis*
	SLO-2	*Groundwater balance and budgeting*	*2D governing equation of flow through porous medium*	*Wells in leaky aquifer*	*Borehole geophysical techniques*	*Problems on quality evaluation*
S-5	SLO-1	*Problems on water balance equation*	*Equation for flow into leaky aquifer*	*Partially penetrating wells*	*Electric logging, radioactive logging*	*Conjunctive use of groundwater and basin management*
	SLO-2	*Problems on groundwater fluctuation*	*Flow through unconfined aquifer*	*Image well theory, multiple wells*	*Induction, fluid and sonic logging*	*Groundwater development under various scales*
S-6	SLO-1	*Groundwater in different rocks*	*Boundary conditions*	*Well capacity and well development*	*Geochemical method of exploration*	*Groundwater modeling, problems in groundwater*

	SLO-2	*Groundwater potential in India*	*Groundwater flow rates and direction*	*Construction and types of open well*	*Application of GIS in groundwater exploration*	*Types of models*
S-7	SLO-1	*Case Study 1*	*Groundwater flow problems*	*Construction and types of tube well*	*Seawater intrusion theory*	*Conceptual model, physical model*
	SLO-2	*Case Study 2*	*Steady one dimensional flow, flow into galleries*	*Problems on well hydraulics*	*Shape of interface*	*Mathematical model and analog model*
S-8	SLO-1	*GEC Norms*	*Aquifer with recharge*	*Problems on Theis recovery*	*Slope of interface*	*Data, input, boundary conditions and output, prediction*
	SLO-2	*Methodology of estimation*	*flow into confined aquifer with constant*	*Pumping test and recuperation test*	*Causes of seawater intrusion*	*Calibration and validation of a model*
S-9	SLO-1	*Status of groundwater in various parts of India- a case study*	*flow into confined aquifer with variable thickness*	*Problems on yield test*	*Effects of seawater intrusion*	*Groundwater models*
	SLO-2	*Threats to groundwater*	*Groundwater Theory, Solution for differential Equations*	*Well losses and determination*	*Various methods of reducing seawater intrusion*	*MODFLOW, MT3D, FEFLOW, SEAWAT*

Learning Resources	*1. Raghunath, H. M., "Ground Water", New Age International (P) Ltd, 2014.* *2. D.K. Todd and L. F. Mays, "Groundwater Hydrology", John Wiley and Sons.* *3. K. R. Karanth, "Hydrogeology", Tata McGraw Hill Publishing Company.*	*4. NPTEL course - Ground Water Hydrology: http://nptel.ac.in/courses/105105042/* *5. NPTEL course - Ground Water Hydrology: http://nptel.ac.in/courses/105103026/*

Learning Assessment

	Bloom's Level of Thinking	Continuous Learning Assessment (50% weightage)								Final Examination (50% weightage)	
		CLA – 1 (10%)		CLA – 2 (15%)		CLA – 3 (15%)		CLA – 4 (10%)#			
		Theory	Practice	Theory	Practice	Theory	Practice	Theory	Practice	Theory	Practice
Level 1	Remember Understand	*40 %*	-	*30 %*	-	*30 %*	-	*30 %*	-	*30%*	-
Level 2	Apply Analyze	*40 %*	-	*40 %*	-	*40 %*	-	*40 %*	-	*40%*	-
Level 3	Evaluate Create	*20 %*	-	*30 %*	-	*30 %*	-	*30 %*	-	*30%*	-
	Total	100 %		100 %		100 %		100 %		100 %	

CLA – 4 can be from any combination of these: Assignments, Seminars, Tech Talks, Mini-Projects, Case-Studies, Self-Study, MOOCs, Certifications, Conf. Paper etc.,

Course Designers

Experts from Industry	Experts from Higher Technical Institutions	Internal Experts
1. Mr. Abdul Hakeem, National Remote Sensing Center, Hyderabad, abdulhakeem_k@nrsc.gov.in	*1. Dr. Rehana Shaik, IIIT, Hyderabad, rehana.s@iiit.ac.in*	*1. Dr. Deeptha Thattai, SRMIST*
2. Dr. Sat Kumar Tomer, Satyukt Analytics Pvt Ltd., Bengaluru, sat@satyukt.com	*2. Dr. S. Saravanan, NIT Trichy, saravanans@nitt.edu*	*2. Ms. T. Saranya, SRMIST*

Course Code	18CEE315T	Course Name	SURFACE HYDROLOGY	Course Category	E	Professional Elective	L	T	P	C
							3	0	0	3

Pre-requisite Courses	Nil	Co-requisite Courses	Nil	Progressive Courses	Nil
Course Offering Department	Civil Engineering	Data Book / Codes/Standards	Nil		

Course Learning Rationale (CLR):	The purpose of learning this course is to:
CLR-1 :	*Create insights into various hydrometeorological variables and components of hydrological cycle*
CLR-2 :	*Address concepts related to precipitation and water losses*
CLR-3 :	*Analyze concepts of runoff and hydrograph analysis*
CLR-4 :	*Address concepts related to floods and their estimation*
CLR-5 :	*Create insights into reservoir routing and stream flow routing*
CLR-6 :	*Address various types of models and their processes*

Course Learning Outcomes (CLO):	At the end of this course, learners will be able to:	Learning 1: Level of Thinking (Bloom)	Learning 2: Expected Proficiency (%)	Learning 3: Expected Attainment (%)	PLO 1: Engineering Knowledge	PLO 2: Problem Analysis	PLO 3: Design & Development	PLO 4: Analysis, Design, Research	PLO 5: Modern Tool Usage	PLO 6: Society & Culture	PLO 7: Environment & Sustainability	PLO 8: Ethics	PLO 9: Individual & Team Work	PLO 10: Communication	PLO 11: Project Mgt. & Finance	PLO 12: Life Long Learning	PLO 13: PSO - 1	PLO 14: PSO - 2	PLO 15: PSO - 3
CLO-1 :	*Identify various hydrometeorological variables and components of hydrological cycle*	2	85	80	H	H	-	-	-	-	-	-	-	-	-	-	H	-	-
CLO-2 :	*Analyze precipitation and water losses*	3	85	75	H	H	-	-	-	-	-	-	-	-	-	-	H	-	-
CLO-3 :	*Understand runoff and hydrograph analysis*	3	85	75	H	H	-	-	-	-	-	-	-	-	-	-	H	-	-
CLO-4 :	*Analyze floods and their estimation*	2	85	80	H	H	-	-	-	-	-	-	-	-	-	-	H	-	-
CLO-5 :	*Understand reservoir routing and channel routing*	2	80	75	H	H	-	-	-	-	-	-	-	-	-	-	H	-	-
CLO-6 :	*Analyze various models and their processes*	3	85	75	H	H	-	-	-	-	-	-	-	-	-	-	H	-	-

Duration (hour)		9	9	9	9	9
S-1	SLO-1	*Weather and climate*	*Precipitation: forms and types*	*Runoff, components of stream flow*	*Floods: Standard project flood, maximum probable flood, PMP, design flood*	*Systems and models – system concept in hydrology*
	SLO-2	*Scope of hydrometeorology*	*Test for consistency of the record, causes of inconsistency in the record*	*Catchment characteristics, watershed concepts*	*Estimation of peak flood: Empirical flood formulae- Dickens, Ryves, Inglis, Myers*	*Types of models – physical, conceptual, empirical, mathematical models*
S-2	SLO-1	*Meteorological variables*	*Double mass curve techniques*	*Classification of streams, isochrones*	*Rational method and concentration time method*	*Life cycle of a model*
	SLO-2	*Temperature, atmospheric pressure*	*Depth-Area relationship, Intensity-Duration-Frequency (IDF) curves*	*Factors affecting runoff*	*Problems on peak discharge*	*Types of mathematical models*
S-3	SLO-1	*Atmospheric humidity*	*Analysis of rainfall data*	*Runoff estimation: rational method, assumptions and drawbacks*	*Flood frequency studies: California method and Weibull method*	*Formulation of a mathematical model – modeling concepts*
	SLO-2	*Simple problems on saturation vapour pressure and relative humidity*	*Problems on mean, median and mode, mass curve, hyetograph, moving average, IDF and frequency curve*	*Components of streamflow hydrograph*	*Problems on flood frequency*	*Watershed–System concept*
S-4	SLO-1	*Clouds: categories and its classification*	*Design storm*	*Baseflow separation methods*	*Encounter probability: probability of exceedance and Probability of non-exceedance*	*Types of watershed models*
	SLO-2	*Atmosphere: different strata of atmosphere*	*Water losses*	*Problems on rainfall excess estimation by baseflow separation methods*	*Problems on encounter probability*	*Models in practice for various hydrologic processes*
S-5	SLO-1	*Wind and wind belts*	*Evaporation from water surfaces, Dalton's law of evaporation*	*Derivation of a unit hydrograph*	*Flood routing: Reservoir routing and channel routing*	*Stochastic model: space independent and space co-related*
	SLO-2	*Evaporation, vertical air motions*	*Evaporation pans: floating pans, land pan and Colorado sunken pan*	*Elements and propositions of unit hydrograph*	*Reservoir routing: ISD method*	*Artificial Neural Network (ANN)*
S-6	SLO-1	*Global distribution of water*	*Pan coefficient, problems on loss of water due to evaporation*	*Problems on unit hydrograph*	*Modified Pul's method*	*ANN activation function*

	SLO-2	*Water resources of India*	*Measures to reduce lake evaporation*	*Problems on unit hydrograph*	*Problem on reservoir routing*	*Network training algorithm – back propagation*
S-7	SLO-1	*Seasons in India*	*Transpiration, transpiration ratio and evapotranspiration*	*S-curve method*	*Problem on reservoir routing*	*Advantages and limitations of ANN*
	SLO-2	*Hydrology and hydrologic cycle*	*Consumptive use determination by Blaney-Criddle method, problems.*	*Problems on S-curve hydrograph*	*Stream flow routing: prism storage and wedge storage*	*Fuzzy sets and fuzzy logic*
S-8	SLO-1	*Distribution of rainfall in India*	*Infiltration, Horton's equation*	*Problems on S-curve hydrograph*	*Muskingum method*	*Fuzzification, evaluation of rules, defuzzification*
	SLO-2	*Scope of hydrology*	*Measurement of infiltration: infiltrometer and rainfall simulator*	*Synthetic unit hydrograph*	*Problem on Muskingum method*	*Fuzzy rule based reservoir operation model*
S-9	SLO-1	*Hydrological data*	*Infiltration indices: phi index and W-index*	*Snyder's method*	*Problem on Muskingum method*	*Changes in climate as related to water*
	SLO-2	*Hydrologic equation, simple problems on water budget.*	*Problems on Horton's equation and infiltration indices*	*Problems on Snyder's method*	*Flood forecasting and warning*	*Impacts and responses – climate change and water resources*

Learning Resources	1. *Raghunath, H.M., Hydrology, New Age International Publishers, New Delhi, 2007.* 2. *Subramanya, K., Engineering Hydrology, McGraw Hill Education (India) Pvt. Ltd., New Delhi, 2014* 3. *Pukh Raj Rakhecha and Vijay P. Singh, Applied Hydrometeorology, Capital Publishing Company, 2009.* 4. *Chow, V.T., and Maidment, Hydrology for Engineers, McGraw Hill Inc., Ltd., 2000* 5. *Vedula, S., and Mujamdar, P.P., Water Resources Systems, McGraw Hill Inc., 2005*	6. *NPTEL Course – Advanced Hydrology: https://nptel.ac.in/courses/105101002/#* 7. *Bates, B.C., Z.W. Kundzewicz, S. Wu and J.P. Palutikof, Eds., 2008: Climate Change and Water. Technical Paper of the Intergovernmental Panel on Climate Change, IPCC Secretariat, Geneva, 210 pp.* 8. *NPTEL course – Watershed Management: https://nptel.ac.in/courses/105101010/16*

Learning Assessment

	Bloom's Level of Thinking	Continuous Learning Assessment (50% weightage)								Final Examination (50% weightage)	
		CLA – 1 (10%)		CLA – 2 (15%)		CLA – 3 (15%)		CLA – 4 (10%)#			
		Theory	Practice	Theory	Practice	Theory	Practice	Theory	Practice	Theory	Practice
Level 1	Remember Understand	*40 %*	-	*30 %*	-	*30 %*	-	*30 %*	-	*30%*	-
Level 2	Apply Analyze	*40 %*	-	*40 %*	-	*40 %*	-	*40 %*	-	*40%*	-
Level 3	Evaluate Create	*20 %*	-	*30 %*	-	*30 %*	-	*30 %*	-	*30%*	-
	Total	100 %		100 %		100 %		100 %		100 %	

CLA – 4 can be from any combination of these: Assignments, Seminars, Tech Talks, Mini-Projects, Case-Studies, Self-Study, MOOCs, Certifications, Conf. Paper etc.,

Course Designers

Experts from Industry	Experts from Higher Technical Institutions	Internal Experts
1. Mr. Abdul Hakeem, National Remote Sensing Center, Hyderabad, abdulhakeem_k@nrsc.gov.in	*1. Dr. Rehana Shaik, IIIT, Hyderabad, rehana.s@iiit.ac.in*	*1. Dr. R. Sathyanathan, SRMIST*
2. Dr. Sat Kumar Tomer, Satyukt Analytics Pvt Ltd., Bengaluru, sat@satyukt.com	*2. Dr. S. Saravanan, NIT Trichy, saravanans@nitt.edu*	*2. Dr. Deeptha Thattai, SRMIST*

Course Code	18CEE401T	Course Name	PAVEMENT ANALYSIS AND DESIGN	Course Category	E	Professional Elective	L	T	P	C
							3	0	0	3

Pre-requisite Courses	Nil	Co-requisite Courses	Nil	Progressive Courses	Nil
Course Offering Department	CIVIL ENGINEERING	Data Book / Codes/Standards	Nil		

Course Learning Rationale (CLR):	*The purpose of learning this course is to:*
CLR-1 :	*Learn layered structure stress-strain analysis*
CLR-2 :	*Understand the viscoelastic characterization of the material*
CLR-3 :	*To impart basic knowledge on various bituminous technology and its characterization*
CLR-4 :	*Familiarize with the design of flexible pavement*
CLR-5 :	*Study about the distress of pavements*
CLR-6 :	*Knowabout the pavement condition survey*

Course Learning Outcomes (CLO):	*At the end of this course, learners will be able to:*	Learning 1: Level of Thinking (Bloom)	2: Expected Proficiency (%)	3: Expected Attainment (%)	PLO 1: Engineering Knowledge	2: Problem Analysis	3: Design & Development	4: Analysis, Design, Research	5: Modern Tool Usage	6: Society & Culture	7: Environment & Sustainability	8: Ethics	9: Individual & Team Work	10: Communication	11: Project Mgt. & Finance	12: Life Long Learning	13: PSO - 1	14: PSO - 2	15: PSO – 3
CLO-1 :	*analyze the critical conditions of the layered structure*	2	85	80	H	H	M	L	H	-	H	-	-	-	-	-	M	-	-
CLO-2 :	*Predict the real time behavior of the material*	2	85	75	H	H	H	H	-	-	H	-	-	-	-	-	M	-	-
CLO-3 :	*Select appropriate material for the bituminous pavement construction*	2	80	75	H	H	M	M	-	-	H	-	-	-	-	-	M	-	-
CLO-4 :	*Design the flexible pavement for different conditions of traffic and with different material combination*	2	85	75	H	H	H	H	-	-	H	-	-	-	-	-	M	-	-
CLO-5 :	*Evaluate the existing condition of the pavement*	2	85	80	H	H	M	M	L	-	M	-	-	-	-	-	M	-	-
CLO-6 :	*Suggest the suitable measures to improve the condition of the pavement*	2	80	75	H	H	M	-	-	-	M	-	-	-	-	-	M	-	-

Duration (hour)		9	9	9	9	9
S-1	SLO-1	*Stress Analysis of Layered Structure: Importance of pavement design*	*Viscoelasticity: Introduction to viscoelasticity*	*Pavement Materials: Bitumen.*	*Design of Flexible pavement: Different layers of flexible pavement*	*Evaluation of pavement: Distress in flexible pavement*
	SLO-2	*Overview of layered system*	*Creep and recovery*	*Modified bitumen*	*Design factors*	*Distress in flexible pavement*
S-2	SLO-1	*Single layer system- stress analysis*	*Stress relaxation*	*Bitumen emulsion-Types*	*Traffic factors*	*Distress of rigid pavement*
	SLO-2	*Single layer system- stress analysis*	*Viscoelastic models*	*Grading of bitumen*	*Traffic factors*	*Distress of rigid pavement*
S-3	SLO-1	*Solving problems*	*Viscoelastic solid model*	*Performance grading*	*Material characteristics*	*Evaluation of distress*
	SLO-2	*Solving problems*	*Derivation of Voigt-Kelvin model*	*Aging of binder*	*Temperature*	*Distress measurement-Surface roughness*
S-4	SLO-1	*Two-layer pavement- stress analysis*	*Creep and recovery response of Voigt-Kelvin model*	*Bituminous mixture*	*Critical locations in pavement*	*Skid resistance*
	SLO-2	*Two-layer pavement- stress analysis*	*Stress relaxation response of Voigt-Kelvin model*	*Hot mix asphalt mixture*	*Pavement design as per IRC*	*Deflection measurements*
S-5	SLO-1	*Solving problems*	*Viscoelastic fluid model*	*Warm mix asphalt mixture*	*Solving problems-VDF*	*Benkelman beam test - concept*
	SLO-2	*Solving problems*	*Derivation of Maxwell model*	*Half warm mix asphalt mixture*	*Solving problems-VDF*	*Benkelman beam test – Method of measuring deflection*
S-6	SLO-1	*Multilayered stress analysis*	*Creep and recovery response of Maxwell model*	*Cold mix asphalt mixture*	*Solving problems-Pavement Design*	*Falling weight deflectometer-Working principle*
	SLO-2	*Multilayered stress analysis*	*Stress relaxation response of Maxwell model*	*Cold mix asphalt mixture*	*Solving problems-Pavement Design*	*Fallingweightdeflectometer-Calculation of moduli*

S-7	SLO-1	*Multilayered stress analysis*	*Burger's model*	*Mixture characterization - Resilient modulus*	*Solving problems-Pavement Design*	*Design of overlay by Benkelman beam method*
	SLO-2	*Multilayered stress analysis*	*Derivation of Burger's model*	*Mixture characterization - Determination of resilient modulus*	*Solving problems-Pavement Design*	*Design procedure*
S-8	SLO-1	*Software demo for multilayered structure*	*Oscillatory shearing*	*Mixture characterization - Dynamic modulus*	*Airfield pavement*	*Design procedure*
	SLO-2	*Software demo for multilayered structure*	*Response of elastic material to Oscillatory shearing*	*Mixture characterization - Determination of dynamic modulus*	*Specifications of airfield pavement*	*Solving problems*
S-9	SLO-1	*Software demo for multilayered structure*	*Response of viscous material to Oscillatory shearing*	*Mixture characterization - Time-temperature superposition*	*Design procedure of airfield pavement*	*Solving problems*
	SLO-2	*Software demo for multilayered structure*	*Response of viscoelastic material to Oscillatory shearing*	*Mixture characterization – Rutting and fatigue characterization*	*Design procedure of airfield pavement*	*Solving problems*

Learning Resources	1. *Yang Huang, Pavement Analysis and Design, Pearson, 2004* 2. *Chakroborthy and A. Das, Priciples of Transportation Engineering, Prentice-Hall of India,2003* 3. *S. K. Khanna, C.E.G. Justo and A. Veeraragavan, Highway Engineering, Revised 10th edition, Nem Chand &Bros., Roorkee, 2014.* 4. *Yoder,E.J., and Witczak, Principles of Pavement Design, 2nd ed.John Wiley and Sons, 1975.*	5. *Wineman, A.S. and Rajagopal, K. R, Mechanical Response Of Polymers: An Introduction, Cambridge University Press, 2000.* 6. *6.Guidelines for the Design of Flexible Pavements, IRC :37, The Indian Road Congress, New Delhi* 7. *Subash C, Saxena, Textbook of Highway and Traffic Engineering, CBS Publishers, 1st Edition,2014* 8. *NEPTEL link - https://nptel.ac.in/courses/105105107/1 and https://nptel.ac.in/courses/112104040/12 (as on 05.07.2019)*

Learning Assessment

	Bloom's Level of Thinking	Continuous Learning Assessment (50% weightage)								Final Examination (50% weightage)	
		CLA – 1 (10%)		CLA – 2 (15%)		CLA – 3 (15%)		CLA – 4 (10%)#			
		Theory	Practice	Theory	Practice	Theory	Practice	Theory	Practice	Theory	Practice
Level 1	Remember Understand	*30%*	-	*30%*	-	*30%*	-	*30%*	-	*30%*	-
Level 2	Apply Analyze	*40%*	-	*40%*	-	*40%*	-	*40%*	-	*40%*	-
Level 3	Evaluate Create	*30%*	-	*30%*	-	*30%*	-	*30%*	-	*30%*	-
	Total	100 %		100 %		100 %		100 %		100 %	

#CLA – 4 can be from any combination of Assignments, Seminars, Tech Talks, Mini-Projects, Case-Studies, Self-Study, MOOCs, Certifications, Conference Paper

Course Designers

Experts from Industry	Experts from Higher Technical Institutions	Internal Experts
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Mr.AnkitPachouri, Transport Planner, IUT, New Delhi, ankit.pachouri@iutundia.org	*Dr. V Sunitha, Assistant Professor, NITT, sunitha@nitt.edu*	*Ms R Dhanya, SRM IST*

Course Code	18CEE402T	Course Name	RAILWAY, AIRPORT AND HARBOUR ENGINEERING	Course Category	E	Professional Elective	L	T	P	C
							3	0	0	3

Pre-requisite Courses	Nil	Co-requisite Courses	Nil	Progressive Courses	Nil
Course Offering Department	CIVIL ENGINEERING	Data Book / Codes/Standards	Nil		

Course Learning Rationale (CLR):	*The purpose of learning this course is to:*
CLR-1 :	*Get exposed to Railway track planning and design*
CLR-2 :	*Understand the process of operation and maintenance of Railway track*
CLR-3 :	*Attain knowledge on the concepts of planning and design of airport components*
CLR-4 :	*Learn the structural design of the airfield pavement*
CLR-5 :	*Understand the process in the Evaluation of the airfield pavement*
CLR-6 :	*Acquire knowledge on the site characteristics and component planning for harbour*

Course Learning Outcomes (CLO):	*At the end of this course, learners will be able to:*	Learning 1: Level of Thinking (Bloom)	Learning 2: Expected Proficiency (%)	Learning 3: Expected Attainment (%)	PLO 1: Engineering Knowledge	PLO 2: Problem Analysis	PLO 3: Design & Development	PLO 4: Analysis, Design, Research	PLO 5: Modern Tool Usage	PLO 6: Society & Culture	PLO 7: Environment & Sustainability	PLO 8: Ethics	PLO 9: Individual & Team Work	PLO 10: Communication	PLO 11: Project Mgt. & Finance	PLO 12: Life Long Learning	PLO 13: PSO - 1	PLO 14: PSO - 2	PLO 15: PSO – 3
CLO-1 :	*Apply the planning and design concepts of railway alignment and geometric design of railway track*	2	85	80	H	H	M	L	-	L	H	-	-	-	-	L	M	-	-
CLO-2 :	*Plan and design the operational facilities for effective rail transportation*	2	85	75	H	H	H	H	-	-	H	-	-	-	-	-	M	-	-
CLO-3 :	*Apply the planning and design concepts of airport components*	2	80	75	H	H	M	M	-	L	H	-	-	-	-	L	M	-	-
CLO-4 :	*Design the airfield pavement*	2	85	75	H	H	H	H	-	-	H	-	-	-	-	-	M	-	-
CLO-5 :	*Evaluate the airfield pavement*	2	85	80	H	H	M	M	L	L	M	-	-	-	-	L	M	-	-
CLO-6 :	*Understand the basic need for handling the cargos in the harbour*	2	80	75	H	H	M	-	-	L	M	-	-	-	-	-	M	-	-

Duration (hour)		9	9	9	9	9
S-1	SLO-1	*RAILWAY PLANNING AND DESIGN Introduction to railway engineering*	*Numericals in length of transition curve*	*AIRPORT PLANNING AND GEOMETRIC DESIGN Importance and limitations Advantages and Limitations of Air Transport.*	*PAVEMENT DESIGN AND EVALUATION Importance of pavement design and evaluation*	*HARBOUR ENGINEERING Importance of Harbour Engineering*
	SLO-2	*Role of Indian Railways in National Development*	*Numericals in length of transition curve*	*Characteristics of Air travel.*	*Components of airfield pavement*	*History and modern trends of waterway transportation,*
S-2	SLO-1	*Track Alignment -Importance*	*Widening of Gauges in Curves , Gradients Grade Compensation*	*Airport Master Plan, Evaluation and Institutional arrangements*	*Wheel and Axle Configurations*	*Definition of Terms - Harbours, Ports, Docks, , Sounding,*
	SLO-2	*Obligatory points in railway track alignment*	*Vertical Curves*	*Site Selection and survey,*	*Traffic considerations*	*Tides and Waves, Sounding, Littoral Drift*
S-3	SLO-1	*Engineering Surveys for Track Alignment*	*RAILWAY TRACK OPERATION AND MAINTENANCE Points and Crossings -*	*Components of airport- Runway Orientation,*	*Stress and strain analysis in airfield pavement*	*Classification of Harbours*
	SLO-2	*Remote Sensing, GIS &GPS, EDM and other equipment*	*Turnouts – Types - Working Principle*	*Cross wind Component, Wind rose Diagram*	*Stress and strain analysis in airfield pavement*	*Site Selection and harbour planning*
S-4	SLO-1	*Permanent Way and its components*	*Signaling*	*Numericals in Type I and II Wind Rose Diagram*	*Numericals in stress and strain*	*Types of Layouts of ports and components*
	SLO-2	*Functions of each component -Concept of Gauges*	*Interlocking*	*Basic Runway length and Corrections*	*Numericals in stress and strain*	*Approach facilities- With head gates, Without head gates*
S-5	SLO-1	*Gauges and the type of gauges*	*Track Circuiting*	*Numericals in Corrections of BRL*	*Cummulative Damage Factor*	*Protection facilities*
	SLO-2	*Coning of Wheels, Creeps and kinks*	*Construction & Maintenance Materials,*	*Numericals in Corrections of BRL*	*Environmental factors*	*Breakwater and its types*
S-6	SLO-1	*Geometric Design of Railway Tracks - basic terms and representations*	*Track Drainage*	*Airport classification, Geometric design and specifications of runway*	*FAARFIELD input*	*Docking facilities*
	SLO-2	*Super-Elevation, Negative superelevation*	*Track Modernization*	*Geometric Design elements and specifications of taxiway*	*Design of airfield pavement using FAARFIELD*	*Wet docks and Dry docks*
S-7	SLO-1	*Numericals in design of superelevation*	*Automated maintenance and upgrading, Technologies,*	*Runway patterns - Minimum Separation Distances*	*Pavement Evaluation - importance*	*Navigational Aids - Buoys and Beacons*

	SLO-2	Numericals in design of superelevation	Re-laying of Track	Clearance over Highways and Railways	Method of evaluation and overview	Light ships, Light house
S-8	SLO-1	Numericals in design of superelevation	Lay outs of Railway Stations and Yards,	Drainage - Airport Zoning	Structural Evaluation - test procedure	Storage Facilities
	SLO-2	Numericals in design of superelevation	Rolling Stock	Aircraft parking systems	Structural Evaluation - evaluation techniques	Dolphins
S-9	SLO-1	Horizontal Curves, Transition Curves,	Tractive Power, Track Resistance	Visual Aids , Wind Direction Indicators	Functional Evaluation - test procedure	Mooring Accessories
	SLO-2	Numericals in length of transition curve	Numericals in Tractive resistance	Runway and Taxiway Markings and Lightings	Functional Evaluation - evaluation techniques	Dredging facilities

Learning Resources	1. *SaxenaSubhash C and Satyapal Arora, "A Course in Railway Engineering", DhanpatRai and Sons, Delhi, 1998.* 2. *Khanna S K, Arora M G and Jain S S, "Airport Planning and Design", Nemchand and Brothers, Roorkee, 1994.* 3. *R Horonjeff and F X Mckelvy, Planning and design of Airport, Mc-Graw Hill International Editions, 1993*	4. *R. Srinivasan, "Harbour, Docks and Tunnel Engineering", Charotar Publishing home, 27th Edition, 2015* 5. *S P Bindra, "A Course in Docks and Harbour Engineering", DhanpatRai and Sons, NewDelhi, 1993.* 6. *NPTEL link - https://nptel.ac.in/courses/105107123/ (as on 05.07.2019)*

Learning Assessment

	Bloom's Level of Thinking	Continuous Learning Assessment (50% weightage)								Final Examination (50% weightage)	
		CLA – 1 (10%)		CLA – 2 (15%)		CLA – 3 (15%)		CLA – 4 (10%)#			
		Theory	Practice	Theory	Practice	Theory	Practice	Theory	Practice	Theory	Practice
Level 1	Remember Understand	*30%*	-	*30%*	-	*30%*	-	*30%*	-	*30%*	-
Level 2	Apply Analyze	*40%*	-	*40%*	-	*40%*	-	*40%*	-	*40%*	-
Level 3	Evaluate Create	*30%*	-	*30%*	-	*30%*	-	*30%*	-	*30%*	-
	Total	100 %		100 %		100 %		100 %		100 %	

CLA – 4 can be from any combination of Assignments, Seminars, Tech Talks, Mini Projects, Case Studies, Self Study, MOOCs, Certifications, Conference Paper

Course Designers

Experts from Industry	Experts from Higher Technical Institutions	Internal Experts
Dr. Asif Ahmed, Business manager, Ingevity, ahmed.asif@ingevity.com	*Dr. VenkaiahChowdary, Associate Professor, NITW, vc@nitw.ac.in*	*Dr. A. Padma Rekha, SRM IST*
Mr.AnkitPachouri, Transport Planner, IUT, New Delhi, ankit.pachouri@iutundia.org	*Dr. V Sunitha, Assistant Professor, NITT, sunitha@nitt.edu*	*MsArunimaJayakumar, SRM IST*

Course Code	18CEE403T	Course Name	TRAFFIC ENGINEERING AND MANAGEMENT	Course Category	E	Professional Elective	L	T	P	C
							3	0	0	3

Pre-requisite Courses	Nil	Co-requisite Courses	Nil	Progressive Courses	Nil
Course Offering Department	CIVIL ENGINEERING	Data Book / Codes/Standards	Nil		

Course Learning Rationale (CLR):	*The purpose of learning this course is to:*
CLR-1 :	*Understand the basics of traffic flow modelling.*
CLR-2 :	*Familiarize the microscopic modelling*
CLR-3 :	*Learn and understand the level of service of traffic flow*
CLR-4 :	*Address the issues related to flow interruptions*
CLR-5 :	*Learn and design the facilities required for the traffic control measures*

Course Learning Outcomes (CLO):	*At the end of this course, learners will be able to:*	Learning 1: Level of Thinking (Bloom)	2: Expected Proficiency (%)	3: Expected Attainment (%)	PLO 1: Engineering Knowledge	2: Problem Analysis	3: Design & Development	4: Analysis, Design, Research	5: Modern Tool Usage	6: Society & Culture	7: Environment & Sustainability	8: Ethics	9: Individual & Team Work	10: Communication	11: Project Mgt. & Finance	12: Life Long Learning	13: PSO - 1	14: PSO - 2	15: PSO – 3
CLO-1 :	*Develop model for the traffic stream parameters*	2	85	80	H	H	M	L	-	L	H	-	-	-	-	L	M	-	-
CLO-2 :	*Create the microscopic models of the traffic flow*	2	85	75	H	H	H	H	-	-	H	-	-	-	-	-	M	-	-
CLO-3 :	*Apply the qualitative rankings on uninterrupted flow*	2	80	75	H	H	M	M	-	L	H	-	-	-	-	L	M	-	-
CLO-4 :	*Provide the facilities for interrupted flow*	2	85	75	H	H	H	H	-	-	H	-	-	-	-	-	M	-	-
CLO-5 :	*Apply the concept of traffic control measures*	2	85	80	H	H	M	M	L	L	M	-	-	-	-	L	M	-	-
		2	80	75	H	H	M	-	-	L	M	-	-	-	-	-	M	-	-

Duration (hour)		9	9	9	9	9
S-1	SLO-1	*TRAFFIC STREAM MODELLING Importance of traffic Engineering and need for flow modelling*	*MICROSCOPIC TRAFFIC FLOW MODELLING Concepts of microscopic modeling*	*UNINTERRUPTED FLOW Concept of uninterrupted flow*	*INTERRUPTED FLOW Concept of interrupted flow - intersections*	*TRAFFIC CONTROL Various traffic control measures*
	SLO-2	*Importance of traffic Engineering and need for flow modelling*	*Car-following model, Basic terms and notations*	*Definitions - Capacity, Level of Service(LoS)*	*Various traffic measures for interrupted flow*	*Applications of control measures*
S-2	SLO-1	*Fundamental parameters - speed, density, volume,travel time,headway, spacing*	*Concept of stimulus - response*	*Highway capacity*	*Traffic signs*	*Traffic signal - elements*
	SLO-2	*Time-Space diagram*	*Application of stimulus response theory in traffic flow modelling*	*Factors affecting LoS*	*Types and specifications*	*Definition and analysis of saturation headway, saturation flow, lost time*
S-3	SLO-1	*Fundamental relations - time mean speed, space mean speed and their relation,*	*General motor's models*	*HCM methods*	*Road markings - longitudinal marking*	*Phase design - two, three, four phases*
	SLO-2	*Numerical problems and solutions*	*Derivation - general motor model*	*Urban Street - Classification*	*Road markings - transverse and object marking*	*Cycle time determination - Green split time*
S-4	SLO-1	*Relation between speeds, flow, density,*	*Simulation Problem in general motor model*	*Operational Performance measures*	*Channelization*	*Definitions and measurement of stopped and control delay*
	SLO-2	*Fundamental diagrams*	*Simulation Problem in general motor model*	*Congestion Management*	*Case studies*	*Webster's delay model*
S-5	SLO-1	*Greenshield's model – Assumptions and model form*	*Simulation Problem in general motor model*	*Case studies for congestion management*	*Traffic rotary*	*Problems in traffic signal design*
	SLO-2	*Derivation -greenshield model*	*Simulation Problem in general motor model*	*Case studies for congestion management*	*Conflict resolution in a rotary*	*Capacity and LoS analysis*
S-6	SLO-1	*Numerical solution - Greenshield model*	*Vehicle arrival model,Poisson distribution*	*Multilane highways - Characteristics, Capacity*	*Geometric layout*	*HCM 2000 method - analysis of a signalized intersections*
	SLO-2	*Numerical solution - Greenshield model*	*Problems in Poisson distribution*	*Multilane highways - Level of service*	*Design elements of rotary*	*Determination of level of service as per HCM 2000*
S-7	SLO-1	*Greenberg's logarithmicmodel*	*Headway modeling*	*Freeway operations*	*Capacity of rotary*	*Signal coordination- concepts*

	SLO-2	*Underwood's exponential model*	*Random vehicle generation*	*Freeway operations- operational considerations*	*Problem in rotary capacity*	*Application of coordinated traffic signal*
S-8	SLO-1	*pipe'sgeneralized model*	*Microscopic traffic simulation*	*Capacity and Level of service of freeway segment*	*Grade separated intersection - road over bridges*	*Concept of offset*
	SLO-2	*multi-regime models*	*Microscopic traffic simulation*	*Capacity and Level of service of freeway segment*	*Underpass, Overpass concepts*	*Common cycle length andbandwidth*
S-9	SLO-1	*Movingobserver method.*	*Design, calibration, validation, applications,*	*Weaving operation*	*Types of interchanges based on the traffic flow*	*Offset for one-way and two-way streets*
	SLO-2	*Numerical solution - moving observer method*	*Operational models.*	*Weaving operation*	*Case studies on interchanges*	*Vehicle actuated signals*

Learning Resources	1. *Roess, R. P. McShane, W. R. &Prassas, E. S. (1998), Traffic Engineering, Prentice – Hall.* 2. *May, A. D. (1990), "Fundamentals of Traffic Flow", second edn, Prentice Hall.* 3. *Papacostas, C. S. (1987), "Fundamentals of Transportation Engineering", Prentice-Hall, India*	4. *Kadiyali, L. R. (1987), "Traffic Engineering and Transportation Planning", KhannaPublishers, India.* 5. *Papacostas, C. S. and Prevedouros, P.D. (2001) "Transportation Engineering and Planning", Prentice Hall of India Pvt. Ltd.* 6. *Highway Capacity Manual (2010), Transportation Research Board, USA* 7. *NPTEL link - https://nptel.ac.in/downloads/105101008/# (as on 05.07.2019)*

Learning Assessment

	Bloom's Level of Thinking	Continuous Learning Assessment (50% weightage)								Final Examination (50% weightage)	
		CLA – 1 (10%)		CLA – 2 (15%)		CLA – 3 (15%)		CLA – 4 (10%)			
		Theory	Practice	Theory	Practice	Theory	Practice	Theory	Practice	Theory	Practice
Level 1	Remember Understand	*30%*	-	*30%*	-	*30%*	-	*30%*	-	*30%*	-
Level 2	Apply Analyze	*40%*	-	*40%*	-	*40%*	-	*40%*	-	*40%*	-
Level 3	Evaluate Create	*30%*	-	*30%*	-	*30%*	-	*30%*	-	*30%*	-
	Total	100 %		100 %		100 %		100 %		100 %	

CLA – 4 can be from any combination of Assignments, Seminars, Tech Talks, Mini Projects, Case Studies, Self Study, MOOCs, Certifications, Conference Paper

Course Designers		
Experts from Industry	Experts from Higher Technical Institutions	Internal Experts
Dr. Asif Ahmed, Business manager, Ingevity, ahmed.asif@ingevity.com	*Dr. VenkaiahChowdary, Associate Professor, NITW, vc@nitw.ac.in*	*Dr. A. Padma Rekha, SRM IST*
Mr.AnkitPachouri, Transport Planner, IUT, New Delhi, ankit.pachouri@iutundia.org	*Dr. V Sunitha, Assistant Professor, NITT, sunitha@nitt.edu*	*Mr. G. Sivaprakash, SRM IST*

Course Code	18CEE404T	Course Name	CONSTRUCTION EQUIPMENT AND AUTOMATION	Course Category	E	Professional Elective	L	T	P	C
							3	0	0	3

Pre-requisite Courses	Nil	Co-requisite Courses	Nil	Progressive Courses	Nil
Course Offering Department	Civil Engineering	Data Book / Codes/Standards	Nil		

Course Learning Rationale (CLR):	*The purpose of learning this course is to:*
CLR-1 :	*Identify the management concepts of construction equipment*
CLR-2 :	*Identify the various earthwork equipments and its applications in real projects*
CLR-3 :	*Identify the various off shore equipments and techniques for dewatering*
CLR-4 :	*Identify the various equipments used on aggregate and concrete production*
CLR-5 :	*Analyze the basic concepts of methods and techniques on demolishing and dismantling structures*
CLR-6 :	*Explore the advanced level of automated equipments for various construction activities*

Course Learning Outcomes (CLO):	*At the end of this course, learners will be able to:*	Learning 1: Level of Thinking (Bloom)	2: Expected Proficiency (%)	3: Expected Attainment (%)	PLO 1: Engineering Knowledge	2: Problem Analysis	3: Design & Development	4: Analysis, Design, Research	5: Modern Tool Usage	6: Society & Culture	7: Environment & Sustainability	8: Ethics	9: Individual & Team Work	10: Communication	11: Project Mgt. & Finance	12: Life Long Learning	13: PSO - 1	14: PSO - 2	15: PSO – 3
CLO-1 :	*Accrue the knowledge of equipment management and cost controlling methods*	*2*	*85*	*75*	*H*	*M*	-	*L*	-	-	-	*H*	*M*	*M*	*H*	*H*	*M*	-	*H*
CLO-2 :	*Apply the knowledge of calculating productivity of earthwork equipments*	*3*	*85*	*75*	*H*	*H*	-	*L*	*L*	-	-	-	*H*	*H*	*H*	*M*	*M*	-	*H*
CLO-3 :	*Accrue the knowledge of equipments used in off shore construction practice*	*2*	*85*	*75*	*H*	*H*	-	*M*	*M*	-	-	-	*H*	*H*	*H*	*M*	*M*	-	*H*
CLO-4 :	*Accrue the knowledge of equipments used for aggregate and concrete production, techniques for demolition*	*3*	*85*	*75*	*H*	*H*	-	*M*	*M*	-	-	-	*H*	*H*	*H*	*M*	*M*	-	*H*
CLO-5 :	*Apply the knowledge in demolition and dismantling the distressed structures*	*2*	*85*	*75*	*H*	*H*	-	*H*	*M*	-	-	-	*H*	*H*	*H*	*M*	*M*	-	*H*
CLO-6 :	*Accrue comprehensive knowledge of automation in construction practices*	*2*	*85*	*75*	*H*	*H*	-	*M*	*H*	-	-	-	*H*	*H*	*H*	*H*	*M*	-	*H*

Duration (hour)		9	9	9	9	9
S-1	SLO-1	*Introduction on Construction Equipment*	*Earth Moving operations*	*Dredging equipment*	*Drilling equipments*	*Lifting equipments*
	SLO-2		*Types of Earthwork Equipment*	*Types of Dredging equipment*	*Types of Drilling equipments*	*Material handling equipments*
S-2	SLO-1	*Equipment Management in Construction Projects*	*Earthwork Equipment - Tractors*	*Types of trenching equipment*	*Principles of Blasting*	*Hoisting Equipments*
	SLO-2	*Management Programme*	*capacity calculations*		*Types of Blasting equipment*	*Types and safety precautions*
S-3	SLO-1	*Maintenance and Safety management*	*Earthwork Equipment - Motor Graders*	*Concept of Pipe jacking techniques*	*Aggregate production equipment*	*Slip form techniques*
	SLO-2	*Equipment requirement for construction project*	*Capacity calculations*	*Equipment used for Pipe jacking*	*Crushers*	
S-4	SLO-1	*Planning of Equipment*	*Earthwork Equipment - Scrapers,*	*Compaction equipments*	*Various types of crushers, feeders and screening equipments*	*Equipments for Conveyors*
	SLO-2	*Selection of Equipment*	*capacity calculations*	*Types of Compaction equipments*		*Types of Conveyors*
S-5	SLO-1	*Cost Control of Equipment*	*Earthwork Equipment - Front end Loaders*	*Pumping and Dewatering equipments*	*Concrete mixers*	*Prestressing techniques*
	SLO-2	*Depreciation on Equipment*	*capacity calculations*	*Types of pumps*	*Types of concrete mixers*	*Insitu prestressing in high rise structures*
S-6	SLO-1	*Conventional construction methods*	*Earthwork Equipment – Bull dozer*	*Well point Dewatering system*	*Pouring and pumping of concrete*	*Aerial transportations*
	SLO-2		*Capacity calculations*	*Vacuum dewatering of concrete flooring*	*Precautions*	*Applications and applications*

S-7	SLO-1	*Mechanized methods*	*Earthwork Equipment – Excavators*	*Pile Driving Equipments*	*Ready mix concrete - concept and procedure*	*Robots in construction*
	SLO-2	*Advanced Mechanized methods*	*Capacity calculations*	*Types and methods*		*Different automated equipments*
S-8	SLO-1	*Types of construction project*	*Equipments Used for Box Jacking Techniques*	*Concept of Coffer dam*	*Demolition equipment*	*Conventional plastering machines*
	SLO-2	*Types of construction equipment*		*Sheet piling*	*Controlled demolition techniques*	*Use of robots for repetitive activities*
S-9	SLO-1	*Safety Management*	*General safety in excavations*	*Tunneling equipments*	*Sequence of demolition*	*Drones in construction*
	SLO-2	*Safety measures*		*Methods of tunneling*	*Procedure for Dismantling*	*Advantages of drones*

Learning Resources	1. *Peurifoy, R.L., Ledbetter, W.B. and Schexnayder.C, "Construction Planning Equipment and Methods", McGraw Hill. Singapore 2005.* 2. *Sharma S.C. "Construction Equipment and Management", Khanna Publishers, Delhi, 2008.* 3. *Deodhar, S.V. "Construction Equipment and Job Planning", Khanna Publishers Delhi, 2008.*	4. *Mahesh Varma .Dr., "Construction Equipment and its planning and application", Metropolitan Book Company, New Delhi,2003.* 5. *https://nptel.ac.in/courses/105104161/12* 6. *https://nptel.ac.in/courses/105103023/*

Learning Assessment

	Bloom's Level of Thinking	Continuous Learning Assessment (50% weightage)								Final Examination (50% weightage)	
		CLA – 1 (10%)		CLA – 2 (15%)		CLA – 3 (15%)		CLA – 4 (10%)#			
		Theory	Practice	Theory	Practice	Theory	Practice	Theory	Practice	Theory	Practice
Level 1	Remember Understand	*40%*	-	*30%*	-	*30%*	-	*30%*	-	*30%*	-
Level 2	Apply Analyze	*40%*	-	*40%*	-	*40%*	-	*40%*	-	*40%*	-
Level 3	Evaluate Create	*20%*	-	*30%*	-	*30%*	-	*30%*	-	*30%*	-
	Total	100 %		100 %		100 %		100 %		100%	

CLA – 4 can be from any combination of these: Assignments, Seminars, Tech Talks, Mini-Projects, Case-Studies, Self-Study, MOOCs, Certifications, and Conf. Paper etc.

Course Designers

Experts from Industry	Experts from Higher Technical Institutions	Internal Experts
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Mr. K. M. Nanthan, , L&T, RKMNNN@lntecc.com	*Dr. J. Saravanan, Annamalai University, ausjs5070@gmail.com*	*Mr. S. Prakashchander, SRMIST*

Course Code	18CEE405T	Course Name	CONTRACTS MANAGEMENT	Course Category	E	Professional Elective	L	T	P	C
							3	0	0	3

Pre-requisite Courses	Nil	Co-requisite Courses	Nil	Progressive Courses	Nil
Course Offering Department	Civil Engineering	Data Book / Codes/Standards	Nil		

Course Learning Rationale (CLR):	*The purpose of learning this course is to:*
CLR-1 :	*To understand Indian Contract Act and to know the various types of construction contracts and their legal aspects*
CLR-2 :	*Learn about contracts and agreements*
CLR-3 :	*Acquire the knowledge of FIDIC concepts*
CLR-4 :	*Apply the concept of various types of taxes*
CLR-5 :	*Learn about the different types of labour laws*
CLR-6 :	*Utilize the knowledge of labour laws and legal requirements in broader perspective*

		Learning			Program Learning Outcomes (PLO)														
		1	2	3	1	2	3	4	5	6	7	8	9	10	11	12	13	14	15
Course Learning Outcomes (CLO):	*At the end of this course, learners will be able to:*	Level of Thinking (Bloom)	Expected Proficiency (%)	Expected Attainment (%)	Engineering Knowledge	Problem Analysis	Design & Development	Analysis, Design, Research	Modern Tool Usage	Society & Culture	Environment & Sustainability	Ethics	Individual & Team Work	Communication	Project Mgt. & Finance	Life Long Learning	PSO - 1	PSO - 2	PSO – 3
CLO-1 :	*Understanding the method of quoting the rates for bidding and tender process*	3	85	75	H	M	-	-	-	M	-	H	H	M	L	M	H	-	L
CLO-2 :	*Knowing the types of contracts*	2	85	75	H	H	-	-	-	M	-	H	H	M	L	M	H	-	L
CLO-3 :	*Steps involved in making contracts and records to be maintained in execution of contract*	2	85	75	H	H	-	-	-	M	-	H	M	M	L	M	H	-	L
CLO-4 :	*Knowledge in legal requirements in construction*	2	85	75	H	M	-	-	-	L	-	H	M	M	L	M	H	-	L
CLO-5 :	*Awareness of labour laws and Indian Contract Act*	2	85	75	H	L	-	-	-	L	-	H	M	M	L	M	H	-	L
CLO-6 :	*Acquiring knowledge to execute a contract*	2	85	75	H	H	-	-	-	M	-	H	H	M	L	M	H	-	L

Duration (hour)		9	9	9	9	9
S-1	SLO-1	*Indian contract act*	*Tender- Definitions and Methods*	*Construction claims: Extra items and causes of claims*	*Legal Requirements- Insurance and Bonding*	*Labour Regulations-social security*
	SLO-2	*Definitions and important terms. Clause 1-75*	*Need for tendering, agreements and bonds in tendering process*	*Types of construction claims, documentation*	*Types of insurance*	*Welfare legislation*
S-2	SLO-1	*Elements of contract*	*Notice inviting tender*	*Settlement of claims*	*Laws governing sale*	*Laws relating to wages, Bonus and industrial disputes*
	SLO-2	*Types of contract – Legal parlance, Engineering contracts*	*Tender- Prequalification process*	*Arbitration- comparison and action of laws*	*Purchase and sale of urban and rural land*	*Labour administration*
S-3	SLO-1	*Features and suitability*	*Bidding, Accepting*	*Agreements, subject matter*	*Land revenue codes*	*Insurance and safety regulations*
	SLO-2	*Design of contract documents*	*Evaluation of technical, contractual and commercial point of view*	*Causes of disputes and importance of role of various stakeholders in prevention of disputes*	*Tax laws- income tax, sales tax ,VAT*	*Workmen compensation act*
S4	SLO-1	*International contract document*	*One cover and two cover system*	*Alternate dispute resolution methods*	*Excise on custom duties and their influence on construction cost*	*Indian factory act*
	SLO-2	*Standard contract document*	*Contract formation and interpretation*	*Violations, Appointment of arbitrator*	*Legal requirements for planning*	*Child labour act*
S-5	SLO-1	*Importance of breach of contract*	*Potential contractual problems*	*Conditions of arbitrator Powers and duties of arbitrator*	*Property law, Agency law*	*Maternity act*
	SLO-2	*Law of torts*	*World bank procedures and guidelines*	*Rules of evidences*	*Local government laws for approval*	*Minimum wages act*
S-6	SLO-1	*Special and general conditions of contract*	*Tamilnadu transparency in tenders Act.*	*Dispute review boards*	*Statutory regulations*	*Payment of wages act,1936*
	SLO-2	*Introduction to FIDIC contracts and types*	*EMD, SD*	*Indian arbitration and conciliation act1996*	*The companies act 1956: nature and definition of a company*	*Industrial dispute act*
S-7	SLO-1	*ICE conditions- introduction*	*Environmental provisions for construction contracts*	*Difference between 1940 act and 1996 act*	*Registration and incorporation*	*Domestic engaging of misconduct*
	SLO-2	*Evaluation of FIDIC document, types*	*Duties and responsibilities- engineers and contractors, Project manager, owner*	*Extent application of 1996 act. objectives and general provisions*	*Memorandum of association*	*The Tamilnadu and country planning act*

S-8	SLO-1	*Design and build contract, EPC contract*	*Important site documents*	*Conciliation and its provisions in the act*	*Articles of association,, prospectus, kinds of company*	*Building and other construction works act,1996*
	SLO-2	*Short forms contract-colour code*	*Process of building permissions*	*Conduct of conciliation and arbitral proceedings, ground for challenge*	*Directors: powers, duties, meetings and winding up*	*Employees state insurance act,1948*
S -9	SLO-1	*Various conditions of red book*	*Provisions for scheduling delays and accelerations*	*Procedure of appeal against the awards.*	*Managing performance- introduction, monitoring and performance*	*Contract labour act,1970*
	SLO-2	*Case study*	*Case study*	*Case study*	*Case study*	*Case study*

Learning Resources	1. *John G. Betty., "Engineering Contracts", McGraw Hill,2003* 2. *Gajaria G.T., "Laws Relating to Building and Engineering Contracts in India", M. M. Tripathi Private Ltd., Bombay, 1982 Tamilnadu PWD Code, 2006.* 3. *Jimmie Hinze, "Construction Contracts", McGraw Hill, 2001*	4. *Joseph T. Bockrath, "Contracts, the Legal Environment for Engineers and Architects", McGraw Hill, 2000.* 5. *Lecture Notes, "Legal Aspects for Civil Engineers, Short Term Course organized by SRMEC", 29th May to 4th June, 2002.* 6. *https://nptel.ac.in/courses/105103093/11* 7. *https://nptel.ac.in/syllabus/105102013/*

Learning Assessment

	Bloom's Level of Thinking	Continuous Learning Assessment (50% weightage)								Final Examination (50% weightage)	
		CLA – 1 (10%)		CLA – 2 (15%)		CLA – 3 (15%)		CLA – 4 (10%)#			
		Theory	Practice	Theory	Practice	Theory	Practice	Theory	Practice	Theory	Practice
Level 1	Remember Understand	*40*	-	*30*	-	*40*	-	*30*	-	*40*	-
Level 2	Apply Analyze	*40*	-	*40*	-	*40*	-	*30*	-	*40*	-
Level 3	Evaluate Create	*20*	-	*30*	-	*20*	-	*40*	-	*20*	-
	Total	100 %		100 %		100 %		100 %		100%	

CLA – 4 can be from any combination of these: Assignments, Seminars, Tech Talks, Mini-Projects, Case-Studies, Self-Study, MOOCs, Certifications, and Conf. Paper etc.

Course Designers

Experts from Industry	Experts from Higher Technical Institutions	Department coordinators
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Mr. Rajeev Srinivasan, , NASS Contacting, Rajeev.srinivasan@nasscontracting.com	*Dr. S. Kamal, University College of Engineering, Ramnad, kamalselva21@gmail.com*	*Mr. S. Anandh, SRM IST*

Course Code	18CEE406T	Course Name	REPAIR AND REHABILITATION OF STRUCTURES	Course Category	E	Professional Elective	L	T	P	C
							3	0	0	3

Pre-requisite Courses	Nil	Co-requisite Courses	Nil	Progressive Courses	Nil
Course Offering Department	Civil Engineering	Data Book / Codes/Standards	Nil		

Course Learning Rationale (CLR):	*The purpose of learning this course is to:*
CLR-1 :	*To assess the diagnosis of distress*
CLR-2 :	*To provide an overview of performance of concrete structures*
CLR-3 :	*To identify the sources of dampness and its prevention remedies*
CLR-4 :	*To choose the appropriate material and its application*
CLR-5 :	*To assess the extent of distress*
CLR-6 :	*To study strengthening and demolition of structural component*

Course Learning Outcomes (CLO):	*At the end of this course, learners will be able to:*	Learning 1: Level of Thinking (Bloom)	2: Expected Proficiency (%)	3: Expected Attainment (%)	PLO 1: Engineering Knowledge	2: Problem Analysis	3: Design & Development	4: Analysis, Design, Research	5: Modern Tool Usage	6: Society & Culture	7: Environment & Sustainability	8: Ethics	9: Individual & Team Work	10: Communication	11: Project Mgt. & Finance	12: Life Long Learning	13: PSO - 1	14: PSO - 2	15: PSO – 3
CLO-1 :	*Diagnosis the distresses*	3	85	75	H	H	-	M	-	H	-	-	-	-	-	-	H	-	-
CLO-2 :	*Understand the performance of the concrete*	3	85	75	H	H	-	M	-	H	-	-	-	-	-	-	H	-	-
CLO-3 :	*Sources of dampness and its remedies can be able to identify*	3	85	75	H	H	-	M	-	H	-	-	-	-	-	-	H	-	-
CLO-4 :	*Know about types of materials and its selection*	3	85	75	H	H	-	M	-	H	M	-	-	-	-	-	H	-	-
CLO-5 :	*Rectify the Distress in various structures*	3	85	75	H	H	-	M	-	H	-	-	H	-	-	-	H	-	-
CLO-6 :	*Strengthen and demolish the structural components*	3	85	75	H	H	-	M	-	H	M	M	H	-	-	-	H	-	-

Duration (hour)		9	9	9	9	9
S-1	SLO-1	*General Consideration – Distresses monitoring, Causes of distresses*	*Sources of dampness*	*Materials: Types*	*Distresses : Concrete Structures: Introduction, Causes of deterioration*	*General principle for Strengthening*
	SLO-2	*Defects due to climate, wear and erosion*	*Moisture movement from ground*	*Essential parameters for Materials*	*Diagnosis of causes, Flow charts for diagnosis*	*Relieving loads*
S-2	SLO-1	*Quality assurance & Inspection*	*DPC*	*Special Mortar And Concretes, Concrete Chemicals*	*Methods of repair – repairing, spalling and disintegration*	*Strengthening super structures*
	SLO-2	*Structural & Economic appraisal*	*Reasons for ineffective DPC*	*Special Cements*	*Repairing of concrete floors and pavements*	*Plating*
S-3	SLO-1	*Life Expectancy of Different Types of Buildings*	*Roof leakage - Pitched roofs*	*High Grade Concrete*	*Steel Structures : Types and causes for deterioration*	*Conversation to composite construction*
	SLO-2	*Influence of Environmental Elements on Buildings*	*Madras Terrace roofs*	*Expansive Cement*	*Types and causes for deterioration – preventive measures*	*Post stressing*
S-4	SLO-1	*Design and Construction Errors*	*Leakage of Concrete slabs*	*Polymer Concrete*	*Repair procedure - Brittle fracture*	*Jacketing*
	SLO-2	*Corrosion Mechanism*	*Protective Seal coatings*	*Epoxies, Resins*	*Lamellar tearing*	*Bonded overlays*
S-5	SLO-1	*Effect of Biological Agents*	*Ferro cement overlay*	*Surface Coatings*	*Defects in welded joints*	*Reinforcement addition*
	SLO-2	*Termite Control and Prevention*	*Resin or polymer slurry injection*	*Parameters & types of coatings*	*Mechanism of corrosion*	*Fiber wrap techniques*
S-6	SLO-1	*Chemical Attack on Building*	*Thin polymer overlay*	*Sulphur Infiltrated Concrete*	*Design of protect against corrosion*	*Pre placed aggregate concrete*
	SLO-2	*Aspects of Fire on Buildings*	*Thin epoxy overlay*	*Properties and application of SIFCON*	*Design and fabrication errors*	*Shortcrete*

S-7	SLO-1	*Building Cracks Causes – diagnosis*	*Dampness in solid walls*	*Ferro cement*	*Distress during erection.*	*Strengthening concrete by surface impregnations*
	SLO-2	*Remedial measures*	*Condensation – hygroscopic salts*	*Application of Ferro cement*	*Masonry Structures: Discoloration and weakening of stones*	*Vacuum methods*
S-8	SLO-1	*Thermal cracks*	*Remedial treatments*	*Fiber Reinforced Concrete*	*Biotical treatments*	*Strengthening the substructures: Shoring*
	SLO-2	*Shrinkage cracks*	*Dry pack & epoxy bonded dry pack*	*Types and applications*	*Preservation – Chemical preservatives*	*Under pinning*
S-9	SLO-1	*Vegetation and trees*	*Chemical coating*	*Admixtures*	*Brick masonry structures*	*Increasing the load capacity of footing*
	SLO-2	*Foundation movements*	*Flexible and rigid coatings*	*Chemical and Mineral admixtures*	*Distresses and remedial measures.*	*Design for rehabilitation.*

Learning Resources	1. *"Handbook on repair and rehabilitation of RCC buildings", CPWD, Government of India, Government of India Press, India, 2011* 2. *Allen R.T and Edwards S.C, "Repair of Concrete Structures", Blakie and Sons, UK, 1987* 3. *Dayaratnam.P and Rao.R, "Maintenance and Durability of Concrete Structures", University Press, India, 1997.* 4. *Denison Campbell, Allen and Harold Roper, "Concrete Structures, Materials, Maintenance and Repair", Longman Scientific and Technical, UK, 1991.* 5. *Dodge Woodson.R,"Concrete Structures – protection, repair and rehabilitation", Elsevier Butterworth – Heinmann, UK, 2009.* 6. *Peter H.Emmons, "Concrete Repair and Maintenance Illustrated", Galgotia Publications Pvt. Ltd., 2001.* 7. *Raikar, R.N., "Learning from failures - Deficiencies in Design, Construction and Service" – Rand D Centre (SDCPL), Raikar Bhavan, Bombay, 1987.* 8. *https://onlinecourses-archive.nptel.ac.in/noc19_mm06/preview*

Learning Assessment

	Bloom's Level of Thinking	Continuous Learning Assessment (50% weightage)								Final Examination (50% weightage)	
		CLA – 1 (10%)		CLA – 2 (15%)		CLA – 3 (15%)		CLA – 4 (10%)#			
		Theory	Practice	Theory	Practice	Theory	Practice	Theory	Practice	Theory	Practice
Level 1	Remember Understand	*40%*	-	*30%*	-	*30%*	-	*30%*	-	*30%*	-
Level 2	Apply Analyze	*40%*	-	*40%*	-	*40%*	-	*40%*	-	*40%*	-
Level 3	Evaluate Create	*20%*	-	*30%*	-	*30%*	-	*30%*	-	*30%*	-
	Total	100 %		100 %		100 %		100 %		100 %	

CLA – 4 can be from any combination of these: Assignments, Seminars, Tech Talks, Mini-Projects, Case-Studies, Self-Study, MOOCs, Certifications, and Conf. Paper etc.

Course Designers

Experts from Industry	Experts from Higher Technical Institutions	Internal Experts
Er. A.G.V Desigan, Design Group Engineering Consultancy Pvt Ltd., designan.agv@gmail.com	*Dr. B. Vidivelli, Annamalai University, vidivellibk@yahoo.com*	*Mr.A.Arokiaprakash, SRMIST*
Mr. Rajesh, Planning manager, Uthra Constructions, uthraconstructions@gmail.com	*Dr. E.B.Perumal Pillai, professor, Veltech University, ebppillai@yahoo.co.in*	*Mr.S.Manikandaprabhu, SRMIST*

ACADEMIC CURRICULA

Professional Elective Courses

COMPUTER SCIENCE AND ENGINEERING

Regulations - 2018

SRM INSTITUTE OF SCIENCE AND TECHNOLOGY

(Deemed to be University u/s 3 of UGC Act, 1956)

Kattankulathur, Kancheepuram, Tamil Nadu, India

Course Code	18CSE351T	Course Name	COMPUTATIONAL LOGIC	Course Category	E	Professional Elective	L	T	P	C
							3	0	0	3

Pre-requisite Courses	Nil	Co-requisite Courses	Nil	Progressive Courses	Nil
Course Offering Department	Computer Science and Engineering	Data Book / Codes/Standards	Nil		

Course Learning Rationale (CLR):	The purpose of learning this course is to:
CLR-1 :	*Understand the basics of Propositional logic*
CLR-2 :	*Acquire skills on rules to handle Propositional logic*
CLR-3 :	*Understand the First order Logic and Meta theorems*
CLR-4 :	*Learn the art of application of AI Concepts.*
CLR-5 :	*Master various theorems on Logic*

Course Learning Outcomes (CLO):	At the end of this course, learners will be able to:	Learning 1: Level of Thinking (Bloom)	2: Expected Proficiency (%)	3: Expected Attainment (%)	PLO 1: Engineering Knowledge	2: Problem Analysis	3: Design & Development	4: Analysis, Design, Research	5: Modern Tool Usage	6: Society & Culture	7: Environment & Sustainability	8: Ethics	9: Individual & Team Work	10: Communication	11: Project Mgt. & Finance	12: Life Long Learning	13: PSO - 1	14: PSO - 2	15: PSO – 3
CLO-1 :	*Apply the skills acquired on propositional logic to solve examples at hand*	2	80	85	H	-	-	-	-	-	-	-	-	-	-	-	-	-	-
CLO-2 :	*Apply the rules learnt towards problem solving*	2	75	80	H	H	-	-	-	-	-	-	-	-	-	-	-	-	-
CLO-3 :	*Acquire mastry over FOL and Meta theorems and apply the same with confidence*	2	85	80	H	M	-	-	-	-	-	-	-	-	-	-	-	-	-
CLO-4 :	*Apply the acquired knowledge on AI under appropriate problem solving contexts*	2	80	75	H	H	H	-	-	-	-	-	-	-	-	-	-	-	-
CLO-5 :	*Attempt to apply the acquired knowledge on logics under appropriate problem solving contexts*	2	75	85	H	M	H	-	-	-	-	-	M	-	-	H	-	-	-

Program Learning Outcomes (PLO)

Duration (hour)		9	9	9	9	9
S-1	SLO-1	*Propositional Logic-Introduction*	*Natural Deduction of Propositional Logic: Rules of Conjunction, Disjunction*	*First Order Logic-Introduction*	*Axiomatic System FC: Introduction*	*Modal Logic K-Introduction*
	SLO-2	*Syntax of PL*	*Natural Deduction of Propositional Logic: Implication, Negation*	*First Order Logic-Illustration*	*Axiomatic System FC: Example applications, Illustrations*	*Modal Logic K-Illustration*
S-2	SLO-1	*Is It a Proposition?*	*Natural Deduction of Propositional Logic: Proofs*	*Syntax of FL*	*Monotonicity Theorem-Detail*	*Syntax and Semantics of K*
	SLO-2	*Unique Parsing, PropDet*	*Natural Deduction of Propositional Logic: Examples*	*Scope and Binding*	*Deduction Theorem- Detail*	*Syntax and Semantics of K: Illustration*
S-3	SLO-1	*Sub Propositions, Precedence rules*	*Natural Deduction of Propositional Logic: Problems*	*Scope and Binding-Illustration*	*Theorem-RA, Fitness- Detail*	*Validity and Consequence in K*
	SLO-2	*Proposition: Theorems and Examples*	*Natural Deduction of Propositional Logic: Problems*	*Substitutions*	*Paradox of material Implication-Detail*	*Validity and Consequence in K: Illustration*
S-4	SLO-1	*Interpretations*	*Derived Rules of Propositional Logic: Introduction*	*Substitutions- Illustrations*	*Strong Generalization Theorem:Introduction*	*Axiomatic System KC*
	SLO-2	*Boolean conditions, Truth table*	*Derived Rules of Propositional Logic: Examples*	*Substitutions- Problems*	*Strong Generalization Theorem: Illustration*	*Axiomatic System KC: Illustration*
S-5	SLO-1	*Interpretations: Theorems, Conventions and Lemma*	*Derived Rules of Propositional Logic:Problems*	*Semantics of FL*	*Adequacy of FC to FL*	*Adequacy of KC to K*
	SLO-2	*Interpretations: Examples*	*Derived Rules of Propositional Logic:Problems*	*Semantics of FL: Illustration*	*Adequacy of FC to FL: Illustration*	*Adequacy of KC to K: Illustration*
S-6	SLO-1	*Models: Introduction to terminologies*	*Parse Tree*	*Translating into FL*	*Compactness of FL*	*Natural Deduction in K*

	SLO-2	*Equivalences and Consequences : Introduction to terminologies*	*Sub Formula*	*Translating into FL: Illustrations*	*Compactness of FL: Proof*	*Natural Deduction in K: Illustration*
S-7	SLO-1	*Equivalences and Consequences : Examples*	*Soundness of Propositional Logic*	*Satisfiability and Validity*	*Laws in FL*	*Analytic Tableau for K*
	SLO-2	*Deduction Theorem (DT)-Introduction*	*Soundness of Propositional Logic: Illustration*	*Satisfiability and Validity:Illustrations*	*Laws in FL: Illustration*	*Analytic Tableau for K: Illustration*
S-8	SLO-1	*RA Theorem, Monotonicity Theorem (M)-Introduction*	*Completeness of Propositional Logic*	*Metatheorems: Introduction*	*Natural Deduction*	*Modalities*
	SLO-2	*Fitness Theorem*	*Completeness of Propositional Logic: Illustration*	*Metatheorems: Deduction, Substitution, Chaining*	*Natural Deduction: Illustration*	*Modalities: Illustration*
S-9	SLO-1	*Theorem-Paradox of material Implication*	*Gentzen sequent calculus*	*Metatheorems: Examples*	*Analytic Tableaux*	*Computation Tree Logic*
	SLO-2	*Replacement Laws*	*Gentzen sequent calculus: Illustration*	*Metatheorems: Problems*	*Analytic Tableaux: Illustration*	*Computation Tree Logic: Illustration*

Learning Resources	1. *Arindama Singh,"Logics for Computer Science", PHI Learning Private Ltd,2nd Edition,2018* 2. *Wasilewska & Anita,"Logics for computer science: classical and non-classical",Springer ,2018* 3. *Huth M and Ryan M ," Logic in Computer Science : Modeling and Reasoning about systems",Cambridge University Press, 2005*	4. *Dana Richards & Henry Hamburger,"Logic And Language Models For Computer Science",Third Edition,World Scientific Publishing Co. Pte. Ltd,2018.* 5. *https://www.cs.cornell.edu/courses/cs3110/2012sp/lectures/lec15-logic-contd/lec15.html*

Learning Assessment

	Bloom's Level of Thinking	Continuous Learning Assessment (50% weightage)								Final Examination (50% weightage)	
		CLA – 1 (10%)		CLA – 2 (15%)		CLA – 3 (15%)		CLA – 4 (10%)#			
		Theory	Practice	Theory	Practice	Theory	Practice	Theory	Practice	Theory	Practice
Level 1	Remember Understand	*40 %*	-	*30 %*	-	*30 %*	-	*30 %*	-	*30%*	-
Level 2	Apply Analyze	*40 %*	-	*40 %*	-	*40 %*	-	*40 %*	-	*40%*	-
Level 3	Evaluate Create	*20 %*	-	*30 %*	-	*30 %*	-	*30 %*	-	*30%*	-
	Total	100 %		100 %		100 %		100 %		100 %	

CLA – 4 can be from any combination of these: Assignments, Seminars, Tech Talks, Mini-Projects, Case-Studies, Self-Study, MOOCs, Certifications, Conf. Paper etc.,

Course Designers

Experts from Industry	Experts from Higher Technical Institutions	Internal Experts
Dr. Paventhan Arumugum, Director (R&D), ERNET India		*Mr. T.Senthil Kumar, SRMIST*
Mr Shiv Kumar Ganesh Full stack developer Altemetric, US		*Dr.Kayalvizhi Jayavel, SRMIST*
		Ms. Jeyasudha, SRMIST

Course Code	18CSE352T	Course Name	NEURO FUZZY AND GENETIC PROGRAMMING	Course Category	E	Professional Elective	L	T	P	C
							3	0	0	3

Pre-requisite Courses	Nil	Co-requisite Courses	Nil	Progressive Courses	Nil
Course Offering Department	Computer Science and Engineering	Data Book / Codes/Standards	Nil		

Course Learning Rationale (CLR):	*The purpose of learning this course is to:*
CLR-1 :	*Understand the fundamentals of Artificial Neural Networks*
CLR-2 :	*Learn the various topologies and learning algorithms of ANN*
CLR-3 :	*Understand the principles and fundamentals of Fuzzy Logic*
CLR-4 :	*Understand the Fuzzy Rule based systems*
CLR-5 :	*Understand the basic concepts and techniques of Genetic Algorithms*
CLR-6 :	*Utilize the Neural, Fuzzy and Genetic Algorithms for real-time application development*

Course Learning Outcomes (CLO):	*At the end of this course, learners will be able to:*	Learning 1: Level of Thinking (Bloom)	Learning 2: Expected Proficiency (%)	Learning 3: Expected Attainment (%)	PLO 1: Engineering Knowledge	PLO 2: Problem Analysis	PLO 3: Design & Development	PLO 4: Analysis, Design, Research	PLO 5: Modern Tool Usage	PLO 6: Society & Culture	PLO 7: Environment & Sustainability	PLO 8: Ethics	PLO 9: Individual & Team Work	PLO 10: Communication	PLO 11: Project Mgt. & Finance	PLO 12: Life Long Learning	PLO 13: PSO - 1	PLO 14: PSO - 2	PLO 15: PSO – 3
CLO-1 :	*Acquire the knowledge on constructing a neural network*	3	80	75	L	H	-	H	L	-	-	-	L	L	-	H	-	-	-
CLO-2 :	*Identify the basic Neural net and learning algorithm to apply for a real time problem*	3	85	75	M	H	M	M	H	-	-	-	M	L	-	H	-	-	-
CLO-3 :	*Acquire the ability to use Fuzzy operators, membership functions, Fuzzification and Defuzzification Techniques*	3	75	70	M	H	M	H	M	-	-	-	M	L	-	H	-	-	-
CLO-4 :	*Gain Knowledge on applying the Fuzzy rules to different applications*	3	85	80	M	H	M	H	H	-	-	-	M	L	-	H	-	-	-
CLO-5 :	*Acquire the knowledge of fitness functions and Genetic operators*	3	85	75	H	H	M	H	M	-	-	-	M	L	-	H	-	-	-
CLO-6 :	*Apply the Genetic Algorithm to real-time applications*	3	80	70	M	H	M	H	H	-	-	-	L	L	-	H	-	-	-

Duration (hour)		9	9	9	9	9
S-1	SLO-1	*Biological and Artificial Neuron*	*Delta Rule, Derivation of GDR*	*Crisp sets*	*Fuzzification of Input Variables, Application of Fuzzy operations*	*History of Evolutionary Computing, Genetic Algorithms, basic concepts*
	SLO-2	*History of ANN*	*Backpropagation Algorithm, Local Minima Problem*	*Fuzzy sets*		*GA Cycle , Fitness Function,*
S-2	SLO-1	*ANN architectures*	*Radial Basis Function Neural Network*	*Fuzzy membership functions*	*Evaluation of Fuzzy rules, Aggregation of output Fuzzy sets*	*Introduction to GA Operators Selection Operators, Crossover, Mutation Operations*
	SLO-2	*Learning Algorithms*	*Pattern Association, Auto Associative nets*	*Operations of Fuzzy sets*		
S-3	SLO-1	*Activation Functions, Bias, Threshold and other parameters*	*Hetero Associative nets*	*Fuzzy Relations, Operations*	*Rule based systems, Conventional programs vs Rule based systems*	*Schema Theorem, Example*
	SLO-2	*McCulloch Pitts model,*	*Bidirectional Associative Memory Network*	*Fuzzy Extension Principle*	*Fuzzy Propositions*	
S-4	SLO-1 SLO-2	*Simulation of Logic Functions*	*Hopfield network Competitive networks: Maxnet*	*Crisp Relations, Fuzzy relations, Properties, operations,*	*Fuzzification*	*Classification of Genetic Algorithm*
S-5	SLO-1	*Perceptron Network*	*Self Organizing Map Network*	*Propositional Logic*	*Defuzzification*	*Holland Classifier Systems*
	SLO-2	*Hebbian network*	*Learning Vector Quantization*	*Crisp Logic*	*Fuzzy Controller : Air conditioner control, Cruise Controller*	*Genetic Programming*
S-6	SLO-1	*ADALINE networks*	*Adaptive Resonance Theory Network*	*Predicate Logic Rules of Inference*	*Fuzzy Decision making*	*Data Representation*
	SLO-2	*MADALINE networks*		*Fuzzy Truth, Fuzzy Rules*		*Genetic Operators*
S-7,8	SLO-1	*Practice of Neural Network tool : Simple Logic functions*	*Practice of Neural Network tool : Delta rule*	*Fuzzy Reasoning*	*Introduction to neuro fuzzy system- Adaptive Neuro-Fuzzy Inference Systems Coactive Neuro-Fuzzy Modeling*	*Application of Genetic Algorithm*
	SLO-2		*Practice of Neural Network tool : Pattern Classification*	*Practice of Fuzzy Logic tool: Fuzzy functions*	*Recent Applications*	*Practice of Optimization and Genetic algorithm tool*
S-9	SLO-1 SLO-2	*Practice of Neural Network tool : XOR problem*	*Practice of Neural Network tool : Pattern Clustering*	*Practice of Fuzzy Logic tool: Fuzzy operations*	*Practice of Fuzzy Logic tool : Fuzzy controller design and applications*	

Learning Resources	1. *Samir Roy, Udit Chakraborty, "Introduction to Soft Computing: Neuro-Fuzzy and Genetic Algorithms", Pearson Education, 2013.* 2. *Michael Negnevitsky. Artificial Intelligence: A Guide to Intelligent Systems, 3rd Edition, Pearson Education, 2011.* 3. *Laurene Fausett, "Fundamentals of Neural Networks, Architectures, Algorithms and Applications", Pearson Education, 2008.*	4. *Timothy J. Ross , "Fuzzy Logic with Engineering Applications", John Wiley & Sons Ltd, 2010.* 5. *David E. Goldberg, "Genetic Algorithms-In Search, optimization and Machine Learning", Pearson Education, 2008.*

Learning Assessment

	Bloom's Level of Thinking	Continuous Learning Assessment (50% weightage)								Final Examination (50% weightage)	
		CLA – 1 (10%)		CLA – 2 (15%)		CLA – 3 (15%)		CLA – 4 (10%)#			
		Theory	Practice	Theory	Practice	Theory	Practice	Theory	Practice	Theory	Practice
Level 1	Remember Understand	*40 %*	-	*30 %*	-	*30 %*	-	*30 %*	-	*30%*	-
Level 2	Apply Analyze	*40 %*	-	*40 %*	-	*40 %*	-	*40 %*	-	*40%*	-
Level 3	Evaluate Create	*20 %*	-	*30 %*	-	*30 %*	-	*30 %*	-	*30%*	-
	Total	100 %		100 %		100 %		100 %		100 %	

CLA – 4 can be from any combination of these: Assignments, Seminars, Tech Talks, Mini-Projects, Case-Studies, Self-Study, MOOCs, Certifications, Conf. Paper etc.

Course Designers		
Experts from Industry	Experts from Higher Technical Institutions	Internal Experts
1. Mr. K. selvaraj, TCS, Bangalore	*1. Dr. A.P. Shanthi, Professor, Dept. of Computer Science & Engineering, Anna University, chennai-600025*	*1. Dr. V. Ganapathy, SRM IST*
2. Mr. Saju G Nair, IBM, Bangalore.	*2. Dr. A, Kannan, Professor Dept. of Computer Science & Engineering, VIT, Vellore*	*2. Dr. D. Malathi, SRM IST*
		3. Dr. Ferni Ukrit, SRM IST

Course Code	18CSE353T	Course Name	DIGITAL IMAGE PROCESSING	Course Category	E	Professional Elective	L	T	P	C
							3	0	0	3

Pre-requisite Courses	Nil	Co-requisite Courses	Nil	Progressive Courses	Nil
Course Offering Department	Computer Science and Engineering	Data Book / Codes/Standards	Nil		

Course Learning Rationale (CLR):	*The purpose of learning this course is to:*
CLR-1 :	*provide deep understanding of basic concepts of digital image acquisition*
CLR-2 :	*provide deep Understanding of various digital image enhancement techniques*
CLR-3 :	*Understand image restoration and segmentation methods*
CLR-4 :	*provide understanding and implementation of image compression techniques*
CLR-5 :	*Provide understanding and knowledge of image recognition methods*

Course Learning Outcomes (CLO):	*At the end of this course, learners will be able to:*	Learning 1: Level of Thinking (Bloom)	Learning 2: Expected Proficiency (%)	Learning 3: Expected Attainment (%)	PLO 1: Engineering Knowledge	PLO 2: Problem Analysis	PLO 3: Design & Development	PLO 4: Analysis, Design, Research	PLO 5: Modern Tool Usage	PLO 6: Society & Culture	PLO 7: Environment & Sustainability	PLO 8: Ethics	PLO 9: Individual & Team Work	PLO 10: Communication	PLO 11: Project Mgt. & Finance	PLO 12: Life Long Learning	PLO 13: PSO - 1	PLO 14: PSO - 2	PLO 15: PSO – 3
CLO-1 :	*Understand basics of digital images and tools for image processing*	*2*	*80*	*85*	*H*	-	-	-	-	-	-	-	-	-	-	-	-	-	-
CLO-2 :	*Learn and implement image Enhancement techniques*	*2*	*75*	*80*	*H*	*H*	*H*	-	*H*	-	-	-	-	-	-	-	-	-	-
CLO-3 :	*Understand and Learn image Restoration and Segmentation Methods*	*2*	*85*	*80*	*H*	*H*	*M*	-	*H*	-	-	-	-	-	-	-	-	-	-
CLO-4 :	*Understand and implement Image Compression techniques*	*2*	*80*	*75*	*H*	*H*	*M*	-	*H*	-	-	-	-	-	-	-	-	-	-
CLO-5 :	*Learn and Implement Image Recognition methods*	*2*	*75*	*85*	*H*	*H*	*M*	-	*H*	-	-	-	-	-	-	-	-	-	-

Duration (hour)		9	9	9	9	9
S-1	SLO-1	*Introduction*	*Introduction to Spatial Domain*	*Noise models – Mean Filters – Order Statistics*	*Wavelets – Subband coding – Multiresolution expansions*	*Boundary representation – Chain Code*
S-2	SLO-1	*Origin- Steps in Digital Image Processing*	*Gray level transformations*	*Adaptive filters – Band reject Filters – Band pass Filters*	*Fundamentals of Compression – Image Compression methods - Error Free Compression*	*Polygonal approximation, signature, boundary segments*
S-3	SLO-1	*Components*	*Histogram processing*	*Inverse Filtering – Wiener filtering Segmentation*	*Variable Length Coding – Bit-Plane Coding – Lossless Predictive Coding*	*Boundary description – Shape number*
S-4	SLO-1	*Elements of Visual Perception*	*Basics of Spatial Filtering*	*Point, Line, and Edge Detection*	*Lossy Compression – Lossy Predictive Coding*	*Fourier Descriptor*
S-5	SLO-1	*Image Sensing and Acquisition*	*Smoothing and Sharpening Spatial Filtering*	*Marr-Hildreth & Canny edge detector*	*Compression Standards-Huffman, Arithmetic coding, LZW coding, Run Length Encoding*	*Regional Descriptors*
S-6	SLO-1	*Image Sampling and Quantization*	*Frequency Domain: Basics of filtering*	*Edge Linking and Boundary detection*	*Compression StandardsHuffman, Arithmetic coding, LZW coding, Run Length Encoding*	*Topological - Texture – Patterns and Pattern classes*
S-7	SLO-1	*Relationships between pixels*	*Smoothing and Sharpening frequency domain filters*	*Local & Regional processing-Region based segmentation*	*Block Transform coding, Wavelet coding, JPEG standard*	*Recognition based on matching*
S-8	SLO-1	*Introduction to Image processing toolbox in MATLAB*	*Smoothing and Sharpening frequency domain filters*	*Morphological processing- Watershed segmentation algorithm*	*MATLAB code for image compression: Huffam coding, Arithmetic coding, wavelet coding*	*MATLAB code for image representation*
S-9	SLO-1	*Tool box practice*	*MATLAB code for histogram equalization*	*MATLAB code for restoring an image after degradation using adaptive and wiener filter*	*MATLAB code for image compression: Huffam coding,*	*MATLAB code for image recognition*
	SLO-2	*Exploring functions*	*MATLAB code for spatial and frequency domain filter.*	*Edge detection operators*	*Arithmetic coding, wavelet coding*	*MATLAB Practice exercises*

Learning Assessment											
	Bloom's Level of Thinking	Continuous Learning Assessment (50% weightage)								Final Examination (50% weightage)	
		CLA – 1 (10%)		CLA – 2 (15%)		CLA – 3 (15%)		CLA – 4 (10%)#			
		Theory	Practice	Theory	Practice	Theory	Practice	Theory	Practice	Theory	Practice
Level 1	Remember Understand	*40 %*	-	*30 %*	-	*30 %*	-	*30 %*	-	*30%*	-
Level 2	Apply Analyze	*40 %*	-	*40 %*	-	*40 %*	-	*40 %*	-	*40%*	-
Level 3	Evaluate Create	*20 %*	-	*30 %*	-	*30 %*	-	*30 %*	-	*30%*	-
	Total	100 %		100 %		100 %		100 %		100 %	

CLA – 4 can be from any combination of these: Assignments, Seminars, Tech Talks, Mini-Projects, Case-Studies, Self-Study, MOOCs, Certifications, Conf. Paper etc.,

Course Designers		
Experts from Industry	Experts from Higher Technical Institutions	Internal Experts
Madhan Thandayithapani kutiyappan, Assistant consultantant, TCS - siruseri	*Dr. S. Sridhar, Anna University*	*Dr. G.Niranjana. Associate Professor/CSE*
	Dr. Senthil kumar, Annauniversity	*Mr. Rajasekar Assistant Professor/IT* *Mr. James Joseph Assistant Professor/SWE*

Course Code	18CSE354T	Course Name	NETWORK SECURITY	Course Category	E	Professional Elective	L	T	P	C
							3	0	0	3

Pre-requisite Courses	Nil	Co-requisite Courses	Nil	Progressive Courses	Nil
Course Offering Department	CSE	Data Book / Codes/Standards	Nil		

Course Learning Rationale (CLR):	*The purpose of learning this course is to:*
CLR-1 :	*Understand the basic concepts of networking devices*
CLR-2 :	*Understand the concept of IP security*
CLR-3 :	*Understand the various methods and protocols to maintain E-mail security*
CLR-4 :	*Understand the various methods and protocols to maintain web security*
CLR-5 :	*Understand security measures for wireless and cell phone Communications*

Course Learning Outcomes (CLO):	*At the end of this course, learners will be able to:*	Learning 1	Learning 2	Learning 3	PLO 1	2	3	4	5	6	7	8	9	10	11	12	13	14	15
		Level of Thinking (Bloom)	Expected Proficiency (%)	Expected Attainment (%)	Engineering Knowledge	Problem Analysis	Design & Development	Analysis, Design, Research	Modern Tool Usage	Society & Culture	Environment & Sustainability	Ethics	Individual & Team Work	Communication	Project Mgt. & Finance	Life Long Learning	PSO - 1	PSO - 2	PSO – 3
CLO-1 :	*Acquire the knowledge of network devices used in data Communication*	*2*	*80*	*85*	*H*									*H*					
CLO-2 :	*Acquire the knowledge of IP security and ability to identify the IP security attack*	*2*	*75*	*80*	*H*														
CLO-3 :	*Acquire the knowledge of Email security and ability to detect the attacks in e-mail*	*2*	*85*	*80*	*H*														
CLO-4 :	*Acquire the knowledge of web security attack and prevention mechanism*	*2*	*80*	*75*	*H*							*H*							
CLO-5 :	*Acquire the knowledge of wireless network security and prevention mechanism*	*2*	*75*	*85*	*H*							*H*							

Duration (hour)		9	9	9	9	9
S-1	SLO-1	*Networking Devices(Layer1,2)*	*Overview of IPSEC- Security Associations, Security Association Database*	*Security Services for E-mail*	*SSL/TLS Basic Protocol*	*Wireless Security:IEEE 802.11 Wireless LAN*
	SLO-2	*Networking Devices(Layer 3)*	*Security Policy databases , AH and ESP*	*Security Services for E-mail*	*SSL/TLS Basic Protocol*	*Wireless Security:IEEE 802.11 Wireless LAN*
S-2	SLO-1	*Different types of network layer attacks*	*Tunnel and Transport mode*	*Establishing keys*	*computing the keys*	*Authentication*
	SLO-2	*Different types of network layer attacks*	*IP header Protection*	*Establishing Public and secret keys*	*computing the keys*	*Authentication and confidentiality*
S-3	SLO-1	*Firewall- ACL*	*IP and IPv6*	*Privacy*	*client authentication*	*Cellphone Security*
	SLO-2	*Packet Filtering*	*IPV4 and IPV6 header*	*End-to end Privacy, Privacy with distribution List Exploders*	*client authentication*	*GSM (2G) Security*
S-4	SLO-1	*DMZ, Alerts*	*Authentication Header*	*Authentication of the source*	*PKI as deployed by SSL*	*Security in UMTS (3G)*
	SLO-2	*Audit Trials*	*Mutable, Immutable and Mutable but predictable*	*Based on public key technology and secret keys and with distribution list*	*PKI as deployed by SSL*	*Security in UMTS (3G)*
S-5	SLO-1	*IDS*	*Encapsulation Security Payload(ESP)*	*Message Integrity*	*SSLAttacks fixed in v3*	*Wireless LAN Vulnerabilities*
	SLO-2	*Advantages and Disadvantages of IDS(Need of IPS)*	*Internet Key Exchange*	*Non-repudiation*	*SSLAttacks fixed in v3*	*Phishing*
S-6	SLO-1	*Advantages of IPS ove IDS*	*Phases of IKE*	*Introduction and Overviw of PGP*	*Exportability*	*Buffer Overflow*
	SLO-2	*IPS*	*Phase I IKE- Modes and key types*	*Efficient Encoding*	*Exportability*	*Buffer Overflow*
S-7	SLO-1	*IPS Types- Signature based*	*Phase I IKE Protocols*	*Certificate and key revocation*	*Encoding*	*Format String Attacks*
	SLO-2	*Anomaly based, Policy based*	*Phase I IKE Protocols*	*Singature types, Private key, Fing types*	*Encrypted Record*	*Cross-site Scripting (XSS)*
S-8	SLO-1	*IPS Types - Honeypot based*	*Phase II IKE*	*Anomalies*	*Handshake messages*	*SQL Injection*
	SLO-2	*Applications*	*Phase II IKE*	*Object Format*	*Changecipherspec and Alerts*	*SQL Injection*
S-9	SLO-1	*Malicious Software*	*ISAKMP/IKE Encoding*	*S/MIME*	*SET*	*Case Studies: Secure Inter-branch Payment Transactions*
	SLO-2	*Malicious Software*	*ISAKMP/IKE Encoding*	*S/MIME*	*SET*	*Virtual Elections*

Learning Resources	1. *Charlie Kaufman, Radia Perlman, Mike Speciner, Network Security, Prentice Hall of India, 2002.* 2. *Bernard Menezes - Network Security and Cryptography- Cengage Learning. 2010.*	3. *William Stallings, Cryptography and Network Security - Principles and Practice, 7th edition, Pearson Publication, 2017* 4. *Cryptography and network security , AtulkahateTata McGraw-Hill Education,2003*

Learning Assessment											
	Bloom's Level of Thinking	Continuous Learning Assessment (50% weightage)								Final Examination (50% weightage)	
		CLA – 1 (10%)		CLA – 2 (15%)		CLA – 3 (15%)		CLA – 4 (10%)#			
		Theory	Practice	Theory	Practice	Theory	Practice	Theory	Practice	Theory	Practice
Level 1	Remember Understand	*40 %*	-	*30 %*	-	*30 %*	-	*30 %*	-	*30%*	-
Level 2	Apply Analyze	*40 %*	-	*40 %*	-	*40 %*	-	*40 %*	-	*40%*	-
Level 3	Evaluate Create	*20 %*	-	*30 %*	-	*30 %*	-	*30 %*	-	*30%*	-
	Total	100 %		100 %		100 %		100 %		100 %	

CLA – 4 can be from any combination of these: Assignments, Seminars, Tech Talks, Mini-Projects, Case-Studies, Self-Study, MOOCs, Certifications, Conf. Paper etc.,

Course Designers		
Experts from Industry	Experts from Higher Technical Institutions	Internal Experts
Mr. M. Sudhakar, M.Tech, (Ph.D)-IIT, IT Infrastructure Service, Tata Consultancy Services.	*Dr. P. Yogesh, Associate Professor, Dept of Information Science and Technology, College of Engineering, Guindy,*	*Dr. A. Jeyasekar, Associate Professor* *Dr. J. Femilda, Associate Professor* *Mrs. G. Sujatha, Assistant Professor*

Course Code	18CSE356T	Course Name	DISTRIBUTED OPERATING SYSTEMS	Course Category	E	Professional Elective	L	T	P	C
							3	0	0	3

Pre-requisite Courses	Nil	Co-requisite Courses	Nil	Progressive Courses	Nil
Course Offering Department	Computer Science and Engineering	Data Book / Codes/Standards	Nil		

Course Learning Rationale (CLR):	The purpose of learning this course is to:
CLR-1 :	*To recognize the essential concepts of distributed system.*
CLR-2 :	*To comprehend about the communication that takes place in Distributed systems*
CLR-3 :	*To realize the necessity of synchronization, consistency and Fault tolerance in a Distributed System.*
CLR-4 :	*To value the Process management, File systems, Shared memory*
CLR-5 :	*To acquire apparent scheme regarding distributed object-oriented based systems*

Course Learning Outcomes (CLO):	At the end of this course, learners will be able to:	Learning 1: Level of Thinking (Bloom)	2: Expected Proficiency (%)	3: Expected Attainment (%)	PLO 1: Engineering Knowledge	2: Problem Analysis	3: Design & Development	4: Analysis, Design, Research	5: Modern Tool Usage	6: Society & Culture	7: Environment & Sustainability	8: Ethics	9: Individual & Team Work	10: Communication	11: Project Mgt. & Finance	12: Life Long Learning	13: PSO - 1	14: PSO - 2	15: PSO – 3
CLO-1 :	*Characterize the fundamental hardware and software concepts of distributed systems.*	3	80	70	H	M	M	H	H	M	-	-	H	M	-	H	-	-	-
CLO-2 :	*Categorize layered protocols and comprehend the communications in distributed systems*	3	85	75	H	M	H	M	H	M	-	-	H	M	-	H	-	-	-
CLO-3 :	*Implement synchronization of distributed systems using various algorithms.*	3	75	70	H	H	H	H	H	M	-	-	H	M	-	H	-	-	-
CLO-4 :	*Demonstrate process scheduling and fault tolerance of distributed systems.*	3	85	80	H	H	H	H	H	M	-	-	H	M	-	H	-	-	-
CLO-5 :	*Evaluate various Distributed Object-Oriented based systems.*	3	85	75	H	H	H	M	H	M	-	-	H	M	-	H	-	-	-

Duration (hour)		9	9	9	9	9
S-1	SLO-1	*Introduction- Distributed Systems*	*Fundamentals of Communication systems*	*Synchronization in Distributed Systems- Fundamentals of Clock Synchronization*	*Processes and Processors in Distributed Operating Systems - Threads*	*Distributed Shared memory - Introduction*
	SLO-2	*Goals of Distributed Systems*		*Logical clock, Physical clock*	*Design issues of Threads package*	*Bus-Based Multiprocessors*
	SLO-2				*Work Station Model*	*Switched Multiprocessors*
S-2	SLO-1	*Hardware Concepts- Bus-based Multiprocessors*	*Layered Protocols*	*Algorithms for Clock synchronization*	*System Model - Introduction*	*Ring-based Multiprocessors*
S-3	SLO-1		*ATM networks*	*Mutual Exclusion-Centralized Algorithm*	*Using Idle Work Stations*	*Numa Multiprocessors*
	SLO-2	*Switched Multiprocessors*				*Comparison of Shared Memory Systems*
S-4	SLO-1	*Bus-based Multicomputers*	*Client Server model - Blocking Primitives*	*Distributed Algorithm*	*Processor Pool Model, Hybrid Model*	*Consistency Models – Strict Consistency, Casual Consistency, PRAM Consistency*
	SLO-2		*Non-Blocking Primitives*	*Token Ring Algorithm*	*Processor Allocation – Allocation Model*	*Weak Consistency, Release Consistency, Entry Consistency*
S-5	SLO-1	*Switched Multicomputers*	*Buffered Primitives*	*Comparison of all three algorithms*	*Design issues for processor Allocation Algorithms*	*Page Based Distributed Shared Memory – Replication, granularity*
	SLO-2		*Unbuffered Primitives*	*Importance of Election Algorithm*	*Example of processor Allocation Algorithms*	*Finding the Owner,Finding the Copies*
S-6	SLO-1	*Software Concepts-Network Operating System*	*Reliable primitives*	*Bully Algorithm*	*Scheduling in Distributed Systems*	*Page Replacement*
	SLO-2		*Unreliable primitives*	*Ring Algorithm*	*Load Balancing and Sharing Approach*	*Synchronization*
S-7	SLO-1	*True Distributed Systems*	*Message passing and its related issues*	*Atomic Transaction- Introduction*	*Fault Tolerance-Component Faults*	*Shared – Variable Distributed Shared memory*
	SLO-2			*Transaction Model, Concurrency Control*	*System Failures*	*Object Based Distributed Shared memory – DOO Architecture*
S-8	SLO-1	*Multiprocessors Timesharing Systems*	*Remote Procedure Call and its related issues*	*Deadlock in Distributed Systems*	*Synchronous versus Asynchronous Systems*	*Distributed Object-Oriented Process*

	SLO-2			*Distributed Deadlock Detection*	*Fault tolerance Using Active Replication, Primary-backup*	*Distributed Object-oriented Communication*
S-9	SLO-1	*Design Issues-Distributed Systems*	*Case Studies: SUN RPC, DEC RPC*	*Distributed Deadlock Prevention*	*Real Time Distributed Systems-Communication*	*Case Study - Amoeba*
	SLO-2				*Real Time Scheduling*	*Mach-OS, Chorus*

Learning Resources	*1. Andrew S. Tanenbaum, "Distributed Operating Systems "PearsonEducation, 2011.* *2. Pradeep K. Sinha "DistributedOperatingSystems Concepts and Design "PHI 2012.*	*3. Mukesh Singhal, Niranjan G Shivratri "Advanced concepts in Operating Systems ", Mc Graw Hill International 2011.* *4. http://www.seas.gwu.edu/~jstanton/courses/cs251/* *5.http://cse.yeditepe.edu.tr/~sbaydere/courses new/cse532/*

Learning Assessment

	Bloom's Level of Thinking	Continuous Learning Assessment (50% weightage)								Final Examination (50% weightage)	
		CLA – 1 (10%)		CLA – 2 (15%)		CLA – 3 (15%)		CLA – 4 (10%)#			
		Theory	Practice	Theory	Practice	Theory	Practice	Theory	Practice	Theory	Practice
Level 1	Remember Understand	40%	-	30%	-	30%	-	30%	-	30%	-
Level 2	Apply Analyze	40%	-	40%	-	40%	-	40%	-	40%	-
Level 3	Evaluate Create	20%	-	30%	-	30%	-	30%	-	30%	-
	Total	100 %		100 %		100 %		100 %		-	

CLA – 4 can be from any combination of these: Assignments, Seminars, Tech Talks, Mini-Projects, Case-Studies, Self-Study, MOOCs, Certifications, Conf. Paper etc.,

Course Designers

Experts from Industry	Experts from Higher Technical Institutions	Internal Experts
JP Vinjamoori, Director, Pavartha Software Pvt.Ltd, jp@pavarthasoftware.com	*Dr. E.Sivasankar,NIT,Trichy*	*Mrs. S. Aruna, Dr.G. Maragatham, Mrs. A. Jackulin Mahriba, SRMIST*

Course Code	18CSE357T	Course Name	BIOMETRICS	Course Category	E	Professional Elective	L	T	P	C
							3	0	0	3

Pre-requisite Courses	Nil	Co-requisite Courses	Nil	Progressive Courses	Nil
Course Offering Department	Computer science	Data Book / Codes/Standards	Nil		

Course Learning Rationale (CLR):	*The purpose of learning this course is to:*
CLR-1 :	*Understand the concept of authentication using biometrics.*
CLR-2 :	*Gain knowledge on the basics of biometric traits, sensors and data acquisition*
CLR-3 :	*Gain knowledge on design of biometric security systems*
CLR-4 :	*Acquire knowledge on pattern recognition systems*
CLR-5 :	*Introduce the various feature extraction and matching techniques for different biological traits.*
CLR-6 :	*Understand the real time application of biometrics*

Course Learning Outcomes (CLO):	*At the end of this course, learners will be able to:*	Learning 1: Level of Thinking (Bloom)	Learning 2: Expected Proficiency (%)	Learning 3: Expected Attainment (%)	PLO 1: Engineering Knowledge	PLO 2: Problem Analysis	PLO 3: Design & Development	PLO 4: Analysis, Design, Research	PLO 5: Modern Tool Usage	PLO 6: Society & Culture	PLO 7: Environment & Sustainability	PLO 8: Ethics	PLO 9: Individual & Team Work	PLO 10: Communication	PLO 11: Project Mgt. & Finance	PLO 12: Life Long Learning	PLO 13: PSO - 1	PLO 14: PSO - 2	PLO 15: PSO – 3
CLO-1 :	*Acquire the knowledge on various biometric traits*	*1*	*80*	*85*	*H*	*M*	*H*	*H*	-	-	*H-*	-	-	-	-	-	-	-	-
CLO-2 :	*Acquire the ability to identify pattern recognition system and its features*	*1*	*75*	*80*	*H*	*H*	*H*	*H*	-	-	*H*	-	-	-	-	-	-	-	-
CLO-3 :	*Understand the basic ideas about physical and hehaviourial biometric traits*	*1*	*85*	*80*	*H*	*M*	*M*	*M*	-	-	*M*	-	-	-	-	-	-	-	-
CLO-4 :	*Apply the knowledge of biometrics on developing identification system.*	*2*	*80*	*75*	*H*	*M*	*M*	*M*	-	*H*	-	*H*	-	-	-	-	-	-	-
CLO-5 :	*Apply the knowledge for designing biometric sytems*	*2*	*75*	*85*	*H*	*H*	*L*	-	-	-	-	-	-	-	-	-	-	-	-
CLO-6 :	*Acquire the knowledge on authentication systems for real time security applications*	*1*	*80*	*85*	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-

Duration (hour)		9	9	9	9	9
S-1	SLO-1	*Introduction of biometric systems*	*Biometrics Sensors and Data Acquisition*	*Introduction to multibiometrics*	*Biometric system authentication*	*Biometric Authentication Applications*
	SLO-2	*Biometric functionalities: verification, identification*	*Biometric data acquisition and database*	*Sources of multiple evidence*	*physiological and behavioral properties of biometric system,*	*access control like a lock or an airport check-in area*
S-2	SLO-1	*The design cycle of biometric systems*	*Biometrics Pre-processing*	*Acquisition sequence*	*Software biometrics systems*	*immigration and naturalization*
	SLO-2	*Building blocks of a generic biometric system*	*The related biometrics preprocessing technologies*	*Processing sequence*	*Hardware biometrics systems*	*welfare distribution*
S-3	SLO-1	*Introduction to unimodal system*	*Image restoration*	*Fusion level*	*Security of biometric systems*	*military application*
	SLO-2	*Introduction to Multimodal biometric system*	*Image segmentation*	*Sensor level fusion*	*Advisory,insider,infrastructure attacks*	*banking, e.g., check cashing, credit card, ATM*
S-4	SLO-1	*Biometric system errors*	*Pattern extraction and classification*	*Feature level fusion*	*Attacks at the user interface*	*computer login; intruder detection; smart card*
	SLO-2	*Performance measures*	*Pattern classification*	*Score level fusion*	*impersonation ,obfuscation, spoofing*	*multi-media Communication; WWW and an electronic purse*
S-5	SLO-1	*Image processing basics*	*Fingerprint Recognition and acquisition*	*Rank level fusion*	*Attacks on biometric processing*	*sensor fusion; decision fusion*
	SLO-2	*what is image, acquisition, type, point operations, Geometric transformations*	*Fingerprint features, matching and synthesis*	*Decision level fusion*	*Attacks on system module and interconnections*	*categorization: e.g., age and gender*
S-6	SLO-1	*First and second derivative*	*Face recognition and acquisition*	*Features Matching and Decision Making*	*Counter measure: Biometric template security*	*industrial automation*
	SLO-2	*steps in edge detection, smoothening, enhancement, thresholding, localization,*	*Face detection, feature extraction and matching*	*Feature matching: null and alternative hypothesis h0, h1, Error type I/II, Matching score distribution, FM/FNM, ROC curve, DET curve, FAR/FRR curve.*	*Countermeasure:spoof dectection*	*gesture interpretation;*
S-7	SLO-1	*Robert's method, Sobel's method, Perwitts*	*Iris recognition and acquisition*	*Introduction to Various matching methods:*	*Challenges in biometric systems like fool proofing, false positives*	*efficient enrollment*

	SLO-2	*Laplacian of Gaussian, Zero crossing*	*Iris Segmentation, normalization and matching*	*LDA*	*Developing Tools for Comparing fingerprints*	*audio-visual tracking*
S-8	SLO-1	*Low level feature extraction, Describing image motion*	*Ear recognition*	*PCA, Eigen vectors and values, 2D-PCA,*	*Enhancing pattern when data is minimum*	*stock market;*
	SLO-2	*High level feature extraction ,Template matching*	*Ear detection*	*generalization to p-dim, covariance and correlation, algebra of PCA, projection of data*	*Biometric failures in special cases like(too much moisture in hands which system can't read)*	*on-line shopping*
S-9	SLO-1	*Hough transform for lines*	*Hand geometry features*	*Introduction to decision theory and their examples*	*Mini project: Fingerprint, Face detection*	*compact embedded systems*
	SLO-2	*Hough transform for circles and ellipses*	*palmprint features*	*Explanation – examples*	*Mini project: signature ,iris detection*	*other commercialized services*

Learning Resources	1. *James wayman,Anil k.Jain ,Arun A.Ross ,Karthik Nandakumar, ―Introduction to. Biometrics‖, Springer, 2011* 2. *Mark S.Nixon, Alberto S.Aguado, Feature Extraction and image processing for computer vision, Third Edition, , Elsevier 2012* 3. *Digital Image Processing using MATLAB, By: Rafael C. Gonzalez, Richard Eugene Woods, 2nd Edition, Tata McGraw-Hill Education 2010*	4. *Guide to Biometrics, By: Ruud M. Bolle, Sharath Pankanti, Nalini K. Ratha, Andrew W. Senior, Jonathan H. Connell, Springer 2009* 5. *Pattern Classification, By: Richard O. Duda, David G.Stork, Peter E. Hart, Wiley 2007* 6. *Shimon K.Modi , ―Biometrics in Identity Management :concepts to applications‖, Artech House 2011*

Learning Assessment

	Bloom's Level of Thinking	Continuous Learning Assessment (50% weightage)								Final Examination (50% weightage)	
		CLA – 1 (10%)		CLA – 2 (15%)		CLA – 3 (15%)		CLA – 4 (10%)#			
		Theory	Practice	Theory	Practice	Theory	Practice	Theory	Practice	Theory	Practice
Level 1	Remember Understand	*40 %*	-	*30 %*	-	*30 %*	-	*30 %*	-	*30%*	-
Level 2	Apply Analyze	*40 %*	-	*40 %*	-	*40 %*	-	*40 %*	-	*40%*	-
Level 3	Evaluate Create	*20 %*	-	*30 %*	-	*30 %*	-	*30 %*	-	*30%*	-
	Total	100 %		100 %		100 %		100 %		100 %	

CLA – 4 can be from any combination of these: Assignments, Seminars, Tech Talks, Mini-Projects, Case-Studies, Self-Study, MOOCs, Certifications, Conf. Paper etc.,

Course Designers

Experts from Industry	Experts from Higher Technical Institutions	Internal Experts
1. *Raghuraghavendra s,* *Chief Executive Officer at Forensic & Biometric Investigation Services FBIS* *Chennai, Tamil Nadu, India* *Chennai Area, India*	1. *Dr. J.Dhalia Sweetlin* *Designation:Assistant Professor [Sr Grade] Madras Institute of Technology, MIT Road, Radha Nagar,Chromepet, Chennai,Tamil Nadu 600044, India.Email:jdsweetlin@mitindia.edu* *Area of Specialization: Image Processing, Soft Computing*	*1. Dr. C. Malathy, SRMIST*
		2. M.Gayathri, SRMIST *3.Ms.Meenakshi/IT Dept,SRMIST*

Course Code	18CSE358T	Course Name	PATTERN RECOGNTION TECHNIQUES	Course Category	E	Professional Elective	L	T	P	C
							3	0	0	3

Pre-requisite Courses	Nil	Co-requisite Courses	Nil	Progressive Courses	Nil
Course Offering Department	CSE	Data Book / Codes/Standards	Nil		

Course Learning Rationale (CLR):	*The purpose of learning this course is to:*	Learning			Program Learning Outcomes (PLO)														
		1	2	3	1	2	3	4	5	6	7	8	9	10	11	12	13	14	15
CLR-1 :	*Understand the fundamentals of Pattern Recognition techniques*	Level of Thinking (Bloom)	Expected Proficiency (%)	Expected Attainment (%)	Engineering Knowledge	Problem Analysis	Design & Development	Analysis, Design, Research	Modern Tool Usage	Society & Culture	Environment & Sustainability	Ethics	Individual & Team Work	Communication	Project Mgt. & Finance	Life Long Learning	PSO - 1	PSO - 2	PSO – 3
CLR-2 :	*Learn Statistical models of Pattern Recognition*																		
CLR-3 :	*Understand the principles of Clustering approaches to Pattern Recognition*																		
CLR-4 :	*Understand the Syntactic Pattern Recognition techniques*																		
CLR-5 :	*Understand the Neural Network approach to Pattern Recognition*																		
Course Learning Outcomes (CLO):	*At the end of this course, learners will be able to:*																		
CLO-1 :	*Acquire the knowledge on various biometric traits*																		
CLO-2 :	*Acquire the ability to identify pattern recognition system and its features*	*2*	*80*	*85*	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-
CLO-3 :	*Understand the basic ideas about physical and hehaviourial biometric traits*	*2*	*75*	*80*	*H*	*H*	-	-	*H*	-	-	-	-	-	-	-	-	-	-
CLO-4 :	*Apply the knowledge of biometrics on developing identification system.*	*2*	*85*	*80*	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-
CLO-5 :	*Apply the knowledge for designing biometric sytems*	*2*	*80*	*75*	-	*H*	-	-	*H*	-	-	-	-	-	-	-	-	-	-

Duration (hour)		9	9	9	9	9
S-1	SLO-1	*Pattern and features*	*Introduction to StatPR, Statistical models,*	*Formulation of unsupervised problems*	*Syntactic Pattern Recognition, Grammar based approaches,*	*Neural Networks fundamentals, Learning in Neural networks,*
	SLO-2	*Classification, Description, Pattern Mappings*	*Gaussian case and Class Dependence*	*Illustration*	*Formal Grammars, Types of Grammars*	*Physical Neural Networks*
S-2	SLO-1	*Patterns and Feature Extraction*	*Discriminant Functions- Uniform Densities*	*Unsupervised Learning Approaches*	*String generation as Pattern Description*	*Artificial Neural Networks model,*
	SLO-2	*Examples*	*Classifier Performance, Risk and Errors*	*Illustration*	*Example*	*activation functions, weights*
S-3	SLO-1	*Classifiers*	*Supervised learning – Parametric estimation*	*Clustering for unsupervised learning and classification*	*Recognition by String Matching and Parsing,*	*Neural Network based Pattern Associators, CAM*
	SLO-2	*Example*	*Maximum Likelihood Estimation*	*Example*	*Example*	*Linear Associative Mappings, Different approaches*
S-4	SLO-1	*Decision Regions*	*Bayesian parameter estimation*	*c-means algorithm*	*Cocke-Younger-Kasami Parsing Algorithm*	*Heteroassociative memory design*
	SLO-2	*Boundaries*	*Example*	*Illustration*	*Illustation*	*Examples*
S-5	SLO-1	*Training in pattern recognition systems*	*Nonparametric approaches-*	*Learning Vector Quantization,*	*Augmented Transition Networks, High Dimensional Grammars,*	*Hebbian learning*
	SLO-2	*Learning in pattern recognition systems*	*Density estimation*	*Example*	*Example*	*Example*
S-6	SLO-1	*Pattern recognition approaches*	*Parzen Windows*	*Formal Characterization of General Clustering Procedures*	*Stochastic Grammars and applications*	*Feedforward Network Architecture, Training in Feedforward networks,*
	SLO-2	*Statistical pattern recognition, Example*	*k-nn Nonparametric estimation*	*Explanation on procedure*	*Example*	*Explanation*
S-7	SLO-1	*Syntactic pattern recognition*	*Nearest Neighbor Rule*	*Clustering Strategies*	*Graph based structural representations*	*GDR, Derivation of Delta Rule*
	SLO-2	*Examples*	*Example*	*Different scenarios*	*Graph Isomorphism*	*Explanation*
S-8	SLO-1	*Neural pattern recognition*	*Linear Discrimant Functions, Fisher's Linear Discriminant*	*Cluster Swapping Approaches*	*Attributed Graphs, Match Graphs,*	*Backpropagation Algorithm,*
	SLO-2	*Comparison*	*Discrete and Binary Classification problems*	*Examples*	*Examples*	*Explanation*
S-9	SLO-1	*Black Box approaches*	*Techniques to directly obtain Linear Classifiers*	*Hierarchical clustering procedure*	*Cliques, Structural Unification using attributed graphs*	*Pattern Associator for Character Classification*
	SLO-2	Reasoning driven pattern recognition	Illustration	Example	Examples	Example

Learning Resources	1. Robert J, Schalkoff, “Pattern Recognition: Statistical, Structural and Neural Approaches”, John Wiley & Sons Inc., New York, Reprint 2014.	2. Earl Gose, Richard Johnsonbaugh, Steve Jost, “Pattern Recognition and Image Analysis”, Prentice Hall of India Private Ltd., New Delhi – 110 001,1999. 3. DudaR.O.andHartP.E.,“Pattern Classification and Scene Analysis”,Wiley,NewYork,1973

Learning Assessment											
	Bloom’s Level of Thinking	Continuous Learning Assessment (50%								Final Examination (50% weightage)	
		CLA – 1 (10%)		CLA – 2 (15%)		CLA – 3 (15%)		CLA – 4 (10%)#			
		Theory	Practice	Theory	Practice	Theory	Practice	Theory	Practice	Theory	Practice
Level 1	Remember Understand	*40 %*	-	*30 %*	-	*30 %*	-	*30 %*	-	*30%*	-
Level 2	Apply Analyze	*40 %*	-	*40 %*	-	*40 %*	-	*40 %*	-	*40%*	-
Level 3	Evaluate Create	*20 %*	-	*30 %*	-	*30 %*	-	*30 %*	-	*30%*	-
	Total	100 %		100 %		100 %		100 %		100 %	

CLA – 4 can be from any combination of these: Assignments, Seminars, Tech Talks, Mini-Projects, Case-Studies, Self-Study, MOOCs, Certifications, Conf. Paper etc.,

Course Designers		
Experts from Industry	Experts from Higher Technical Institutions	Internal Experts
Mr.Deepan Raj, Visteon,Chennai	*Dr.T.Nagarajan, Professor and Head, Dept. of IT, SSN college of Engineering.*	*1. Dr. M. Thenmozhi, SRMIST*
		2. Dr.S Prabakaran, SRMIST
		3. Dr. Alice Nithya , SRMIST

Course Code	18CSE359T	Course Name	NATURAL LANGUAGE PROCESSING	Course Category	E	Professional Elective	L	T	P	C
							3	0	0	3

Pre-requisite Courses	Nil	Co-requisite Courses	Nil	Progressive Courses	Nil
Course Offering Department	CSE	Data Book / Codes/Standards	Nil		

Course Learning Rationale (CLR):	*The purpose of learning this course is to:*
CLR-1 :	*Teach students the leading trends and systems in natural language processing.*
CLR-2 :	*Make them understand the concepts of morphology, syntax, semantics and pragmatics of the language and that they are able to give the appropriate examples that will illustrate the above mentioned concepts.*
CLR-3 :	*Teach them to recognize the significance of pragmatics for natural language understanding.*
CLR-4 :	*Enable students to be capable to describe the application based on natural language processing and to show the points of syntactic, semantic and pragmatic processing.*
CLR-5 :	*To conceive basics of knowledge representation, inference, and relations to the artificial intelligence.*
CLR-6	*To understand natural language processing and to learn how to apply basic algorithms in this field*

Course Learning Outcomes (CLO):	*At the end of this course, learners will be able to:*	Learning 1 Level of Thinking (Bloom)	Learning 2 Expected Proficiency (%)	Learning 3 Expected Attainment (%)	PLO 1 Engineering Knowledge	PLO 2 Problem Analysis	PLO 3 Design & Development	PLO 4 Analysis, Design, Research	PLO 5 Modern Tool Usage	PLO 6 Society & Culture	PLO 7 Environment & Sustainability	PLO 8 Ethics	PLO 9 Individual & Team Work	PLO 10 Communication	PLO 11 Project Mgt. & Finance	PLO 12 Life Long Learning	PLO 13 PSO - 1	PLO 14 PSO - 2	PLO 15 PSO – 3
CLO-1 :	*Understand approaches to syntax and semantics in NLP.*																		
CLO-2 :	*Understand approaches to discourse, generation, dialogue and summarization within NLP.*	*2*	*80*	*85*	*H*	*H*	*H*	*H*	*H*	-	-	-	*H*	*M*	*M*	*H*	*H*	*H*	*H*
CLO-3 :	*Understand current methods for statistical approaches to machine translation.*	*2*	*75*	*80*	*H*	*H*	*H*	*H*	*H*	-	-	-	*H*	*M*	*M*	*H*	*H*	*H*	*H*
CLO-4 :	*Understand machine learning techniques used in NLP, including the probabilistic context-free grammars and unsupervised methods, as applied within NLP*	*2*	*85*	*80*	*H*	*L*	*M*	*H*	*H*	-	-	-	*H*	*M*	*M*	*H*	*H*	*H*	*H*
CLO-5 :	*Understand the knowledge of various levels of analysis involved in NLP*	*2*	*80*	*75*	*H*	*H*	*H*	*H*	*H*	-	-	-	*H*	*M*	*M*	*H*	*H*	*H*	*H*
CLO-6	*Gain knowledge in automated Natural Language Generation and Machine Translation*	*2*	*75*	*85*	*H*	*H*	*H*	*H*	*H*	-	-	-	*H*	*M*	*M*	*H*	*H*	*H*	*H*

Duration (hour)		9	9	9	9	9
S-1	SLO-1	*Introduction to Natural Language Processing*	*Syntax Parsing*	*Semantic Relations*	*Information Extraction and its approaches*	*Introduction to Probabilistic Approaches*
	SLO-2	*Steps – Morphology – Syntax – Semantics*	*Dependency Parsing*	*Semantic Role Labeling*		*Statistical Approaches to NLP Tasks*
S-2	SLO-1	*Morphological Analysis (Morphological Parsing)*	*Semantics*	*Semantic Frames*	*Information Retrieval*	*Sequence Labeling*
	SLO-2	*Stemming – Lemmatization*	*Semantic Parsing*	*Ontology and Semantics*		
S-3	SLO-1	*Parts of Speech Tagging*	*Word Sense Disambiguation*	*Semantic Network and Knowledge Graph*	*Semantic Search*	*Problems - Similarity Measures*
	SLO-2					
S-4	SLO-1	*Approaches on NLP Tasks (Rule-based, Statistical, Machine Learning)*	*Lexical Disambiguation*	*Intent Detection and Classification*	*Summarization*	*Word Embeddings*
	SLO-2				*Extractive Vs Abstractive, Summarization*	
S-5	SLO-1	*N-grams*	*Structural Disambiguation*	*Paraphrase Extraction*	*Information Fusion*	*CBOW*
	SLO-2					
S-6	SLO-1	*Multiword Expressions*	*Word, Context and Sentence-level Semantics*	*Discourse*	*Single and Multi-document*	*Skip-gram*
	SLO-2			*Coreference Resolution*	*Summarization – Question Answering*	
S-7	SLO-1	*Collocations (Association Measures, Coefficients and Context Measures)*	*Pronoun Resolution*	*Text Coherence*	*Introduction to Chatbot Applications*	*Sentence Embeddings*
	SLO-2				*Retrieval based- Conversation based*	
S-8	SLO-1	*Vector Representation of Words*	*Semantic Representation of text*	*DiscourseStructure*	*NLU and NLG*	*Recurrent Neural Networks (RNN)*
	SLO-2			*Coherence*		
S-9	SLO-1	*Language Modeling*	*Introduction to Semantic Relations*	*Discourse Planning*	*Machine Translation*	*Long Short-Term Memory (LSTM)*

Learning Resources	1. *DanielJurafskyandPrenticeHallJamesHMartin,"SpeechandLanguageProcessing:An introductionton NaturalLanguage Processing, Computational Linguistics and Speech Recognition", Prentice Hall, 2nd Edition,2018.* 2. *C.Manning and H.Schutze, "Foundations of Statistical Natural Language Processing", MIT Press. Cambridge,MA:,1999*	3. *JamesAllen,Bejamin/cummings,"NaturalLanguageUnderstanding",2ndedition,1995* 4. *YoavGoldberg,Neural Network Methods for Natural Language Processing.* 5. *http://mccormickml.com/2106/04/19/word2vec-tutorial-the-skip-gram-model/* 6. *https://nlp.stanford.edu/pubs/glove.pdf*

Learning Assessment

	Bloom's Level of Thinking	Continuous Learning Assessment (50% weightage)								Final Examination (50% weightage)	
		CLA – 1 (10%)		CLA – 2 (15%)		CLA – 3 (15%)		CLA – 4 (10%)#			
		Theory	Practice	Theory	Practice	Theory	Practice	Theory	Practice	Theory	Practice
Level 1	Remember Understand	40 %	-	30 %	-	30 %	-	30 %	-	30%	-
Level 2	Apply Analyze	40 %	-	40 %	-	40 %	-	40 %	-	40%	-
Level 3	Evaluate Create	20 %	-	30 %	-	30 %	-	30 %	-	30%	-
	Total	100 %		100 %		100 %		100 %		100 %	

CLA – 4 can be from any combination of these: Assignments, Seminars, Tech Talks, Mini-Projects, Case-Studies, Self-Study, MOOCs, Certifications, Conf. Paper etc.,

Course Designers

Experts from Industry	Experts from Higher Technical Institutions	Internal Experts
1. Dr. J.Balaji, Associate Manager,Allstate Solutions Pvt Ltd, jagank.balaji@gmail.com	*1. Dr.G.Nagappan, Professor, nagappan@saveetha.ac.in*	*1. Dr. M.Ferni Ukrit, SRMIST*
		2. Dr.A.Pandian, SRMIST
		3.Ms.K.Meenakshi, SRMIST

Course Code	18CSE360T	Course Name	INFORMATION STORAGE AND MANAGEMENT	Course Category	E	Professional Elective	L	T	P	C
							3	0	0	3

Pre-requisite Courses	Nil	Co-requisite Courses	Nil	Progressive Courses	Nil
Course Offering Department	Computer Science and Engineering	Data Book / Codes/Standards	Nil		

Course Learning Rationale (CLR):	*The purpose of learning this course is to:*
CLR-1 :	*Understand the components of storage infrastructure.*
CLR-2 :	*Gain knowledge to evaluate storage architectures including storagesubsystems*
CLR-3 :	*Understand the business continuity, backup and recovery methods.*
CLR-4 :	*Acquire knowledge on information security framework*
CLR-5 :	*Introduce the working principle of storage infrastructure with monitoring principles*
CLR-6 :	*Understand the structure of cloud computing and its techniques*

Course Learning Outcomes (CLO):	*At the end of this course, learners will be able to:*	Learning 1: Level of Thinking (Bloom)	Learning 2: Expected Proficiency (%)	Learning 3: Expected Attainment (%)	PLO 1: Engineering Knowledge	PLO 2: Problem Analysis	PLO 3: Design & Development	PLO 4: Analysis, Design, Research	PLO 5: Modern Tool Usage	PLO 6: Society & Culture	PLO 7: Environment & Sustainability	PLO 8: Ethics	PLO 9: Individual & Team Work	PLO 10: Communication	PLO 11: Project Mgt. & Finance	PLO 12: Life Long Learning	PLO 13: PSO - 1	PLO 14: PSO - 2	PLO 15: PSO – 3
CLO-1 :	*Acquire the knowledge on the components of storage infrastructure*	*3*	*80*	*70*	*M*	-	-	-	-	-	-	-	*L*	-	-	*M*	-	-	-
CLO-2 :	*Acquire the ability to evaluate storage architectures including storagesubsystems*	*3*	*85*	*75*	*M*	*M*	*M*	*M*	-	-	-	-	*L*	-	-	*H*	-	-	-
CLO-3 :	*Understand the business continuity, backup and recovery methods.*	*3*	*75*	*70*	*M*	*M*	*M*	*M*	-	-	-	-	*L*	-	-	*H*	-	-	-
CLO-4 :	*Appreciate the concepts of storage security and information security applied to virtual machine*	*3*	*85*	*80*	*M*	*M*	*L*	*L*	-	-	-	-	*M*	-	-	*H*	-	-	-
CLO-5 :	*Apply the knowledge for storage infrastructure*	*3*	*85*	*75*	*L*	*M*	-	-	-	-	-	-	*M*	-	-	*H*	-	-	-
CLO-6 :	*Acquire the knowledge on structure of cloud computing and its techniques*	*3*	*80*	*70*	*M*	-	-	-	-	-	-	-	*L*	-	-	*H*	-	-	-

Duration (hour)		9	9	9	9	9
S-1	SLO-1	*Introduction to Information Storage Management*	*Virtualization and Cloud Computing : Fiber Channel: Overview*	*Business Continuity And Back Up Recovery Business Continuity: Information Availability.*	*Storage Security And Management :*	*Cloud Computing:Cloud Enabling Technologies*
	SLO-2	*Evolution of Storage Architecture*	*SAN and its Evolution*	*BC Terminology, BC Planning life cycle*	*Information Security Framework*	*Characteristics of Cloud Computing*
S-2	SLO-1	*Data Centre Infrastructure*	*Components of FC SAN, FCConnectivity, FC Architecture*	*Failure Analysis, Business Impact Analysis*	*Risk Triad*	*Benefits of Cloud Computing*
	SLO-2	*Virtualization and Cloud Computing*	*IPSAN-iSCSI components*	*BC Technology Solutions*	*Storage Security Domains*	*Cloud Service Models*
S-3	SLO-1	*Key challenges in managing information.*	*iSCSI Protocol StackiSCSI Names*	*Backup and Archive: Backup Purpose*	*Security Implementations in Storage Networking*	*Cloud Deployment models*
	SLO-2	*Data Center Environment: Application*	*NAS: General Purpose Servers versus NAS Devices*	*Backup Considerations*	*Securing Storage Infrastructure in Virtualized and Cloud Environments*	*Cloud Infrastructure Mechanism: Logical Network Perimeter*
S 4-5	SLO-1 SLO-2	*Database Management System (DBMS)*	*Benefits of NAS- File Systems and Network File Sharing*	*Backup Granularity , Recovery considerations*	*RSA and VMware Security Products*	*Virtual Server , Cloud Storage Device*
S-6	SLO-1	*Host : Connectivity, Storage*	*Components of NAS*	*Backup Methods, Backup Architecture*	*Monitoring the Storage Infrastructure*	*Cloud Usage Monitor*
	SLO-2	*Disk Drive Components,Disk Drive Performance*	*NAS I/O Operation*	*Backup and Restore Operations*	*Monitoring Parameters,*	*Resource Replication*
S-7	SLO-1	*Intelligent Storage System*	*NAS Implementations*	*Backup Topologies*	*Components Monitored, Monitoring examples*	*Ready Made environment*
	SLO-2	*Components of an Intelligent Storage System*	*NAS File Sharing Protocols*	*Backup in NAS Environments*	*Storage Infrastructure Management Activities*	*Container*
S-8	SLO-1	*Storage Provisioning*	*Object Based Storage Devices*	*Backup Targets, Data Deduplication for Backup*	*Storage Infrastructure Management Challenges, Storage Management Examples*	*Cloud Challenges*
	SLO-2	*Types of Intelligent Storage Systems*	*Content Addressed Storage*	*Backup in Virtualized Environments*	*Storage Allocation to a New Server/Host,*	*Cloud Adoption Considerations*
S-9	SLO-1 SLO-2	*Creation of Virtual storage machine, Navigation of storage system .*	*Configuration and Tracing of FC scan and iSCSI scan*	*Sharing Files between host and Virtual Machines, Usage of Backup techniques*	*Creation of an Linux Instance in Public Cloud, Generate a private key, Access using SSH client*	*Usage of Cloud services with open source cloud tools (like Eucalyptus, Openstack, Open Nebula and others)*

Learning Resources	1. *EMC Corporation, "Information Storage and Management",2nd edition Wiley India, ISBN13: 978-1118094839* 2. *Thomas Erl, "Cloud Computing: Concepts, Technology & Architecture", Prentice Hall , 2013,ISBN: 9780133387568*	3. *UifTroppen Rainer Wolfgang Muller,"Storage Networks Explained", India, Wiley, 2010, ISBN13: 978-0470741436*

Learning Assessment											
	Bloom's Level of Thinking	Continuous Learning Assessment (50% weightage)								Final Examination (50% weightage)	
		CLA – 1 (10%)		CLA – 2 (15%)		CLA – 3 (15%)		CLA – 4 (10%)#			
		Theory	Practice	Theory	Practice	Theory	Practice	Theory	Practice	Theory	Practice
Level 1	Remember Understand	*40%*	-	*30%*	-	*30%*	-	*30%*	-	*30%*	-
Level 2	Apply Analyze	*40%*	-	*40%*	-	*40%*	-	*40%*	-	*40%*	-
Level 3	Evaluate Create	*20%*	-	*30%*	-	*30%*	-	*30%*	-	*30%*	-
	Total	100 %		100 %		100 %		100 %		100%	

CLA – 4 can be from any combination of these: Assignments, Seminars, Tech Talks, Mini-Projects, Case-Studies, Self-Study, MOOCs, Certifications, Conf. Paper etc.,

Course Designers		
Experts from Industry	Experts from Higher Technical Institutions	Internal Experts
	Dr.V.Masillamani	*1. Dr.B.Amutha SRMIST*
		2. Dr.A.Shanthini, SRMIST

Course Code	18CSE451T	Course Name	WIRELESS SENSOR NETWORKS	Course Category	E	Professional Elective	L	T	P	C
							3	0	0	3

Pre-requisite Courses	Nil	Co-requisite Courses	Nil	Progressive Courses	Nil
Course Offering Department	CSE	Data Book / Codes/Standards	Nil		

Course Learning Rationale (CLR):	The purpose of learning this course is to:
CLR-1 :	*Understand basic sensor network concepts*
CLR-2 :	*Know physical layer issues, Medium Access Control Protocols*
CLR-3 :	*Comprehend network and transport layer characteristics and protocols*
CLR-4 :	*Understand the network management and Middleware services*

Course Learning Outcomes (CLO):	At the end of this course, learners will be able to:	Learning 1: Level of Thinking (Bloom)	Learning 2: Expected Proficiency (%)	Learning 3: Expected Attainment (%)	PLO 1: Engineering Knowledge	PLO 2: Problem Analysis	PLO 3: Design & Development	PLO 4: Analysis, Design, Research	PLO 5: Modern Tool Usage	PLO 6: Society & Culture	PLO 7: Environment & Sustainability	PLO 8: Ethics	PLO 9: Individual & Team Work	PLO 10: Communication	PLO 11: Project Mgt. & Finance	PLO 12: Life Long Learning	PLO 13: PSO - 1	PLO 14: PSO - 2	PLO 15: PSO – 3
CLO-1 :	*Understand the basic ideas about sensor network concepts with Applications and Apply the knowledge for WSN tools*	2	80	85	H	H	H	H	M	M	M	M	M	H	L	H	H	H	H
CLO-2 :	*Acquire the knowledge on wireless transmission technology ,hardware and Medium Access Protocols*	2	75	80	H	H	H	H	M	M	M	M	M	H	L	H	H	H	H
CLO-3 :	*Understand the basic ideas about Wireless Sensor Networks Routing protocols and network - transport layer characteristics*	2	85	80	H	H	H	H	M	M	M	M	M	H	L	H	H	H	H
CLO-4 :	*Apply the knowledge for network management and Middleware services*	2	80	75	H	H	H	H	M	M	M	M	M	H	L	H	H	H	H

Duration (hour)		9	9	9	9	9
S-1	SLO-1	*Introduction to computer and wireless sensor networks*	*Wireless Transmission Technology and systems*	*Overview-Wireless Mac Protocols*	*Design Issues in WSN routing- Data Dissemination and Gathering*	*WSN middleware principles-*
	SLO-2				*Routing Challenges in WSN*	
S-2	SLO-1	*Motivation for a network of Wireless Sensor nodes -*	*Radio Technology Primer*	*Characteristics of MAC protocols in Sensor networks*	*Flooding*	*Middleware architecture*
	SLO-2	*Sensing and sensors*	*Available Wireless Technologies*			*Data related functions, Architecture*
S-3	SLO-1	*Challenges and constraints*	*Hardware- Telosb*	*Contention free MAC Protocols*	*Flat Based Routing – SAR*	*Existing middleware*
	SLO-2				*Directed Diffusion*	*MiLAN, IrisNet*
S-4	SLO-1	*Node architecture*	*Hardware -Micaz motes*	*MAC Protocols -Characteristics*	*MCFA Coherent processing*	*AMF,DSWare*
	SLO-2	*Sensing sub system*		*Traffic Adaptive Medium Access*	*Non-Coherent Processing*	*CLMF*
S-5	SLO-1	*Processor sub system*	*Time Synchronization- Clock*	*Y-MAC*	*Hierarchical Routing- LEACH,TEEN, APTEEN,PEGASIS*	*Operating systems for wireless sensor networks*
	SLO-2	*Communication interfaces-- prototypes*		*Low energy Adaptive Clustering*		
S-6	SLO-1	*Application of Wireless sensors*	*Synchronization Problems*	*Contention based MAC Protocols*	*Query Based Routing*	*Performance and traffic management*
	SLO-2				*Negotiation Based Routing*	
S-7	SLO-1	*WSN Tools- Overview and Limitations*	*Basics of time synchronization*	*Sensor MAC*	*Geographical Based Routing*	*Fundamentals of network security*
	SLO-2		*Time synchronization protocols*	*Timeout MAC and pattern MAC*		
S-8	SLO-1	*Contiki -Introduction*	*Localization*	*MAC protocols in ContikiOS simulator*	*Routing protocol simulation in contiki*	*Network security Challenges*
	SLO-2		*Ranging Techniques*	*Nullmac in Contiki simulator*	*RPL objective function &simulation using DGRM model cooja*	
S-9	SLO-1	*Characteristics of Contiki WSN simulator*	*Range based Localization Range Free Localization*	*CSMA in Contiki simulator*	*RPL(Routing Protocol for Low-Power and Lossy Networks) Border Router simulation in Contiki 2.7 OS*	*Attacks Protocols mechanisms for security*
	SLO-2		*Event driven Localization*			

Learning Resources	1. *Kazem Sohraby, Daniel manoli , "Wireless Sensor networks- Technology, Protocols and Applications", Wiley InterScience Publications 2013.* 2. *Waltenegus Dargie, Christian Poellabauer , "Fundamentals of Wireless Sensor Networks, Theory and Practice", Wiley Series on wireless Communication and Mobile Computing, 2011* 3. *S.Swapna Kumar, "A Guide to Wireless Sensor Networks", kindle Edition, USP publications,2017* 4. *C.S Raghavendra, Krishna M.Sivalingam, Taieb znati , "Wireless Sensor Networks", Springer Science 2010.*	5. *Bhaskar Krishnamachari , " Networking Wireless Sensors", Cambridge University Press, 2005* 6. *https://www.amazon.in/Guide-Wireless-Sensor-Networks-ebook/dp/B072R53JJM* 7. *https://anrg.usc.edu/contiki/index.php/Contiki_tutorials* 8. *file:///C:/Users/Administrator.RD27/Downloads/Fundamentals-of-Wireless-Sensor-Networks-Waltenegus-Dargie.pdf*

Learning Assessment											
	Bloom's Level of Thinking	Continuous Learning Assessment (50% weightage)								Final Examination (50% weightage)	
		CLA – 1 (10%)		CLA – 2 (15%)		CLA – 3 (15%)		CLA – 4 (10%)#			
		Theory	Practice	Theory	Practice	Theory	Practice	Theory	Practice	Theory	Practice
Level 1	Remember Understand	*40 %*	-	*30 %*	-	*30 %*	-	*30 %*	-	*30%*	-
Level 2	Apply Analyze	*40 %*	-	*40 %*	-	*40 %*	-	*40 %*	-	*40%*	-
Level 3	Evaluate Create	*20 %*	-	*30 %*	-	*30 %*	-	*30 %*	-	*30%*	-
	Total	100 %		100 %		100 %		100 %		100 %	

CLA – 4 can be from any combination of these: Assignments, Seminars, Tech Talks, Mini-Projects, Case-Studies, Self-Study, MOOCs, Certifications, Conf. Paper etc.,

Course Designers		
Experts from Industry	Experts from Higher Technical Institutions	Internal Experts
1.Mr.Anirban Chowdhry, Director, Frugal Labs	*1. Dr. P.T.V. Bhuvaneshwari, Professor, MIT campus, Anna University*	*1. Dr. Revathi Venkatraman, SRMIST* *2. Dr.N.Snehalatha, SRMIST* *3. Dr.MB.Mukesh krishnan, SRMIST*

Course Code	18CSE452T	Course Name	NETWORK PROTOCOLS AND PROGRAMMING	Course Category	E	Professional Elective	L	T	P	C
							3	0	0	3

Pre-requisite Courses	Nil	Co-requisite Courses	Nil	Progressive Courses	Nil
Course Offering Department	CSE	Data Book / Codes/Standards	Nil		

Course Learning Rationale (CLR):	*The purpose of learning this course is to:*
CLR-1 :	*Describe the importance of various Internet protocols like ARP, RARP, ICMP, Multicasting and multi routing, SCTP*
CLR-2 :	*Understand the transport layer protocols , application layer protocol and its characteristics*
CLR-3 :	*Learn and Understand IPV6 technologies*
CLR-4 :	*Work with client server sockets and develop related applications to communicate with each other.*
CLR-5 :	*Understand the wide area network protocols*
CLR-6 :	*Learn the basics of MPLS protocol*

Course Learning Outcomes (CLO):	*At the end of this course, learners will be able to:*	Learning 1: Level of Thinking (Bloom)	2: Expected Proficiency (%)	3: Expected Attainment (%)	PLO 1: Engineering Knowledge	2: Problem Analysis	3: Design & Development	4: Analysis, Design, Research	5: Modern Tool Usage	6: Society & Culture	7: Environment & Sustainability	8: Ethics	9: Individual & Team Work	10: Communication	11: Project Mgt. & Finance	12: Life Long Learning	13: PSO - 1	14: PSO - 2	15: PSO – 3
CLO-1 :	*Identify the basics of different types of network and transport layer protocols*	*2*	*80*	*85*	*H*	-	-	-	-	-	-	-	-	-	-	-	-	-	-
CLO-2 :	*Design and implement the socket programming*	*2*	*75*	*80*	*H*	*H*	-	-	-	-	-	-	-	-	-	-	-	-	-
CLO-3 :	*Enumerate the types of application layer protocols*	*2*	*85*	*80*	*H*	-	-	-	-	-	-	-	-	-	-	-	-	-	-
CLO-4 :	*Analyze and compare the IPv4 and IPv6 protocols*	*2*	*80*	*75*	*H*	*H*	-	-	-	-	-	-	-	-	-	-	-	-	-
CLO-5 :	*Familiarize with wide area technologies*	*2*	*75*	*85*	*H*	-	-	*H*	-	-	-	-	-	-	-	-	-	-	-
CLO-6 :	*Describe the working of MPLS protocol*	*2*	*80*	*85*	*H*	-	-	-	-	-	-	-	-	-	-	-	-	-	-

Duration (hour)		9	9	9	9	9
S-1	SLO-1	*IP header*	*Byte ordering*	*DNS*	*IPV6 Overview*	*DSL*
	SLO-2	*IP fragmentation*	*Byte ordering conversion functions*	*DNS in the Internet,*	*IPV6 Features*	*Other DSL Technology*
S-2	SLO-1	*ARP*	*System calls*	*DNS Resolution*	*IPV6 Addressing Modes*	*DSL Benefits*
	SLO-2	*RARP*	*Sockets*	*DNS Messages*	*IPV6 Address Types*	*Cable Technology*
S-3	SLO-1	*ICMP -introduction*	*System calls used with Sockets*	*TELNET*	*Introduction*	*Compare DSL Vs Cable*
	SLO-2	*ICMP-Messages*	*Iterative and concurrent server*	*SSH*	*Address Space Allocation*	*Frame Relay*
S-4	SLO-1	*Debugging tools*	*Socket Interface*	*FTP*	*Global Unicast Addresses*	*ATM Introduction*
	SLO-2	*ICMP package*	*Structure and Functions of Socket*	*TFTP*	*Autoconfiguration*	*ATM Cell Format*
S-5	SLO-1	*UDP Datagram*	*Remote Procedure Call*	*WWW Architecture*	*Renumbering*	*ATM Layer*
	SLO-2	*UDP characteristics*	*RPC Model, Features*	*WWW Documents*	*IPV6 Routing Protocols*	*AAL Layer*
S-6	SLO-1	*TCP Header*	*TCP Client Server Program*	*HTTP*	*Introduction*	*ATM Application*
	SLO-2	*TCP connection establishment process*	*Input, Output Processing Module*	*HTTP Request and Reply*	*IPV6 Packet Format*	*PPP*
S-7	SLO-1	*TCP Error Control*	*UDP Client Server Program*	*DHCP Operation*	*Comparison between IPV4 and IPV6 Header*	*PPP Services, Components*
	SLO-2	*TCP Congestion Control*	*UDP Control block table & Module*	*DHCP Configuration*	*IPV4 to IPV6 Tunneling*	*PPP frame and byte stuffing*
S-8	SLO-1	*TCP Flow Control*	*UDP Input & Output Module*	*SMTP*	*IPV4 to IPV6 Translation Techniques*	*HDLC*
	SLO-2	*Multicasting*	*SCTP Sockets*	*POP3*	*NAT Protocol Translation*	*HDLC Transfer Modes, Frame*
S-9	SLO-1	*Multicasting and Multicast Routing Protocol*	*SCTP Services and Features, Packet Format*	*IMAP*	*IPV6 Mobility*	*Types of HDLC Frame*
	SLO-2	*Stream Control Transmission Protocol*	*SCTP Client/Server*	*MIME*	*Protocols Changed to Support IPV6*	*MPLS*

Learning Resources	1. *BehrouzA.Forouzan,"TCPIPProtocolSuite"4th edition,2013,McGraw-HillISBN:0073376043* 2. *DouglasE.Comer,InternetworkingwithTCP/IP,Principles,protocols,andarchitecture,Vol15th Edition,2006 ISBN: 0131876716, ISBN:978-0131876712*	3. *Richard Stevens, Unix Network Programming, vol.1, 3rd edition, 2003, McGraw-HillISBN 0-07-246060-1*

Learning Assessment											
	Bloom's Level of Thinking	Continuous Learning Assessment (50%								Final Examination (50% weightage)	
		CLA – 1 (10%)		CLA – 2 (15%)		CLA – 3 (15%)		CLA – 4 (10%)#			
		Theory	Practice	Theory	Practice	Theory	Practice	Theory	Practice	Theory	Practice
Level 1	Remember Understand	*40 %*	-	*30 %*	-	*30 %*	-	*30 %*	-	*30%*	-
Level 2	Apply Analyze	*40 %*	-	*40 %*	-	*40 %*	-	*40 %*	-	*40%*	-
Level 3	Evaluate Create	*20 %*	-	*30 %*	-	*30 %*	-	*30 %*	-	*30%*	-
	Total	100 %		100 %		100 %		100 %		100 %	

CLA – 4 can be from any combination of these: Assignments, Seminars, Tech Talks, Mini-Projects, Case-Studies, Self-Study, MOOCs, Certifications, Conf. Paper etc.,

Course Designers		
Experts from Industry	Experts from Higher Technical Institutions	Internal Experts
1. Mr.Thamaraiselvam,zoho, thamaraiselvam.s@zohocorp.com	*1.Dr.Ema,Anna University Chennai,umaramesh@auist.net*	*1. Dr. G.Usha,SRMIST,Dr.J.Kalaivani,SRMIST*
2.Mr.Mithun, Cognizant,Mithun.SS@cognizant.com	*2.Dr.KunvarSingh,NITTrichy,kunwar@nitt.edu*	*2. Mr.J.GodwinPon,SRMIST*

Course Code	18CSE453T	Course Name	NETWORK ROUTING ALGORITHMS	Course Category	E	Professional Elective	L	T	P	C
							3	0	0	3

Pre-requisite Courses	18CSC302J	Co-requisite Courses	Nil	Progressive Courses	Nil
Course Offering Department	Computer Science and Engineering	Data Book / Codes/Standards	Nil		

Course Learning Rationale (CLR):	*The purpose of learning this course is to:*
CLR-1 :	*Understand how addressing and routing are tied together and different architectural components are related to routing.*
CLR-2 :	*Gain knowledge on the need for routers, its functionality and different architectures.*
CLR-3 :	*Understand fundamental basis of various algorithms in centralized and distributed point of view.*
CLR-4 :	*Apply the knowledge of IP addressing in various routing algorithms.*
CLR-5 :	*Understand the various types of key routing protocols used in wireless networks.*
CLR-6 :	*Gain knowledge on past experiences and prepare for next generation networks and routing*

Course Learning Outcomes (CLO):	*At the end of this course, learners will be able to:*	Learning 1: Level of Thinking (Bloom)	Learning 2: Expected Proficiency (%)	Learning 3: Expected Attainment (%)	PLO 1: Engineering Knowledge	PLO 2: Problem Analysis	PLO 3: Design & Development	PLO 4: Analysis, Design, Research	PLO 5: Modern Tool Usage	PLO 6: Society & Culture	PLO 7: Environment & Sustainability	PLO 8: Ethics	PLO 9: Individual & Team Work	PLO 10: Communication	PLO 11: Project Mgt. & Finance	PLO 12: Life Long Learning	PLO 13: PSO - 1	PLO 14: PSO - 2	PLO 15: PSO – 3
CLO-1 :	*Acquire the knowledge of how data transfer happens in conventional networks*	2	80	85	H	M	-	-	L	-	-	-	-	M	-	H		-	-
CLO-2 :	*Comprehend Router Architectures and IP Address Lookup Algorithms*	2	75	80	H	H	M	M	L	-	-	-	-	-	L	H	-	-	-
CLO-3 :	*Compare routing techniques and protocols*	2	85	80	H	H	L	M	M	-	-	-	M	-	L	H	-	-	-
CLO-4 :	*Examine how different dimensions of routing differ for different types of network*	2	80	75	H	H	H	H	H	L	-	M	M	-	-	H	-	-	-
CLO-5 :	*Apply various routing algorithms in wireless network scenario.*	2	75	85	H	H	H	H	M	-	-	-	M	-	-	H	-	-	-
CLO-6 :	*Understand various routing paradigms in next generation*	2	80	85	H	H	H	M-	M	L	-	-	-	-	-	H	-	-	-

Duration (hour)		8	9	9	9	10
S-1	SLO-1	*Network Routing: An Introduction to Routing algorithms*	*Router Architectures: Basic Forwarding Functions*	*Bellman-Ford algorithm*	*Routers, Networks, and Routing Information: Some Basics*	*Routing in Wireless Networks: Internet based mobile ad-hoc networking*
	SLO-2	*Functions of Router*	*Routing table versus forwarding table*	*Distance Vector Approach*	*Routing Table, Communication of Routing Information*	*Classifications of routing protocols*
S-2	SLO-1	*IP addressing- Classful Addressing*	*Types of router*	*Dijkstra's Algorithm*	*Routing Information Protocol, Version 1 (RIPv1)*	*Table-Driven Routing Protocols: Destination Sequenced Distance-Vector Routing Protocol*
	SLO-2	*Classless Addressing*	*Elements of Router*	*Comparison of Bellman-Ford and Distance Vector Approach*	*Routing Information Protocol, Version 2 (RIPv2)*	*Cluster-Head Gateway Switch Routing Protocol*
S-3	SLO-1	*Protocol architecture stack – OSI Reference Model*	*Packet Flow*	*Shortest Path Computation with Candidate Path Caching*	*Interior Gateway Routing Protocol (IGRP)*	*On-Demand Routing Protocols: Dynamic Source Routing Protocol*
	SLO-2	*IP Protocol Stack Architecture*	*Packet Processing*	*Widest Path Computation with Candidate Path Caching*	*Enhanced Interior Gateway Routing Protocol (EIGRP), Route Redistribution*	*Ad Hoc On-Demand Distance-Vector Routing Protocol*
S-4	SLO-1	*Network Topology Architecture*	*Shared CPU architecture, Shared forwarding Engine Architecture*	*Widest Path Algorithm*	*OSPF: Protocol Features*	*Hybrid Routing Protocols: Core Extraction Distributed Ad Hoc Routing Protocol*
	SLO-2	*Network Management Architecture*	*Shared Nothing Architectures, Clustered Architectures*	*k-Shortest Paths Algorithm*	*OSPF Packet Format*	*Zone Routing Protocol*
S-5	SLO-1	*Public Switched Telephone Network*	*Impact of Addressing on lookup*	*Routing Protocol, Routing Algorithm, and Routing Table*	*Integrated IS-IS*	*Routing Protocols With Efficient Flooding Mechanisms : Preferred Link-Based Routing Protocols*
			Longest Prefix Matching	*Routing Information Representation and Protocol Messages*	*Similarities and Differences Between IS-IS and OSPF*	*Optimized Link State Routing*
S-6	SLO-1	*Communication Technologies*	*Naïve Algorithms, Binary Tries*	*Distance Vector Routing Protocol*	*IP Traffic Engineering: Traffic, Stochasticity, Delay, and*	*Hierarchical Routing Protocols*

					Utilization	
					Applications' View	Power-Aware Routing Protocols
S-7	SLO-1	Standard Committees – International TeleCommunication Union	Multi-bit Tries	Link State Routing Protocol	Traffic Engineering: An Architectural Framework	Toward Next Generation Routing:Quality of Service Routing
	SLO-2	Internet Engineering Task Force, MFA Forum	Compressing multi-bit strides		Traffic Engineering: A Four-Node Illustration	
S-8	SLO-1	Type Length Value	Search By Length Algorithms	Path Vector Routing Protocol	BGP Operations, configuration, faces of BGP	Multiprotocol Label Switching(MPLS)
	SLO-2	Network Protocol Analyzer	Search By value approaches		BGP Decision Process	Generalized MPLS
S-9	SLO-1		Hardware Algorithms	Network Flow Modeling: Single-Commodity Network Flow	Internal BGP Scalability	Routing and Traffic Engineering with MPLS
	SLO-2		Comparing Different Approaches	Multicommodity Network Flow: Three-Node Example	Protocol Message Format	
S-10	SLO-1					PSTN Call Routing Using the Interne
	SLO-2					

Learning Resources	1. D.Medhi and K.Ramasamy, Network Routing: Algorithms, Protocols and Architectures, MorganKaufmann Publishers, First Edition2007. 2. C.Siva Ram Murthy and B.S.Manoj, Adhoc Wireless Networks, Pearson Education, 2007. 3. D.Medhi and K.Ramasamy, Network Routing: Algorithms, Protocols and Architectures, Morgan Kaufmann Publishers, Second Edition2017.	4. SteenStrubM, Routing in Communication networks, Prentice Hal lInternational, 1995. 5. InternetworkingTechnologiesHandbook,Inc.CiscoSystems,ILSGCisco

Learning Assessment												
	Bloom's Level of Thinking	Continuous Learning Assessment (50%								Final Examination (50% weightage)	
		CLA – 1 (10%)		CLA – 2 (15%)		CLA – 3 (15%)		CLA – 4 (10%)#			
		Theory	Practice	Theory	Practice	Theory	Practice	Theory	Practice	Theory	Practice
Level 1	Remember Understand	40 %	-	30 %	-	30 %	-	30 %	-	30%	-
Level 2	Apply Analyze	40 %	-	40 %	-	40 %	-	40 %	-	40%	-
Level 3	Evaluate Create	20 %	-	30 %	-	30 %	-	30 %	-	30%	-
	Total	100 %		100 %		100 %		100 %		100 %	

CLA – 4 can be from any combination of these: Assignments, Seminars, Tech Talks, Mini-Projects, Case-Studies, Self-Study, MOOCs, Certifications, Conf. Paper etc.,

Course Designers		
Experts from Industry	Experts from Higher Technical Institutions	Internal Experts
Mr.T.Bernald , Senior Consulatant , TCS Chennai. bernald.t@tcs.com	Dr. S.Anbuchelian, Anna University. anbuchelian@annauniv.edu	1. Dr.FemildaJosephin J S,SRMIST
		2. Mr.RajeshBabu,SRMIST
		3. Mr. J.Godwin,SRMIST

Course Code	18CSE454T	Course Name	HIGH PERFORMANCE COMPUTING	Course Category	E	Professional Elective	L	T	P	C
							3	0	0	3

Pre-requisite Courses	Nil	Co-requisite Courses	Nil	Progressive Courses	Nil
Course Offering Department	Computer Science Engineering	Data Book / Codes/Standards	Nil		

Course Learning Rationale (CLR):	*The purpose of learning this course is to:*
CLR-1 :	*To learn about Modern Processors and concepts*
CLR-2 :	*To understand the basic concepts of optimizations*
CLR-3 :	*To learn about Parallel Computers and programming*
CLR-4 :	*To understand the basic concepts of parallelization*
CLR-5 :	*To Study about Memory Parallel Programming using OpenMP*
CLR-6 :	*To Study about Memory Parallel Programming using and MPI*

Course Learning Outcomes (CLO):	*At the end of this course, learners will be able to:*	Learning 1: Level of Thinking (Bloom)	Learning 2: Expected Proficiency (%)	Learning 3: Expected Attainment (%)
CLO-1 :	*Acquire the knowledge of Modern processors and concepts*	*2*	*80*	*85*
CLO-2 :	*Understand the basic ideas about Optimizations*	*2*	*75*	*80*
CLO-3 :	*Acquire the ability to identify parallel computers*	*2*	*85*	*80*
CLO-4 :	*Appreciate the concepts of parallelization*	*2*	*80*	*75*
CLO-5 :	*Apply the knowledge on parallel programming using Open MP*	*2*	*75*	*85*
CLO-6 :	*Acquire the knowledge on parallel programming using MPI*	*2*	*80*	*85*

Program Learning Outcomes (PLO)

	1 Engineering Knowledge	2 Problem Analysis	3 Design & Development	4 Analysis, Design, Research	5 Modern Tool Usage	6 Society & Culture	7 Environment & Sustainability	8 Ethics	9 Individual & Team Work	10 Communication	11 Project Mgt. & Finance	12 Life Long Learning	13 PSO - 1	14 PSO - 2	15 PSO – 3
CLO-1	*H*	*H*		-	-			-	-	*H*	-	-	-	-	-
CLO-2	-	*H*	-	-	-	-	-	-	-	-	-	-	-	-	*H*
CLO-3	-	-	*H*	-	-	-	-	*M*	-	-	*L*	-	-	-	-
CLO-4	-	*H*	-	-	*H*	-	-	-	*H*	-	-	*H*		-	-
CLO-5	-	-	-	*H*	-	*L*	*L*	-	-	-	-	-	-	-	-
CLO-6	-	-	-	-	-	-	-	-	-	-	-	-	*H*	*H*	-

Duration (hour)		9	9	9	9	9
S-1	SLO-1	*Stored Program Computer Architecture*	*Scalar profiling- Function- and line-based runtime profiling*	*Taxonomy of parallel computing paradigms*	*Introduction to OpenMP*	*Distributed-memory parallel programming with MPI- Message passing*
	SLO-2	*General-ptupose cache-based microprocessor architecture*	*Hardware performance counters .*	*Shared-memory computers*	*Parallel execution*	*introduction to MPI*
S-2	SLO-1	*Performance based metrics and Benchmarks*	*Manual instrumentation*	*Cache coherence*	*Data scoping*	*Messages and point-to-point Communication, Collective Communication*
	SLO-2	*Transistors galore:*	*Common sense optimizations- Do less work!*	*UMA – ccNUMA*	*OpenMP worksharing for loops*	*Nonblocking point-to-point Communication*
S-3	SLO-1	*Moore's Law*	*Avoid expensive operations!*	*Distributed-memory computers*	*Synchronization*	*Virtual topologies*
	SLO-2	*Pipelining*	*Shrink the working set!*	*Hierarchical (hybrid) systems*	*Reductions*	*Example: MPI parallelization of a Jacobi solver*
S-4	SLO-1	*Superscalarity*	*Simple measures, large impact- Elimination of common subexpressions*	*Networks- Basic performance characteristics of networks*	*Loop scheduling, Tasking*	*MPI implementation*
	SLO-2	*SIMD*	*Avoiding branches*	*Buses, Switched and fat-tree networks*	*Miscellaneous*	*Performance properties, MPI performance tools*
S-5	SLO-1	*Memory hierarchies*	*Using SIMD instruction sets*	*Mesh networks, Hybrids*	*Case study: OpenMP-parallel Jacobi algorithm*	*Communication parameters*
	SLO-2	*Cache*	*The role of compilers*	*Parallelism- Data parallelism*	*Advanced OpenMP: Wavefront parallelization*	*Synchronization, serialization, contention*
S-6	SLO-1	*Cache mapping*	*General optimization options*	*Functional parallelism*	*Efficient OpenMP programming*	*Implicit serialization and synchronization*
	SLO-2	*Prefetch*	*Inlining, Aliasing*	*Parallel scalability*	*Profiling OpenMP programs*	*Contention*
S-7	SLO-1	*Multicore processors*	*Computational accuracy*	*Factors that limit parallel execution*	*Performance pitfalls*	*Reducing Communication overhead*
	SLO-2	*Multithreaded processors*	*Register optimizations, Using compiler logs*	*Scalability metrics, Simple scalability laws*	*Ameliorating the impact of OpenMP worksharing constructs*	*Optimal domain decomposition*

S-8	SLO-1	*Vector processors-*	*C++ optimizations- Temporaries*	*Parallel efficiency, Serial performance versus strong scalability*	*Determining OpenMP overhead for short loops*	*Aggregating messages*
	SLO-2	*Design principles*	*Dynamic memory management*	*Refined performance models*	*Serialization*	*Collective Communication*
S-9	SLO-1	*Maximum performance estimates*	*Loop kernels and iterators*	*Choosing the right scaling baseline*	*False sharing*	*Nonblocking vs. asynchronous Communication,*
	SLO-2	*Programming for vector architectures*	*Storage order- Case study: Jacobi algorithm and Dense matrix transpose.*	*Load imbalance*	*Case study: Parallel sparse matrix-vector multiply*	*Understanding intranode point-to-point Communication*

Learning Resources	1. *GeorgHager, GerhardWellein,"IntroductiontoHighPerformanceComputingforScientistsand Engineers", Chapman&Hall/CRCComputationalScienceseries,2011.* 2. *JohnLevesque,GeneWagenbreth,"HighPerformanceComputing:Programmingand Application"CRC Press,2010*	3. *KaiHwang,Zhiweixu"ScalableParallelComputing:Technology,Architecture,Programming",* 4. *CharlesSeverance,KevinDowd,"HighPerformanceComputing", O'ReillyMedia,2ndEdition,1998.*

Learning Assessment

	Bloom's Level of Thinking	Continuous Learning Assessment (50%								Final Examination (50% weightage)	
		CLA – 1 (10%)		CLA – 2 (15%)		CLA – 3 (15%)		CLA – 4 (10%)#			
		Theory	Practice	Theory	Practice	Theory	Practice	Theory	Practice	Theory	Practice
Level 1	Remember Understand	*40 %*	-	*30 %*	-	*30 %*	-	*30 %*	-	*30%*	-
Level 2	Apply Analyze	*40 %*	-	*40 %*	-	*40 %*	-	*40 %*	-	*40%*	-
Level 3	Evaluate Create	*20 %*	-	*30 %*	-	*30 %*	-	*30 %*	-	*30%*	-
	Total	100 %		100 %		100 %		100 %		100 %	

CLA – 4 can be from any combination of these: Assignments, Seminars, Tech Talks, Mini-Projects, Case-Studies, Self-Study, MOOCs, Certifications, Conf. Paper etc.,

Course Designers

Experts from Industry	Experts from Higher Technical Institutions	Internal Experts
1. *Mr.Kesavan, HCL Technologies*	*1. Dr. Surendran Rajendran, AMA International University, Bahrain*	*1. J. Godwin Ponsam, SRMIST*
2. *Mr.R.Celein , Symmantec India Limited*		*2. Mr.SivakumarSRMIST*
		3.. Mr. Jothikumar, SRMIST

Course Code	18CSE455T	Course Name	DATABASE SECURITY AND PRIVACY	Course Category	E	Professional Elective	L	T	P	C
							3	0	0	3

Pre-requisite Courses	Nil	Co-requisite Courses	Nil	Progressive Courses	Nil
Course Offering Department	CSE	Data Book / Codes/Standards	Nil		

Course Learning Rationale (CLR):	*The purpose of learning this course is to:*
CLR-1 :	*Understand the fundamentals of security relates to information*
CLR-2 :	*how security is maintained in information systems*
CLR-3 :	*Understand the concept of security models in database*
CLR-4 :	*Implementation of virtual private dtabase*
CLR-5 :	*Learn the procedures of database auditing*
CLR-6 :	*Implementation of data mining algorithms for PPDM*

Course Learning Outcomes (CLO):	*At the end of this course, learners will be able to:*	Learning 1: Level of Thinking (Bloom)	2: Expected Proficiency (%)	3: Expected Attainment (%)	PLO 1: Engineering Knowledge	2: Problem Analysis	3: Design & Development	4: Analysis, Design, Research	5: Modern Tool Usage	6: Society & Culture	7: Environment & Sustainability	8: Ethics	9: Individual & Team Work	10: Communication	11: Project Mgt. & Finance	12: Life Long Learning	13: PSO - 1	14: PSO - 2	15: PSO – 3
CLO-1 :	*Acquire the knowledge of information system and information security*	*2*	*80*	*85*	*H*	-	-	-	-	-	-	-	-	-	-	-	-	-	-
CLO-2 :	*Able to manage the security of information system as well as database*	*2*	*75*	*80*	*H*	*H*	-	-	-	-	-	-	-	-	-	-	-	-	-
CLO-3 :	*Able to design and develop the security model in database*	*2*	*85*	*80*	*H*	-	-	-	-	-	-	-	-	-	-	-	-	-	-
CLO-4 :	*Able to implement VPD in various database*	*2*	*80*	*75*	*H*	*H*	-	-	-	-	-	-	-	-	-	-	-	-	-
CLO-5 :	*Able to audit the database activities, users, security*	*2*	*75*	*85*	*H*	-	-	*H*	-	-	-	-	-	-	-	-	-	-	-
CLO-6 :	*Apply the security mechanism in PPDM using various algorithms*	*2*	*80*	*85*	*H*	-	-	-	-	-	-	-	-	-	-	-	-	-	-

Duration (hour)		9	9	9	9	9
S-1	SLO-1	*Security Architecture: Introduction*	*Administration of Users-Introduction*	*Database Application Security Models: Introduction-*	*Auditing Database Activities-introduction*	*Privacy Preserving Data Mining Techniques: Introduction*
	SLO-2	*Information Systems*	*Authentication*	*Types of Users*	*Oracle Database Activities*	*Data Mining Techniques:*
S-2	SLO-1	*Database Management Systems*	*Creating Users*	*-Security Models*	*Oracle Database Activities*	*Privacy Preserving Data Mining Algorithms*
	SLO-2	*Information Security Architecture*	*SQL Server User*	*Application Types*	*Creating DLL Triggers with Oracle*	*Privacy Preserving Data Mining Algorithms*
S-3	SLO-1	*- Database Security*	*Removing, Modifying Users*	*-Application Security Models*	*Creating DLL Triggers with Oracle*	*General Survey-Data Mining Techniques*
	SLO-2	*Asset Types and value*	*Default users*	*Data Encryption*	*Auditing Database Activities with Oracle*	*Randomization Methods*
S-4	SLO-1	*Security Methods*	*Remote Users*	*Virtual Private Databases: Introduction*	*Auditing Database Activities with Oracle*	*Randomization Methods*
	SLO-2	*Operating System Security Fundamentals: Introduction*	*Database Links*	*-Overview of VPD*	*Auditing Server Activity with SQL Server 2000*	*Group Based Anonymization*
S-5	SLO-1	*Operating System Overview*	*Linked Servers*	*Implementation of VPD using Views*	*Auditing Server Activity with SQL Server 2000*	*Group Based Anonymization*
	SLO-2	*Security Environment*	*Remote Servers*	*Application Context in Oracle*	*Auditing Server Activity with SQL Server 2000*	*Distributed Privacy Preserving Data Mining*
S-6	SLO-1	*Security Components*	*Practices for Administrators and Managers-*	*Implementing Oracle VPD-*	*Auditing Server Activity with Oracle*	*Distributed Privacy Preserving Data Mining*
	SLO-2	*Authentication Methods*	*Profiles, Password Policies, Privileges and Roles: Introduction*	*Implementing Oracle VPD*	*Auditing Server Activity with Oracle*	*Curse of Dimensionality*
S-7	SLO-1	*User Administration*	*Defining and Using Profiles*	*Viewing VPD Policies*	*Security and Auditing*	*Application of Privacy Preserving Data Mining*
	SLO-2	*Password Policies*	*Designing and Implementing Password Policies*	*VPD using views*	*Security and Auditing*	*Application of Privacy Preserving Data Mining*
S-8	SLO-1	*Vulnerabilities*	*Best Practices*	*Application contexts using Data Dictionary*	*Casestudy: projest security and auditing*	*Casestudy: on PPDM*
	SLO-2	*Vulnerabilities*	*Granting and Revoking User Privileges*	*Policy manager implementation*	*Casestudy: projest security and auditing*	*Casestudy: on PPDM*

S-9	SLO-1	*Email Security*	*Creating, Assigning and Revoking User Roles*	*Policy Manager Implementing Row and Column level Security with SQL Server*	*Casestudy: projest security and auditing*	*Casestudy: on PPDM*
	SLO-2	*Internet security*	*Best practices*	*Policy Manager Implementing Row and Column level Security with SQL Server*	*Casestudy: projest security and auditing*	*Casestudy: on PPDM*

Learning Resources	1. *HassanA.Afyouni,"DatabaseSecurityandAuditing",ThirdEdition,CengageLearning,2009.* 2. *RonBenNatan,"ImplementingDatabaseSecurityandAuditing",ElsevierDigitalPress,2005*	3. *Charu C. Aggarwal, Philip S Yu, "Privacy Preserving Data Mining": Models and Algorithms, Kluwer Academic Publishers, 2008*

Learning Assessment											
	Bloom's Level of Thinking	Continuous Learning Assessment (50%								Final Examination (50% weightage)	
		CLA – 1 (10%)		CLA – 2 (15%)		CLA – 3 (15%)		CLA – 4 (10%)#			
		Theory	Practice	Theory	Practice	Theory	Practice	Theory	Practice	Theory	Practice
Level 1	Remember Understand	*40 %*	-	*30 %*	-	*30 %*	-	*30 %*	-	*30%*	-
Level 2	Apply Analyze	*40 %*	-	*40 %*	-	*40 %*	-	*40 %*	-	*40%*	-
Level 3	Evaluate Create	*20 %*	-	*30 %*	-	*30 %*	-	*30 %*	-	*30%*	-
	Total	100 %		100 %		100 %		100 %		100 %	

CLA – 4 can be from any combination of these: Assignments, Seminars, Tech Talks, Mini-Projects, Case-Studies, Self-Study, MOOCs, Certifications, Conf. Paper etc.,

Course Designers		
Experts from Industry	Experts from Higher Technical Institutions	Internal Experts
1. Mr.SomuChockalingam, Founder and President,Doyensys,Chennai	*Dr.K.Vivekanandan,Professor,Pondicherry Engineering College*	*1. Dr.B.Murugananthan,SRMIST*
		2.. Ms.Thenmozhi,SRMIST
		3.. M.Maheswari,SRMIST

Course Code	18CSE456T	Course Name	SOFTWARE DEFINED NETWORKS	Course Category	E	Professional Elective	L	T	P	C
							3	0	0	3

Pre-requisite Courses	18CSC302J	Co-requisite Courses	Nil	Progressive Courses	
Course Offering Department	CSE	Data Book / Codes/Standards	Nil		

Course Learning Rationale (CLR):	*The purpose of learning this course is to:*
CLR-1 :	*cover topics more advanced than a typical undergraduate networking course*
CLR-2 :	*prepare students for a market that is going to demand computer scientists and software engineers to deliver the next generation of network switches*
CLR-3 :	*describe the principles by which large computer networks and applications atop them are designed and maintained*
CLR-4 :	*Make students understand the state-of-the art networking technologies proposed in literature or used throughout industry in a variety of areas*
CLR-5 :	*Make students learn to critique research literature through a number of paper reviews and attempt to improve the state-of-the-art through minor and major projects*

Course Learning Outcomes (CLO):	*At the end of this course, learners will::*	Learning 1: Level of Thinking (Bloom)	Learning 2: Expected Proficiency (%)	Learning 3: Expected Attainment (%)	PLO 1: Engineering Knowledge	PLO 2: Problem Analysis	PLO 3: Design & Development	PLO 4: Analysis, Design, Research	PLO 5: Modern Tool Usage	PLO 6: Society & Culture	PLO 7: Environment & Sustainability	PLO 8: Ethics	PLO 9: Individual & Team Work	PLO 10: Communication	PLO 11: Project Mgt. & Finance	PLO 12: Life Long Learning	PLO 13: PSO - 1	PLO 14: PSO - 2	PLO 15: PSO – 3
CLO-1 :	*have a knowledge of the technology evolution leading to SDN as well as the Open Source role in SDN and OpenFlow specifications*	*3*	*75*	*80*	*H*	*M*	*H*	*-*	*H*	*-*	*-*	*-*	*-*	*-*	*-*	*H*	*H*	*H*	*H*
CLO-2 :	*gain a knowledge of the advantages and disadvantages of SDN, API approaches, Hypervisor overlays, and Data Center SDN, SDN WAN etc*	*3*	*75*	*80*	*H*	*M*	*H*	*-*	*H*	*-*	*-*	*-*	*-*	*-*	*-*	*H*	*H*	*H*	*H*
CLO-3 :	*Understand different network virtualization techniques and can deploy SDN/NFV applications*	*3*	*75*	*80*	*H*	*M*	*H*	*-*	*H*	*-*	*-*	*-*	*-*	*-*	*-*	*H*	*H*	*H*	*H*
CLO-4 :	*understand the economics of SDN and its impacts in the marketplace*	*3*	*75*	*80*	*H*	*M*	*H*	*-*	*H*	*-*	*-*	*-*	*-*	*-*	*-*	*H*	*H*	*H*	*H*

Duration (hour)		9	9	9	9	9
S-1	SLO-1	*Introduction*	*Why SDN? Genesis of SDN*	*Alternative definitions of SDN*	*Emerging SDN Models*	*SDN Ecosystem*
	SLO-2	*How to Read a Paper (S. Keshav)*	*How SDN Works*	*Potential drawbacks of Open SDN*	*Protocol Models: NETCONF, BGP, MPLS*	*White-box switching*
S-2	SLO-1	*Ho to Review a Paper (Timothy Roscoe), How to Disagree (Paul Graham)*	*SDN Evolution, SDN Basics*	*SDN via APIs*	*Controller Models*	*Open Sourcing SDN*
	SLO-2	*Networking Basics: Switching, Addressing, Routing*	*SDN Architecture*	*SDN via Hypervisor-Based Overlays*	*Application Models: Proactive, Declarative, External*	*Open Networking Foundation*
S-3	SLO-1	*Paper Reading: 4D*	*Plane Separation*	*SDN via Opening Up the Device*	*SDN in Datacenters: Multitenancy, Failure Recovery*	*OpenDaylight*
	SLO-2	*Paper Reading: 4D*	*Simple Device and Centralized Control*	*Building our own SDN Switch*	*SDN in Internet eXchange Points (IXPs)*	*The ONOS Project*
S-4	SLO-1	*Paper Reading: ALF*	*Network Automation and Virtualization*	*SDN on Raspberry Pi, Zodiac Fx*	*Tunneling and Path Technologies, Ethernet Fabrics in the Data Center*	*Hypervisors: Background, Types*
	SLO-2	*Paper Reading: ALF*	*Openness, Northbound and Southbound APIs*	*Ryu on Raspberry Pi, Zodiac Fx*	*SDN Use Cases, Open SDN versus Overlays in the Data Center*	*OpenStack Deployment*
S-5	SLO-1	*Switching Architecture: Data, Control, and Management Planes*	*Paper Reading: OpenFlow: Enabling Innovation in Campus Networks*	*Network Function Virtualization (NFV)*	*Real-World Data Center Implementations, SDN in Other Environments*	*OpenStack Orchestration*
	SLO-2	*Hardware Lookup*	*Review 1*	*Review 2*	*Review 3*	*Review 4*
S-6	SLO-1	*Forwarding Rules*	*OpenFlow, Switch-Controller Interaction*	*SDN vs. NFV*	*Wide Area Networks*	*OpenSwitch*
	SLO-2	*Dynamic Forwarding Tables*	*Flow Table, Packet Matching*	*OPNFV*	*Paper Reading: B4: Experience with a Globally-Deployed Software Defined WAN, SIGCOMM, 2013*	*Reactive versus Proactive Applications*

S-7	SLO-1	*Autonomous Switches and Routers*	*Actions and Packet Forwarding*	*Service Creation and Chaining*	*Service Provider and Carrier Networks*	*Analyzing Simple SDN Applications*
	SLO-2	*Internet Architecture*	*Extensions and Limitations*	*NFV Orchestration*	*Campus Networks*	*Other SDN Applications*
S-8	SLO-1	*Control-Data Plane Separation*	*Paper Reading: P4: Programming Protocol-Independent Packet Processors*	*Creating Network Virtualization Tunnels*	*Hospitality Networks, Mobile Networks*	*Future of SDN*
	SLO-2	*Packet Scheduling*	*SDN Controllers: POX, RyuMininet Programming*	*Offloading Flows in the Data Center*	*In-Line Network Functions*	*SDN Security*
S-9	SLO-1	*Paper Reading: The Road to SDN: An Intellectual History of Programmable Networks*	*SDN Controllers: OpenDaylight, Mininet Programming*	*Access Control for the Campus*	*Optical Networks*	*Use Cases*
	SLO-2	*Project Proposal Due*	*SDN Controllers: ONOS, Mininet Programming*	*Traffic Engineering for Service Providers*	*SDN vs. P2P/Overlay Networks*	*Group Project Presentation*

Learning Resources	1. *Software Defined Networks: A Comprehensive Approach, 2nd Edition Morgan Kaufmann, 2016* 2. *SDN: Software Defined Networks, Thomas D. Nadeau, Ken Gray, O'Reilly Media, 2013.*	3. *Network Function Virtualization, Ken Gray, Thomas D. Nadeau, Morgan Kaufmann, 2016*

Learning Assessment											
	Bloom's Level of Thinking	Continuous Learning Assessment (50% weightage)								Final Examination (50% weightage)	
		CLA – 1 (10%)		CLA – 2 (15%)		CLA – 3 (15%)		CLA – 4 (10%)#			
		Theory	Practice	Theory	Practice	Theory	Practice	Theory	Practice	Theory	Practice
Level 1	Remember Understand	*40 %*	-	*30 %*	-	*30 %*	-	*30 %*	-	*30%*	-
Level 2	Apply Analyze	*40 %*	-	*40 %*	-	*40 %*	-	*40 %*	-	*40%*	-
Level 3	Evaluate Create	*20 %*	-	*30 %*	-	*30 %*	-	*30 %*	-	*30%*	-
	Total	100 %		100 %		100 %		100 %		100 %	

CLA – 4 can be from any combination of these: Assignments, Seminars, Tech Talks, Mini-Projects, Case-Studies, Self-Study, MOOCs, Certifications, Conf. Paper etc.,

Course Designers		
Experts from Industry	Experts from Higher Technical Institutions	Internal Experts
		1. *Dr. Femilda*
		2. *Mr. K. Venkatesh*
		3. *Mr. KarthickNanmaran*

Course Code	18CSE457T	Course Name	SEMANTIC WEB	Course Category	E	Professional Elective	L	T	P	C
							3	0	0	3

Pre-requisite Courses	Nil	Co-requisite Courses	Nil	Progressive Courses	Nil
Course Offering Department	Computer Science and Engineering	Data Book / Codes/Standards	Nil		

Course Learning Rationale (CLR):	The purpose of learning this course is to:
CLR-1 :	*Learn how the Semantic Web allows new uses of data*
CLR-2 :	*Understand how semantic technologies promote data portability*
CLR-3 :	*Become familiar with semantic standards-RDF,OWL*
CLR-4 :	*Make use of semantic programming techniques to both enrich web application development*

Course Learning Outcomes (CLO):	At the end of this course, learners will be able to:	Learning 1: Level of Thinking (Bloom)	2: Expected Proficiency (%)	3: Expected Attainment (%)	PLO 1: Engineering Knowledge	2: Problem Analysis	3: Design & Development	4: Analysis, Design, Research	5: Modern Tool Usage	6: Society & Culture	7: Environment & Sustainability	8: Ethics	9: Individual & Team Work	10: Communication	11: Project Mgt. & Finance	12: Life Long Learning	13: PSO - 1	14: PSO - 2	15: PSO – 3
CLO-1 :	*Apply flexible approach for integrating and future-proofing systems and data*	1	80	85	H	L	H	-	H	-	-	-	-	-	-	H	H	-	M
CLO-2 :	*Program the Semantic Web provides a standard*	3	75	80	H	H	-	-	H	-	-	-	-	-	-	H	H	H	M
CLO-3 :	*Incorporate existing data sources into semantically aware applications and publish rich semantic data*	3	85	80	H	H	H	-	H	-	-	-	-	-	-	H	-	-	H
CLO-4 :	*Make the machines to find, share, and combine data on the Web*	3	80	75	H	H	-	-	H	-	-	-	-	-	-	H	H	H	H

Duration (hour)		9	9	9	9	9
S-1	SLO-1	*The Semantic Web Vision*	*Querying the Semantic Web*	*Web Ontology Language*	*Logic and Inference: Rules*	*Applications*
	SLO-2	*Motivation for the Semantic Web*	*SPARQL Infrastructure*	*Requirements for Ontology Languages*	*Logic and Rules*	
S-2	SLO-1	*Semantic Web Technologies*	*Matching Patterns*	*OWL Syntax*	*Rules on the Semantic Web*	*e-commerce*
	SLO-2	*Explicit Metadata*		*Formal Semantics*	*Monotonic Rules*	*Adoption*
S-3	SLO-1	*Ontologies*	*Filters*	*Expressivity*	*Monotonic Rules: Syntax*	*Publication*
	SLO-2	*RDF,OWL*			*Rules, Facts*	*News website application*
S-4	SLO-1	*Logics-Principles of reasoning*	*Constructs for Dealing with an Open World*		*Logic Programs*	*Adoption*
	SLO-2	*The Semantic Web versus Artificial Intelligence*		*Reasoning Support*	*Monotonic Rules: Semantics*	*Publication*
S-5	SLO-1	*A Layered Approach*	*Organizing Result Sets*	*Compatibility of OWL2 with RDF/RDFS*	*Predicate Logic Semantics*	*Constructing Ontologies Manually*
	SLO-2			*OWL2 Full: RDF-Based Semantics*	*OWL2 RL*	*Reusing Existing Ontologies*
S-6	SLO-1	*RDF: Data Model*	*Other Forms of SPARQL Queries*	*OWL2 DL: Direct Semantics*		
	SLO-2				*Rule Interchange Format: RIF*	*Semiautomatic Ontology Acquisition*
S-7	SLO-1	*RDF/XML*	*Querying Schemas*	*The OWL2 primitives*	*RIF-BLD*	
	SLO-2	*RDFS: Adding Semantics*		*OWL2 Syntax*	*Compatibility with RDF and OWL Semantic Web Rules Language (SWRL)*	*Ontology Mapping*
S-8	SLO-1	*Classes and Properties*	*Adding Information with SPARQL Update*	*OWL2 Property Types*		
	SLO-2	*Class Hierarchies and Inheritance*	*Inserting and Loading Triples*	*OWL2 Property Axioms*		
S-9	SLO-1	*Property Hierarchies*	*Deleting Triples*	*OWL2 Class Axioms*	*Rules in SPARQL: SPIN*	*SemanticWeb Application Architecture*
	SLO-2	RDF Schema	Case study	Individual Facts	RuleML	

Learning Resources	1. *Grigoris Antoniou and Frank Van Harmelen,-A Semantic Web Primer - The MIT Press, Cambridge, Massachusetts London, England, Edition 3,2012* 2. *Toby Segaran, Colin Evans, Jamie Taylor, Programming the Semantic Web Build Flexible Applications with Graph Data, O'Reilly Media,2009*	3. *John Hebeler , Matthew Fisher, Ryan Blace, Andrew Perez-Lopez , Mike Dean Semantic Web Programming, 1st Edition,Wiley, 2009.* 4. *Thomas B. Passin, Explorer's Guide to the Semantic Web, Manning, 2004*

Learning Assessment											
	Bloom's Level of Thinking	Continuous Learning Assessment (50% weightage)								Final Examination (50% weightage)	
		CLA – 1 (10%)		CLA – 2 (15%)		CLA – 3 (15%)		CLA – 4 (10%)#			
		Theory	Practice	Theory	Practice	Theory	Practice	Theory	Practice	Theory	Practice
Level 1	Remember Understand	*40 %*	-	*30 %*	-	*30 %*	-	*30 %*	-	*30%*	-
Level 2	Apply Analyze	*40 %*	-	*40 %*	-	*40 %*	-	*40 %*	-	*40%*	-
Level 3	Evaluate Create	*20 %*	-	*30 %*	-	*30 %*	-	*30 %*	-	*30%*	-
	Total	100 %		100 %		100 %		100 %		100 %	

CLA – 4 can be from any combination of these: Assignments, Seminars, Tech Talks, Mini-Projects, Case-Studies, Self-Study, MOOCs, Certifications, Conf. Paper etc.,

Course Designers		
Experts from Industry	Experts from Higher Technical Institutions	Internal Experts
1. 1. Dr.Harisekharan,CTO,Sri SeshaaTechnologies Pvt. Ltd., Chennai	*1. Dr.J.Suresh, SSN College of Engineering*	*Dr.G.Vadivu*
	2. Dr. Sharmila Shankar, Crescent Institute of Science and Technology	*Dr.C.N.Subalalitha*
		Ms.S.Veena

Course Code	18CSE458T	Course Name	WIRELESS AND MOBILE COMMUNICATION	Course Category	E	Professional Elective	L	T	P	C
							3	0	0	3

Pre-requisite Courses	Nil	Co-requisite Courses	Nil	Progressive Courses	
Course Offering Department	Computer Science and Engineering	Data Book / Codes/Standards	Nil		

Course Learning Rationale (CLR):	*The purpose of learning this course is to:*
CLR-1 :	*Analyze the fundamental of transmission and cellular systems*
CLR-2 :	*Apply skills in real time engineering problems and can have capability to evaluate the transmission errors*
CLR-3 :	*Comprehend the concept of mobile network, transport layer and wireless technologies*
CLR-4 :	*Differentiate the various types of cellular standard by their unique services.*
CLR-5 :	*Grasp GSM. GPRS, Handover and Localization techniques*
CLR-6 :	*Apply skills in various Routing protocols*

Course Learning Outcomes (CLO):	*At the end of this course, learners will be able to:*	Learning 1: Level of Thinking (Bloom)	2: Expected Proficiency (%)	3: Expected Attainment (%)	PLO 1: Engineering Knowledge	2: Problem Analysis	3: Design & Development	4: Analysis, Design, Research	5: Modern Tool Usage	6: Society & Culture	7: Environment & Sustainability	8: Ethics	9: Individual & Team Work	10: Communication	11: Project Mgt. & Finance	12: Life Long Learning	13: PSO - 1	14: PSO - 2	15: PSO – 3
CLO-1 :	*Apply Wireless Technology concepts to Engineering problems related to Communication*	3	80	70	H	H	H	H	H	H	H	H	H	H	M	H	H	H	H
CLO-2 :	*Improve their knowledge on Digital and analog Modulation techniques.*	3	85	75	H	H	H	H	H	H	H	H	H	H	M	H	H	H	H
CLO-3 :	*Equip themselves familiar with principle of Mobile Communication*	3	75	70	H	H	H	H	H	H	H	H	H	H	M	H	H	H	H
CLO-4 :	*Familiarize with Digital Cellular Standards*	3	85	80	H	H	H	H	H	H	H	H	H	H	M	H	H	H	H
CLO-5 :	*Acquaint with routing protocols*	3	85	75	H	H	H	H	H	H	H	H	H	H	M	H	H	H	H
CLO-6 :	*Expose to the emerging wireless technologies*	3	80	70	H	H	H	H	H	H	H	H	H	H	M	H	H	H	H

Duration (hour)		9	9	9	9	9
S-1	SLO-1	*Introduction to wireless Communication*	*Cellular Concept*	*Introduction to GSM*	*Mobile IP*	*IEEE 802.11*
	SLO-2	*Elements of wireless Communication system*	*Cell area*	*Frequency Bands and Channels*	*IP packet delivery*	*System Architecture*
S-2	SLO-1	*Frequencies for radio Communication*	*Signal strength*	*Frames in GSM*	*Tunneling – Reverse Tunneling*	*Protocol Architecture*
	SLO-2	*Signals, Noise – Types of Noise*	*Cell parameter*	*Planes and layers of GSM*	*IPv6*	*MAC Layer and Management*
S-3	SLO-1	*Introduction to modulation and demodulation*	*Capacity of Cell*	*Protocols*	*DHCP*	*802.11a, 802.11b*
	SLO-2	*Signals in the modulation*	*Co channel interference*	*Localization and calling*	*Tradition TCP*	*HIPERLAN*
S-4	SLO-1	*Introduction to Analog modulation schemes*	*Frequency reuse*	*Handoff – Short messaging system*	*Congestion control*	*Bluetooth Architecture*
	SLO-2	*Amplitude Modulation Frequency modulation*	*Cell splitting Cell sectoring*	*GPRS EDGE*	*Classical TCP Snooping ,*	*IEEE 802.15* *IEEE 802.15.4*
S-5	SLO-1	*Phase Modulation Introduction to Analog modulation schemes*	*Multiple Radio access protocols Frequencydivision Multiple Access*	*3G CELLULAR SystemsMMS*	*Mobile TCPFast retransmit / Fast recovery*	*MANET characteristicsROUTING*
	SLO-2	*Amplitude Shift Keying Frequency Shift Keying Phase Shift Keying- BPSK, QPSK*	*Time division Multiple Access Fixed ALOHA , Slotted ALOHA*	*UMTS Release and standards UMTS system architecture UTRAN*	*Transaction oriented TCP TCP over 2.5/3G wireless Networks*	*AODV Routing VANETCommunications in VANET*
S-6	SLO-1	*Multiplexing and multiple access techniques*	*Multiple Access with Collision Avoidance*	*Handover*	*Introduction to WAP WAP Architecture*	*Wireless Sensor Networks*
S-7	SLO-1	*Frequency-division multiplexing*	*Space division Multiple Access Code division Multiple Access*	*Satellite System Infrastructure- GEO, LEO, MEO*	*Wireless Datagram ProtocolWireless Transaction Protocol*	*RFID TechnologyTwo tags of RFID*
	SLO-2	*Time-division multiplexing*	*Spread ALOHA multiple Access*	*Limitations of GPS*	*Wireless Session Protocol*	*Wi-Fi Standards*
S-8	SLO-1	*Code-division multiplexing*	*OFDM*	*GPSBeneficiaries of GPS*	*Wireless Transport Layer Security*	*WiMax Standards*
	SLO-2	*Spread spectrum modulation*	*Variants of OFDM*			
S-9	SLO-1	*frequency hopping Spread spectrum*	*Comparison of Multiple Access Technique*	*4G Cellular systems*	*Wireless Markup Language*	*Fem-to-Cell Network*
	SL0-2	*Direct Sequence Spread spectrum*		*4G Standards (LTE/WiMax)*	*Push Architecture*	*Push-to-talk technology for SMS*

Learning Resources	1. Roy Blake, Wireless Communication Technology" CENGAGE learning, Sixth indian reprint 2013. 2. Dharma Prakash Agarwal, Qing-An Zeng , "Introduction to Wireless and Mobile Systems" CENGAGE learning, First edition 2014. 3. Jochen Schiller, "Mobile Communications", Addision Wesley, 2nd edition 2011. 4. Singal TL, "Wireless Communication", Tata McGraw Hill Education Private Limited. 5. G.I.Papadimitriou, A.S.Pomportsis, P.Nicopolitids, M.S.Obaidat, "Wireless Networks", John Wiley and Sons, 2003	6. Gray J.Mullet "Wireless TeleCommunication System and Networks", CENGAGE learning, reprint 2014. 7. Upena Dalal, "Wireless Communication" Oxford University Press, First edition 2009. 8. Kaveh Pahlavan & Prashant Krishnamurthy, "Wireless Networks" PHI 2002. 9. Martyn Mallick, "Mobile and Wireless Design Essentials", Wiley Dreamtech India Pvt.Ltd., 2014.

Learning Assessment											
	Bloom's Level of Thinking	Continuous Learning Assessment (50% weightage)								Final Examination (50% weightage)	
		CLA – 1 (10%)		CLA – 2 (15%)		CLA – 3 (15%)		CLA – 4 (10%)#			
		Theory	Practice	Theory	Practice	Theory	Practice	Theory	Practice	Theory	Practice
Level 1	Remember Understand	40 %	-	30 %	-	30 %	-	30 %	-	30%	-
Level 2	Apply Analyze	40 %	-	40 %	-	40 %	-	40 %	-	40%	-
Level 3	Evaluate Create	20 %	-	30 %	-	30 %	-	30 %	-	30%	-
	Total	100 %		100 %		100 %		100 %		100 %	

CLA – 4 can be from any combination of these: Assignments, Seminars, Tech Talks, Mini-Projects, Case-Studies, Self-Study, MOOCs, Certifications, Conf. Paper etc.,

Course Designers		
Experts from Industry	Experts from Higher Technical Institutions	Internal Experts
Dr.Madan Lakshmanan	*Prof. Subra Ganesan*	*Dr.S.Suresh*
Senior Scientist	*Professor, Electrical and Computer Engineering*	*Mrs.Jeya*
CEERI, CSIR, Chennai (R&D Industry)	*Oakland University, USA*	*Mr.H.Karthikeyan*

Course Code	18CSE459T	Course Name	SERVICE ORIENTED ARCHITECTURE	Course Category	E	Professional Elective	L	T	P	C
							3	0	0	3

Pre-requisite Courses	Nil	Co-requisite Courses	Nil	Progressive Courses	Nil
Course Offering Department	Computer Science and Enginering	Data Book / Codes/Standards	Nil		

Course Learning Rationale (CLR):	*The purpose of learning this course is to:*
CLR-1 :	*Learn service oriented analysis techniques*
CLR-2 :	*Learn technology underlying the service design*
CLR-3 :	*Learn advanced concepts in building SOA*
CLR-4 :	*Understand the Java Web services*
CLR-5 :	*To know about various Web services specification standards*
CLR-6 :	

Course Learning Outcomes (CLO):	*At the end of this course, learners will be able to:*	Learning 1 Level of Thinking (Bloom)	2 Expected Proficiency (%)	3 Expected Attainment (%)	PLO 1 Engineering Knowledge	2 Problem Analysis	3 Design & Development	4 Analysis, Design, Research	5 Modern Tool Usage	6 Society & Culture	7 Environment & Sustainability	8 Ethics	9 Individual & Team Work	10 Communication	11 Project Mgt. & Finance	12 Life Long Learning	13 PSO - 1	14 PSO - 2	15 PSO – 3
CLO-1 :	*Acquire the knowledge on service oriented design technology*	*2*	*80*	*85*	*H*	-	-	-	-	-	-	-	-	-	-	-	-	-	-
CLO-2 :	*Acquire the ability to identify web services in SOA*	*2*	*75*	*80*	*H*	*H*	-	-	-	-	-	-	-	-	-	-	-	-	-
CLO-3 :	*Understand the basic ideas about building SOA*	*2*	*85*	*80*	*H*	-	-	-	-	-	-	-	-	-	-	-	-	-	-
CLO-4 :	*Appreciate the concepts of standards and security on SOA*	*2*	*80*	*75*	*H*	*H*	-	-	-	-	-	-	-	-	-	-	-	-	-
CLO-5 :	*Apply the knowledge in Java based web servise*	*2*	*75*	*85*	*H*	-	-	*H*	-	-	-	-	-	-	-	-	-	-	-
CLO-6 :	*Acquire the knowledge on ASP .NET based web servises.*	*2*	*80*	*85*	*H*	-	-	-	-	-	-	-	-	-	-	-	-	-	-

Duration (hour)		9	9	9	9	9
S-1	SLO-1	*Introduction to SOA , Defining SOA*	*Introduction to Web Services*	*Phases of the SOA delivery lifecycle*	*SOA support in J2EE*	*Introduction to WS-BPEL*
	SLO-2	*Necessity of SOA.*	*Primitive SOA*	*SOA Delivery Strategies Top- down strategy, Bottom-up strategy*	*SOA platform basics and building blocks*	*Basic terms used in the BPEL terminology*
S-2	SLO-1	*SOA timeline from XML to Web services to SOA*	*Web Service Framework with respect to SOA*	*Agile strategy with Pros and cons*	*Overview of Java API for XML-based web services(JAX- WS)*	*WS-Coordination overview*
	SLO-2	*History about XML*	*Logical components of the Web services framework*	*Objectives and service-oriented process steps*	*Java Architecture for XML binding (JAXB)*	*WS-Choreography*
S-3	SLO-1	*Web Services and SOA*	*Service descriptions with WSDL layout*	*Benefits of a business-centric SOA*	*Building web services and client with examples*	*WS-Policy with SOA*
	SLO-2	*Service Oriented Enterprise (SOE)*	*Meta data and service contracts*	*Service- oriented design*	*Introduction to Java API for XML Registries(JAXR)*	*WS Security*
S-4	SLO-1	*Analyze the past architectures*	*Messaging with SOAP protocol and SOAP nodes*	*Introduction to WSDL language basics*	*Java API for XML based RPC (JAX-RPC)*	*Notification and Eventing*
	SLO-2	*Scope Of SOA*	*SOAP message path*	*Define the structure of WSDL*	*Web Services Interoperability*	*Transaction Management*
S-5	SLO-1	*SOA Reference Model*	*Message exchange Patterns and Coordination*	*Implement sample WSDL file*	*SOA support in .NET*	*Case study-SOA in cloud*
	SLO-2	*Key Service characteristics of SOA*	*Web Services a Activity Management,*	*Introduction to SOAP basics*	*NET Platform overview*	*research focus on SOA and issues*
S-6	SLO-1	*Anatomy of SOA*	*Coordination types and protocols*	*SOAP language basics*	*ASP.NET Page Handling*	*Comparative Analysis of SOA and Cloud Computing*
	SLO-2	*SOA architecture*	*ACID properties*	*Structure of SOAP*	*Post back vs Non post back events*	
S-7	SLO-1	*Components in SOA interrelate*	*Analyze atomic transaction with SOA*	*Implement SOAP style web services in Java.*	*ASP.NET web services*	*Case Study On Vehicle management system- create a service for identify the vehicle by entering the vehicle number.*
	SLO-2	*SOA component and specific behaviors*	*Business activities and protocols*	*SOA Composition*	*Creating a Web Site Using Visual Studio IDE*	

S-8	SLO-1	*Relationships among these components*	*Orchestration*	*service layers and standards*	*ASP.NET Programming Basics*	*Case Study on Online Healthcare System-Design an API to help healthcare providers collect, store, retrieve and exchange patient healthcare information more efficiently and enable better patient care.*
	SLO-2	*Technical Benefits of SOA*	*Choreography*	*Entity-centric business service design: List the step-by-step process*	*Creating a Web Site Using Visual Studio IDE*	
S-9	SLO-1	*Business Benefits of SOA*	*Service layer configuration scenarios*	*Application service design: process steps*	*Case Studies: Implement the Small Business Customer Management application as a web applications using ASP.NET*	*Case study on Simple Library Management System using API to get, post, edits and update book data from server.*
	SLO-2	*Principles of service orientation*	*Application Service Layer*	*Task centric business service design process steps*	*Web Services Enhancements (WSE)*	

Learning Resources	1. *ThomasErl,"Service-Oriented Architecture: Concepts, Technology, and Design", Pearson Education, 2009.* 2. *EricNewcomer,Lomow,"UnderstandingSOAwithWebServices",PearsonEducation,2005* 3. *JamesMcGovern,SameerT yagi, Michael EStevens, Sunil Mathew, Java WebServices Architecture",Elsevier,2003.*	4. *AchievingService-Oriented Architecture: Applying an Enterprise Architecture Approach, Rick Sweeney, 2010* 5. *Shankar Kambhampaly, "Service –Oriented Architecture for Enterprise Applications", Wiley India Pvt Ltd, 2008 3.Newcomer, Lomow, "Understanding SOA with Web Services", Pearson Education, 2005 4.Sandeep Chatterjee, James Webber, "Developing Enterprise Web Services, An Architect's Guide", Pearson Education,2005*

Learning Assessment

	Bloom's Level of Thinking	Continuous Learning Assessment (50%								Final Examination (50% weightage)	
		CLA – 1 (10%)		CLA – 2 (15%)		CLA – 3 (15%)		CLA – 4 (10%)#			
		Theory	Practice	Theory	Practice	Theory	Practice	Theory	Practice	Theory	Practice
Level 1	Remember Understand	*40 %*	-	*30 %*	-	*30 %*	-	*30 %*	-	*30%*	-
Level 2	Apply Analyze	*40 %*	-	*40 %*	-	*40 %*	-	*40 %*	-	*40%*	-
Level 3	Evaluate Create	*20 %*	-	*30 %*	-	*30 %*	-	*30 %*	-	*30%*	-
	Total	100 %		100 %		100 %		100 %		100 %	

CLA – 4 can be from any combination of these: Assignments, Seminars, Tech Talks, Mini-Projects, Case-Studies, Self-Study, MOOCs, Certifications, Conf. Paper etc.,

Course Designers		
Experts from Industry	Experts from Higher Technical Institutions	Internal Experts

Course Code	18CSE460T	Course Name	NETWORK DESIGN AND MANAGEMENT	Course Category	E	Professional Elective	L	T	P	C
							3	0	0	3

Pre-requisite Courses	Nil	Co-requisite Courses	Nil	Progressive Courses	Nil
Course Offering Department	Computer Science Engineering	Data Book / Codes/Standards	Nil		

Course Learning Rationale (CLR):	The purpose of learning this course is to:
CLR-1 :	Understand the various type of Networks and the Network Management basics
CLR-2 :	Understand the Network Management Standards
CLR-3 :	Understand the working of Simple Network Management Protocol and its various versions
CLR-4 :	Understand the working of Remote Monitoring
CLR-5 :	Understand the Network Management Applications
CLR-6 :	To Understand Network Designing and Planning

Course Learning Outcomes (CLO):	At the end of this course, learners will be able to:	Learning 1: Level of Thinking (Bloom)	2: Expected Proficiency (%)	3: Expected Attainment (%)	PLO 1: Engineering Knowledge	2: Problem Analysis	3: Design & Development	4: Analysis, Design, Research	5: Modern Tool Usage	6: Society & Culture	7: Environment & Sustainability	8: Ethics	9: Individual & Team Work	10: Communication	11: Project Mgt. & Finance	12: Life Long Learning	13: PSO - 1	14: PSO - 2	15: PSO – 3
CLO-1 :	*Acquire knowledge on networks and network management*	1	70	75	H	-	-	-	-	-	-	-	-	-	-	-	-	-	-
CLO-2 :	*Gain knowledge of the various standards*	1	75	80	H	-	-	-	-	-	-	-	-	-	-	-	-	-	-
CLO-3 :	*Gain knowledge on the working of SNMP protocol and its various applications*	1	85	80	H	-	-	-	M	-	-	-	M	-	-	-	-	-	-
CLO-4 :	*To apply the network management tools and gather information from the network*	2	75	70	H	-	-	-	M	-	-	-	M	-	-	-	-	-	-
CLO-5 :	*To Familiarize with the working of various management applications*	2	75	80	H	-	-	-	-	-	-	-		-	-	-	-	-	-
CLO-6 :	*Apply the knowledge to create an efficient network*	3	70	75	H	H	H	H	H	-	-	-	H	-	-	-	-	-	-

Duration (hour)		9	9	9	9	9
S-1	SLO-1	*Telephone Network Management*	*Introduction to SNMP*	*Remote Monitoring*	*Network Management Applications*	*Network Design and Planning*
	SLO-2	*Distributed Computing Environment*	*SNMP v1 model*	*RMON SMI and MIB*	*Fault Management -Architecture*	*Network Design for Enterprise Network*
S-2	SLO-1	*TCP/IP Based Networks*	*Organization Model*	*RMON1*	*Fault location ,Fault isolation*	*Network Design Process*
	SLO-2	*Communication Protocols and Standards*	*System overview*	*RMON2*	*Algorithm*	*Data Collection*
S-3	SLO-1	*Protocol Layer and Services*	*SNMP v1 Information model*	*System Utilities for Management*	*Self-healing*	*Data Generation*
	SLO-2	*Challenges of IT Managers*	*Structure of Management Information*	*Tools*	*Avoiding failures*	*Traffic Generators*
S-4	SLO-1	*Network Management*	*Managed Objects*	*Network Statistics Measurement Systems*	*Configuration setting,*	*Cost Generators*
	SLO-2	*Network and System Management*	*MIB-Object Group*	*Traffic Load*	*Configuration discovery and Change Control*	*Topology*
S-5	SLO-1	*Network Management System Platform*	*System Group, Interfaces Group, Address Translation group*	*Protocol Statistics*	*Configuration Management Applications*	*Architecture*
	SLO-2	*Current status and future of Network Management*	*IP Group, ICMP Group, TCP Group, UDP Group*	*Data and Error Statistics*	*Patch Management*	*Graph*
S-6	SLO-1	*Network Management Standards*	*SNMP v1Communication model*	*Network Management System*	*Approaches for Performance Management*	*Link*
	SLO-2	*Network Management Model - Organizational model*	*Functional model*	*Components, Requirements*	*Performance Monitoring and Reporting*	*Algorithms*
S-7	SLO-1	*Information Model*	*SNMPv2*	*System Management*	*Performance trouble shooting,*	*Network Design Techniques*
	SLO-2	*Management Information Trees*	*System Architecture, MIB, Protocol*	*Network Management Applications*	*Capacity Planning*	*Performance Analysis*
S-8	SLO-1	*Communication Model*	*SNMPv3*	*Configuration Management*	*Account Management*	*Queuing Essentials*
	SLO-2	*ASN.1*	*Architecture, Applications, MIB*	*Inventory Management*	*Report Management-System and User Reports*	*Loss and Delay*
S-9	SLO-1	*Terminology, Symbols and Conventions*	*User Based Security Model*	*Performance Management*	*Policy Management*	*Reliability*
	SLO-2	*Functional Model*	*Access Control*	*Tools*	*Service Level Management*	*Network Cost*

Learning Resources	1. *Mani Subramanian "Network Management Principles and Practice", Second Edition, Pearson Publication, 2012.* 2. *DineshChandraVerma,"PrinciplesofComputerSystemsandNetworkManagement",Springer,2009.*	3. *Greg Tomsho, Ed Tittel, David Johnson, "Guide to Network Essentials", Fifth Edition, Cengage Learning, 2010 4.Teresa C.Piliouras ," Network Design Management and Technical Perspectives", Second Edition ,2004*

Learning Assessment											
	Bloom's Level of Thinking	Continuous Learning Assessment (50%								Final Examination (50% weightage)	
		CLA – 1 (10%)		CLA – 2 (15%)		CLA – 3 (15%)		CLA – 4 (10%)#			
		Theory	Practice	Theory	Practice	Theory	Practice	Theory	Practice	Theory	Practice
Level 1	Remember Understand	*40 %*	-	*40 %*	-	*20 %*	-	*30 %*	-	*40%*	-
Level 2	Apply Analyze	*40 %*	-	*40 %*	-	*40 %*	-	*40 %*	-	*40%*	-
Level 3	Evaluate Create	*20 %*	-	*20 %*	-	*40 %*	-	*30 %*	-	*20%*	-
	Total	100 %		100 %		100 %		100 %		100 %	

CLA – 4 can be from any combination of these: Assignments, Seminars, Tech Talks, Mini-Projects, Case-Studies, Self-Study, MOOCs, Certifications, Conf. Paper etc.,

Course Designers		
Experts from Industry	Experts from Higher Technical Institutions	Internal Experts
1. Mr.Vivekanandan ,Nokia Technology Specialist, anandanviv1@gmail.com	*1.*	*1. Dr.B.Amutha, SRMIST*
2.Mr.SanthoshKumar.S,Associate Consultant,TCS, santhosh.sansoft@gmail.com	*2.*	*2.Dr.N.Snehalatha, SRMIST*

Course Code	18CSE387T	Course Name	GENETIC ALGORITHM AND MACHINE LEARNING	Course Category	E	Professional Elective	L	T	P	C
							3	0	0	3

Pre-requisite Courses	Nil	Co-requisite Courses	Nil	Progressive Courses	Nil
Course Offering Department	Computer Science and Engineering	Data Book / Codes/Standards	Nil		

Course Learning Rationale (CLR):	*The purpose of learning this course is to:*
CLR-1 :	*Evolutionary Computation and Genetic Algorithms*
CLR-2 :	*Terminologies and operators of GA and*
CLR-3 :	*Advanced Operators and Techniques in GA and Classification of Genetic Algorithms*
CLR-4 :	*Genetic Programming and Genetic Algorithm Optimization problems*
CLR-5 :	*Applications of Genetic Algorithms*

Course Learning Outcomes (CLO):	*At the end of this course, learners will be able to:*	Learning 1: Level of Thinking (Bloom)	2: Expected Proficiency (%)	3: Expected Attainment (%)	PLO 1: Engineering Knowledge	2: Problem Analysis	3: Design & Development	4: Analysis, Design, Research	5: Modern Tool Usage	6: Society & Culture	7: Environment & Sustainability	8: Ethics	9: Individual & Team Work	10: Communication	11: Project Mgt. & Finance	12: Life Long Learning	13: PSO - 1	14: PSO - 2	15: PSO – 3
CLO-1 :	*Provides a introduction to genetic algorithm including fundamentals of genetic concepts*	3	80	75	L	H	-	H	L	-	-	-	L	L	-	H	-	-	-
CLO-2 :	*To have a clear view of genetic operators*	3	85	75	M	H	L	H	L	-	-	-	M	L	-	H	-	-	-
CLO-3 :	*To explore Genetic Algorithm optimization problems*	3	80	75	M	H	M	H	L	-	-	-	M	L	-	H	-	-	-
CLO-4 :	*Discuss applications of Genetic Algorithms for various optimization problems.*	3	85	80	M	H	M	H	L	-	-	-	M	L	-	H	-	-	-

Duration (hour)		9	9	9	9	9
S-1	SLO-1	*The Historical Development of Evolutionary Computing. Genetic Algorithms and Genetic Programming*	*Terminologies and operators of GA.Key elements, Individuals,*	*Diploidy, Dominance etc. Inversion and Reordering. Order Crossover and Cycle crossover.*	*Genetic programming (GP). Comparison of GP and other algorithms. Genetic operators. Tree based GP, Representation of GP.*	*Specific Applications of Genetic Algorithms. GA in network synthesis, Control systems engineering and Fuzzy based speed control of Brushless DC motor.*
	SLO-2		*Genes, Fitness, Populations. Data Structures.*			
S-2	SLO-1	*Features of Evolutionary Computation Advantages of Evolutionary computation.*	*Breeding, Selection, Crossover, Mutation and Replacement.*	*Micro operators: Segregation and translocation, Duplications and Deletion, Sexual determination.*	*Attributes in GP. Steps of GP, Characteristics of GP. What are Human Competitive, High-Return, Routine, and Machine Intelligence?*	*Feature selection in machine learning using GA. Designing texture filters with GA.*
	SLO-2					
S-3	SLO-1	*Genetic algorithms-Biological background. Cell, Chromosomes, Genetics, Reproduction and Natural selection.*	*Search Termination or Convergence criteria.*	*Non-binary representation, Multi-objective optimization, combined optimization and Knowledge based techniques.*	*Applications of Genetic Programming*	*GA based knowledge acquisition in Image Processing. Object localization in image using GA.*
	SLO-2					
S-4	SLO-1	*Search space, GA world, Evolution and optimization*	*Best individual, Worst individual, Sum of fitness and Medium fitness.*	*Classification of GAs. Simple Genetic algorithms (SGA). Parallel and distributed GAs.*	*GA Optimization problems: Fuzzy optimization problems, Multi objective Reliability Design Problem. Network and bicriteria reliability problems.*	*Data mining applications such as feature selection in data mining, GA in intrusion detection, etc.*
	SLO-2					
S-5	SLO-1	*Evolution and genetic algorithms. Conventional optimization and search techniques.*	*Why do genetic algorithms work? Building block hypothesis*	*Master-slave, Fine-grained parallel GAs. Multiple-Deme Parallel GAs.*	*Combinatorial Optimization problems. Linear integer model,*	*Applications in wireless networks for topology planning. GA application in ATM network.*
	SLO-2					
S-6	SLO-1	*Gradient based, Random search, Stochastic Hill climbing*	*A Macro mutation hypothesis. An adaptive mutation hypothesis.*	*Hierarchical Parallel algorithms. Hierarchical Genetic Algorithms: Crossover, Initialization heuristics. Remove sharp algorithms.*	*Applications of combinatorial optimization methods.*	*VLSI design applications Genetic layout optimization using GA.*
	SLO-2					
S-7	SLO-1	*Simulated Annealing, Symbolic AI. A simple Genetic Algorithm.*	*The schema theorem*	*Adaptive GA., Initialization, Evaluation function, Selection operators, Crossover operators, and mutation operators.*	*Network design and Routing problems*	*Introduction to Particle Swam Optimization [PSO] and Ant Colony Optimization [ACO].*
	SLO-2		*Optimal allocation of Trials. Implicit Parallelism*			

S-8	SLO-1	*Comparison of GA with other optimization techniques.*	*Advanced operators and techniques in GA,*	*Independent sampling GA and Breeding Phase.*	*Planning of passive optical networks, Packet switched networks,*	*Examples on PSO and ACO.*
S-9		*Limitations of GA.*	*Convergence problems in GA*	*Niched pareto genetic algorithm*	*Optimal topological design of all terminal networks.*	*Comparison of GA with PSO and ACO*

Learning Resources	1. *S.N. Sivanandam and S.N. Deepa , "Introduction to Genetic Algorithms", Springer, 2nd edition (2008)* 2. *Mitsuo Gen and Runwei Cheng, "Genetic Algorithms and Engineering Optimization", John Wiley, Fourth edition (2010)* 3. *Michael Negnevitsky, "Artificial Intelligence, A Guide to Intelligent Systems", Second edition ((2005))*

Learning Assessment

	Bloom's Level of Thinking	Continuous Learning Assessment (50% weightage)								Final Examination (50% weightage)	
		CLA – 1 (10%)		CLA – 2 (15%)		CLA – 3 (15%)		CLA – 4 (10%)#			
		Theory	Practice	Theory	Practice	Theory	Practice	Theory	Practice	Theory	Practice
Level 1	Remember Understand	*40 %*	-	*30 %*	-	*30 %*	-	*30 %*	-	*30%*	-
Level 2	Apply Analyze	*40 %*	-	*40 %*	-	*40 %*	-	*40 %*	-	*40%*	-
Level 3	Evaluate Create	*20 %*	-	*30 %*	-	*30 %*	-	*30 %*	-	*30%*	-
	Total	100 %		100 %		100 %		100 %		100 %	

CLA – 4 can be from any combination of these: Assignments, Seminars, Tech Talks, Mini-Projects, Case-Studies, Self-Study, MOOCs, Certifications, Conf. Paper etc.,

Course Designers

Experts from Industry	Experts from Higher Technical Institutions	Internal Experts
Mr. K. Selvaraj, Caterpillar, Bangalore	*Dr. A.P. Shanthi, CSE, Anna University, Chennai*	*1.Dr. V. Ganapathy SRMIST*
	Dr. A. Kannan, CSE, VIT, Vellore.	*2.Dr. D. Rajeswari SRMIST*
		3.S. Saranya SRMIST

Course Code	18CSE388T	Course Name	ARTIFICIAL NEURAL NETWORKS	Course Category	E	Professional Elective	L	T	P	C
							3	0	0	3

Pre-requisite Courses	Nil	Co-requisite Courses	Nil	Progressive Courses	Nil
Course Offering Department	Computer Science and Engineering	Data Book / Codes/Standards	Nil		

Course Learning Rationale (CLR):	*The purpose of learning this course is to:*
CLR-1 :	*Connect Biology with Computers*
CLR-2 :	*Understand components of artificial neural networks*
CLR-3 :	*Understand supervised learning networkparadigms*
CLR-4 :	*Understand unsupervised learning networkparadigms*

Course Learning Outcomes (CLO):	*At the end of this course, learners will be able to:*	Learning 1 Level of Thinking (Bloom)	2 Expected Proficiency (%)	3 Expected Attainment (%)	PLO 1 Engineering Knowledge	2 Problem Analysis	3 Design & Development	4 Analysis, Design, Research	5 Modern Tool Usage	6 Society & Culture	7 Environment & Sustainability	8 Ethics	9 Individual & Team Work	10 Communication	11 Project Mgt. & Finance	12 Life Long Learning	13 PSO - 1	14 PSO - 2	15 PSO – 3
CLO-1 :	*Know the purpose of Artificial Neural Networks*	*1*	*80*	*85*	*H*	*L*	-	-	*H-*	-	-	-	-	-	-	*H*	*L*	*L*	-
CLO-2 :	*Apply the concepts of activation, propogation functions*	*2*	*75*	*80*	*H*	*H*	-	-	*H*	-	-	-	-	-	-	*H*	*H*	*H*	*H*
CLO-3 :	*Work with supervised learning network paradigm*	*3*	*85*	*80*	*H*	*H*	*H*	-	*H*	-	-	-	-	-	-	*H*	*H*	*H*	*H*
CLO-4 :	*Work with unsupervised learning network paradigm*	*3*	*80*	*75*	*H*	*H*	-	-	*H*	-	-	-	-	-	-	*H*	*H*	*H*	*H*

Duration (hour)		9	9	9	9	9
S-1	SLO-1	*Why neural network?*	*Components of artificial neural networks*	*Learning and training samples*	*Radial basis functions*	*Unsupervised learning networkparadigms*
	SLO-2	*Basics of Artificial Neural Networks*	*The concept of time in neural networks*	*Paradigms of Learning*	*Information processing of an RBF network*	*Structure of a self-organizing map(SOM)*
S-2	SLO-1	*A brief history of neural networks*	*Connections*	*Using training samples*	*Training of RBF networks*	*Functionality*
	SLO-2	*Biological neural networks*	*Propagation function*	*Gradient Optimization Procedure*	*Growing of RBF networks*	*Training*
S-3	SLO-1	*Biological neural networks*	*Activation*	*Hebbian learning rule*		*Topology function*
	SLO-2	*The vertebrate nervous system*	*Threshold value, Activation function*	*Supervised learning networkparadigms*	*Compare multilayer perceptrons and RBF*	*Decreasing Learning Rate*
S-4	SLO-1	*peripheral nervous system*	*Common activation functions*	*The perceptron, back propagation and its variants*	*Recurrent perceptron-like networks*	*Variations of SOMs*
	SLO-2	*Cerebrum, cerebellum, diencephalon,brainstem*	*Output function, Learning strategies*	*Singlelayer perceptron*	*Jordan networks*	*Neural gas*
S-5	SLO-1		*Network topologies*	*Linear Separability*	*Elman networks*	*Multi-SOM*
	SLO-2	*The Neuron*	*Feedforward networks*	*Multilayer perceptron*	*Training recurrent networks*	*Multi-neural gas*
S-6	SLO-1	*Components*	*Recurrentnetworks*	*Backpropagation of error*		*Growing neural gas*
	SLO-2	*Electrochemical processes*	*Completely linked networks*	*Selecting learning rate*	*Unfolding in time*	*Adaptive resonance theory(ART)*
S-7	SLO-1	*Receptor cells- Various types*	*Bias neuron*	*Resilient Backpropagation*	*Teacher forcing*	*Task and structure of an ART network*
	SLO-2	*Information processing within nervous system*	*Representing Neurons*	*Adaption of Weights*	*Recurrent backpropagation*	*Resonance*
S-8	SLO-1	*Light Sensing organs*	*Orders of Activation*	*Variations in Backpropagation*		
	SLO-2	*Neurons in living organisms*	*Synchronous activation*			
S-9	SLO-1	*Transition to technical neurons*	*Asynchronous activation*	*Multilayer perceptron*	*Evolutionary algorithms*	*Learning process of an ART network*
	SLO-2		input and outputof data			

Learning Resources		
	1. *David Kriesel, A BriefIntroduction to Neural Networks, dkriesel.com, 2005*	3. *Raul Rojas, Neural Networks: A Systematic Introduction, 1996.*
	2. *GunjanGoswami, Introduction to Artificial Neural Networks, S.K. Kataria& Sons, 2012*	4. *S. Sivanandam, Introduction to Artificial Neural Networks, 2003*

Learning Assessment											
	Bloom's Level of Thinking	Continuous Learning Assessment (50% weightage)								Final Examination (50% weightage)	
		CLA – 1 (10%)		CLA – 2 (15%)		CLA – 3 (15%)		CLA – 4 (10%)#			
		Theory	Practice	Theory	Practice	Theory	Practice	Theory	Practice	Theory	Practice
Level 1	Remember Understand	*40 %*	-	*30 %*	-	*30 %*	-	*30 %*	-	*30%*	-
Level 2	Apply Analyze	*40 %*	-	*40 %*	-	*40 %*	-	*40 %*	-	*40%*	-
Level 3	Evaluate Create	*20 %*	-	*30 %*	-	*30 %*	-	*30 %*	-	*30%*	-
	Total	100 %		100 %		100 %		100 %		100 %	

CLA – 4 can be from any combination of these: Assignments, Seminars, Tech Talks, Mini-Projects, Case-Studies, Self-Study, MOOCs, Certifications, Conf. Paper etc.,

Course Designers		
Experts from Industry	Experts from Higher Technical Institutions	Internal Experts
1. Dr.Harisekharan,CTO,Sri SeshaaTechnologies Pvt. Ltd., Chennai	*1. Dr.J.Suresh, SSN College of Engineering*	*Dr.G.Vadivu*
	2. Dr. Sharmila Shankar, Crescent Institute of Science and Technology	*Dr. D.Rajeswari*
		Dr.M.S.Abirami

Course Code	18CSE389T	Course Name	FUZZY LOGIC FOR MACHINE LEARNING	Course Category	E	Professional Elective	L	T	P	C
							3	0	0	3

Pre-requisite Courses	Nil	Co-requisite Courses	Nil	Progressive Courses	Nil
Course Offering Department	Computer Science & Engg	Data Book / Codes/Standards	Nil		

Course Learning Rationale (CLR):	*The purpose of learning this course is to:*
CLR-1 :	*Understand the Fuzzy Logic Basics*
CLR-2 :	*Gain knowledge on the Machine learning concepts*
CLR-3 :	*Gain knowledge on Fuzzy based clustering concepts*
CLR-4 :	*Acquire knowledge on Fuzzy Integrated classification*
CLR-5 :	*Understanding Neuro-Fuzzy Modeling concepts*
CLR-5 :	*Acquiring better understanding on Fuzzy logic usage*
CLR-6	*Understanding the fuzzylogics in Machine learning*

Course Learning Outcomes (CLO):	*At the end of this course, learners will be able to:*	Learning 1: Level of Thinking (Bloom)	Learning 2: Expected Proficiency (%)	Learning 3: Expected Attainment (%)	PLO 1: Engineering Knowledge	PLO 2: Problem Analysis	PLO 3: Design & Development	PLO 4: Analysis, Design, Research	PLO 5: Modern Tool Usage	PLO 6: Society & Culture	PLO 7: Environment & Sustainability	PLO 8: Ethics	PLO 9: Individual & Team Work	PLO 10: Communication	PLO 11: Project Mgt. & Finance	PLO 12: Life Long Learning	PLO 13: PSO - 1	PLO 14: PSO - 2	PLO 15: PSO – 3
CLO-1 :	*Acquire the knowledge on Basics of Fuzzy Logic*	*2*	*80*	*85*	*H*	*M*	-	*H*	-	-	-	-	-	-	-	*H*	*L*	*H*	*M*
CLO-2 :	*Understand the basic concepts in Machine learning*	*2*	*75*	*80*	*H*	*H*	-	*H*	-	-	-	-	-	-	-	*H*	*L*	*H*	*M*
CLO-3 :	*Apply the knowledge of Clustering in Fuzzy logics*	*2*	*85*	*80*	*H*	-	-	*H*	-	-	-	-	-	-	-	*H*	*L*	*H*	*M*
CLO-4 :	*Apply the concept of Classification in Fuzzy Logics*	*2*	*80*	*75*	*H*	*H*	-	*H*	-	-	-	-	-	-	-	*H*	*L*	*H*	*M*
CLO-5 :	*Acquire the knowledge on Neuro-Fuzzy resoning*	*2*	*75*	*85*	*H*	-	-	*H*	-	-	-	-	-	-	-	*H*	*L*	*H*	*M*
CLO-6 :	*Acquire the insight of Neuro-Fuzzy Modeling*	*2*	*75*	*85*	*H*	-	*H*	*H*	*H*	-	-	-	-	-	-	*H*	*L*	*H*	*M*

Duration (hour)		9	9	9	9	9
S-1	SLO-1	*Fuzzy Logic Introduction : Comparison of traditional logic and fuzzy logic*	*Machine learning : Importance of ML*	*Fuzzy Clustering Basics: Cluster analysis Objective function-based cluster analysis, Fuzzy analysis of data*	*Fuzzy Integral Classification: Introduction and Notation , Reduction vs. Ordering*	*Neuro Fuzzy Modeling : ANFIS – Adaptive Neuro Fuzzy Inference system*
	SLO-2	*Basic History of Fuzzy Logic*	*Types of MachineLearning : SupervisedLearning-Unsupervised Learning, reinforcement Learning*	*Special objective functions, A principal clustering algorithm*	*The Borda Count*	*ANFIS - architecture*
S-2	SLO-1	*The case of Imprecision, A Historical perspective*	*TheCurse of dimensionality Overfitting and linear regression*	*Classical Fuzzy Clustering Algorithms : The fuzzy c-means algorithm*	*The Average Rule , The Median Alternative*	*Hybrid learning algorithm*
	SLO-2	*The Utility of Fuzzy systems, Limitations of Fuzzy systems*		*The Gustafson-Kessel algorithm*	*The Product Rule, The MaxMax and MaxMin Rules*	*Coactive Neuro fuzzy modeling : Towards generalized ANFIS*
S-3	SLO-1	*Fuzzy sets and membership*	*Bias andVariance LearningCurve*		*The Intersection Method , The Union Rule*	*Framework*
	SLO-2	*Chance Vs Fuzziness*		*The Gath-Geva algorithm*	*Logistic Regression : The Logit Transform and Maximum Likelihood Estimation*	*Neuron functions for adaptive netwoks*
S-4	SLO-1	*Classical sets and Fuzzy sets : Operations on classical sets, properties of classical sets*	*Classification*	*Computational effort*	*Separate Weight Sets*	*Fuzzy membership functions Vs Receptive field units*
	SLO-2	*Operations on fuzzy sets, properties of fuzzy sets*	*Error and noise*	*Linear and Ellipsoidal Prototypes : The fuzzy c-varieties algorithm*	*Model Selection by Local Accuracy*	*Non-linear rule*
S-5	SLO-1	*Classical relations : Cartesian product, crisp relations*	*Measuring(dis)similarity-Evaluating the output of clusteringmethod*	*The adaptive fuzzy clustering algorithm*	*Maximizing the Fuzzy Integral : What Does This Have to Do with Classifier Combination?*	*Neuro-fuzzy spectrum*
	SLO-2	*Fuzzy relations: cardinality of fuzzy relations, operations on fuzzy relations*	*Hierarchical clustering, Agglomerativeclustering - Divisiveclustering*	*Algorithms by Gustafson/Kessel and Gath/Geva*	*Pairwise Coupling - Pairwise Threshold Optimization*	*Analysis of Adaptive learning capability : Convergence based on the steepest descend method alone*
S-6	SLO-1	*Properties of fuzzy relations*	*K-Meansclustering*		*Comparing the Combination Methods : Small Training Set, Three Models*	*Interpretability spectrum*

	SLO-2	*Tolerance and Equivalence relations: crisp tolerance*		*Cluster Estimation Models :AO membership functions*	*Large Training Set, Three Models*	*Evolution of antecedents*
S-7	SLO-1	*Fuzzy Tolerance*	*Perceptrons*	*ACE membership functions*	*Small Training Set, Three Good Models , One Worthless*	*Evolution of consequence*
	SLO-2	*Properties of Membership functions, Fuzzification and defuzzification – Features of the memberfunction*	*Feedforwardnetworks.*	*Hyperconic clustering (dancing cones)*	*Large Training Set, Three Good Models, One Worthless*	*Evolving partitions*
S-8	SLO-1	*Various forms*	*MultilayerNetworks and Back PropagationAlgorithms*	*Cluster Validity : Global validity measures*	*Small Training Set, Worthless and Noisy Models Included*	*Neuro Fuzzy Control : Feedback control systems and Neuro fuzzy control*
	SLO-2	*Defuzzification of crisp sets*	*Linear Models – Linear regression,Logistic regression*	*Solid clustering validity measures, Shell clustering validity measures*	*Large Training Set, Worthless and Noisy Models Included*	*Expert control*
S-9	SLO-1	*Lamda cuts of fuzzy relations, Defuzzification to scalars*	*Tree learning : Decision trees*	*Local validity measures : The compatible cluster merging algorithm, The unsupervised FCSS algorithm*	*Fuzzy Association rules*	*Inverse learning, specialized learning*
	SLO-2	*Conclusion : Benefits of Fuzzy in comparison with crisp*	*Conclusion : Summary of ML concepts*	*Conclusion : Fuzzy based clustering merits*	*Conclusion : Fuzzy based classifier benefits*	*Conclusion : Summary / benefits of Neuro-fuzzy systems*

Learning Resources	1. *Vojislav Kecman, Learning and soft computing: Support vector Machines, Neural networks and Fuzzy logic models, A Bradford Book, The MIT Press., 2001, ISBN : 0-262-11255-8* 2. *Timothy J. Ross,University of New Mexico, USA., Fuzzy Logic with Engineering Applications, 3rd Edition, Wiley, 2010. ISBN 978-0-470-74376-8* 3. *Frank Höppner, Frank Klawonn, Rudolf Kruse and Thomas Runkler: Fuzzy Cluster Analysis, Wiley (1999)ISBN 0-471-98864-2*	4. *Timothy Masters, Assessing andImproving Predictionand ClassificationTheory and Algorithms in C++, ISBN-13 (pbk): 978-1-4842-3335-1 ISBN-13 (electronic): 978-1-4842-3336-8 ,https://doi.org/10.1007/978-1-4842-3336-8,2018.* 5. *Jyh-Shing, Roger Jang, Chuen-Tsai sun, Eiji Mizutani., Neuro fuzzy and softcomputing – A computational approach to learning and machine intelligence, Prentice Hall (1997) , ISBN : 0-13-2610663* 6. *Kevin P. Murphy,"MachineLearning: AProbabilistic Perspective",MIT Press, 2012* 7. *EthemAlpaydin,"Introduction to MachineLearning",Prentice Hall ofIndia, 2005* 8. *TomMitchell,"MachineLearning",McGraw-Hill, 1997.*

Learning Assessment											
	Bloom's Level of Thinking	Continuous Learning Assessment (50% weightage)								Final Examination (50% weightage)	
		CLA – 1 (10%)		CLA – 2 (15%)		CLA – 3 (15%)		CLA – 4 (10%)#			
		Theory	Practice	Theory	Practice	Theory	Practice	Theory	Practice	Theory	Practice
Level 1	Remember Understand	*40 %*	-	*30 %*	-	*30 %*	-	*30 %*	-	*30%*	-
Level 2	Apply Analyze	*40 %*	-	*40 %*	-	*40 %*	-	*40 %*	-	*40%*	-
Level 3	Evaluate Create	*20 %*	-	*30 %*	-	*30 %*	-	*30 %*	-	*30%*	-
	Total	100 %		100 %		100 %		100 %		100 %	

CLA – 4 can be from any combination of these: Assignments, Seminars, Tech Talks, Mini-Projects, Case-Studies, Self-Study, MOOCs, Certifications, Conf. Paper etc.,

Course Designers		
Experts from Industry	Experts from Higher Technical Institutions	Internal Experts
1. *Dr.R.Gokulakrishnan, Additional Director(EXIM), Software Technology Parks of India , r.gokul@stpi.in* 2. *Dr.Prabhu, Coherant , US., prabu.balu@coherant.com*	*Dr.Subrat Kumar Nayak, Associate professor, Institute of Technical education and Research, subratnayak@soa.ac.in*	*Dr.G.Maragatham , Dr. Manas Ranjan ,Ms.A.Saranya*

Course Code	18CSE390T	Course Name	COMPUTER VISION	Course Category	E	Professional Elective	L	T	P	C
							3	0	0	3

Pre-requisite Courses	Nil	Co-requisite Courses	Nil	Progressive Courses	Nil
Course Offering Department	Computer Science and Engineering	Data Book / Codes/Standards	Nil		

Course Learning Rationale (CLR):	*The purpose of learning this course is to:*
CLR-1 :	*Recognize and describe both the theoretical and practical aspects of computing with images. Connect issues from Computer Vision to Human Vision*
CLR-2 :	*Describe the foundation of image formation and image analysis. Understand the basics of 2D and 3D Computer Vision.*
CLR-3 :	*Become familiar with the major technical approaches involved in computer vision. Describe various methods used for registration, alignment, and matching in images.*
CLR-4 :	*Get an exposure to advanced concepts leading to object and scene categorization from images.*
CLR-5 :	*Build computer vision applications.*
CLR-5 :	*Recognize and describe both the theoretical and practical aspects of computing with images. Connect issues from Computer Vision to Human Vision*

Course Learning Outcomes (CLO):	*At the end of this course, learners will be able to:*	Learning 1: Level of Thinking (Bloom)	Learning 2: Expected Proficiency (%)	Learning 3: Expected Attainment (%)	PLO 1: Engineering Knowledge	PLO 2: Problem Analysis	PLO 3: Design & Development	PLO 4: Analysis, Design, Research	PLO 5: Modern Tool Usage	PLO 6: Society & Culture	PLO 7: Environment & Sustainability	PLO 8: Ethics	PLO 9: Individual & Team Work	PLO 10: Communication	PLO 11: Project Mgt. & Finance	PLO 12: Life Long Learning	PLO 13: PSO - 1	PLO 14: PSO - 2	PLO 15: PSO – 3
CLO-1 :	*Provide an introduction to computer vision including fundamentals of image formation*	*3*	*80*	*75*	*L*	*H*	-	*H*	*L*	-	-	-	*L*	*L*	-	*H*	-	-	-
CLO-2 :	*Provide a clear view of image formation*	*3*	*85*	*75*	*M*	*H*	*L*	*H*	*L*	-	-	-	*M*	*L*	-	*H*	-	-	-
CLO-3 :	*Provide a clear view of image processing*	*3*	*80*	*75*	*M*	*H*	*M*	*H*	*L*	-	-	-	*M*	*L*	-	*H*	-	-	-
CLO-4 :	*Provide knowledge about Computational photography*	*3*	*85*	*80*	*M*	*H*	*M*	*H*	*L*	-	-	-	*M*	*L*	-	*H*	-	-	-
CLO-5 :	*Provide knowledge about Image rendering*	*3*	*80*	*75*	*H*	*H*	*M*	*H*	*L*	-	-	-	*M*	*L*	-	*H*	-	-	-

Duration (hour)		9	9	9	9	9
S-1	SLO-1	*Introduction to Computer Vision*	*Points and patches-An Introduction*	*Active contours*	*Triangulation*	*Motion models*
	SLO-2	*Image formation*	*Feature detectors*	*Snakes*	*Two-frame structure from motion*	*Planar perspective motion*
S-2	SLO-1	*Geometric primitives*	*Feature descriptors*	*Dynamic snakes and CONDENSATION*	*Projective reconstruction*	*Rotational panoramas*
	SLO-2	*2D,3D Transformations*			*Self-calibration*	
S-3	SLO-1	*3D to 2D Projection*	*Feature matching*	*Scissors*	*Perspective and projective factorization*	*Gap closing*
	SLO-2	*Lighting,Reflectance and shading*		*Level Sets*	*Bundle adjustment*	
S-4	SLO-1	*Sampling and aliasing*	*Feature tracking*	*Split and merge*	*Exploiting sparsity*	*Cylindrical and spherical coordinates*
	SLO-2	*Image processing Point operators*				
S-5	SLO-1	*Pixel transforms*	*Edge detection*	*Mean shift and mode finding*	*Constrained structure and motion*	*Bundle adjustment*
	SLO-2	*Color transforms*				
S-6	SLO-1	*Histogram equalization*	*Edge linking*	*Normalized cuts*	*Hierarchical motion estimation*	*Parallax removal*
	SLO-2					
S-7	SLO-1	*Linear filtering*	*Successive approximation*	*Graph cuts and energy-based methods*	*Fourier-based alignment*	*Recognizing panoramas*
	SLO-2	*Non Linear filtering*	*Hough transforms*			
S-8	SLO-1	*Fourier transforms*	*Hough transforms*	*2D and 3D feature-based alignment*	*Incremental refinement*	*Compositing*
S-9	SLO-1	*Two-dimensional Fourier transforms, Wiener filtering*	*Vanishing points*	*Pose estimation*	*Case Study*	*Case Study*

Learning Resources	1. *RichardSzeliski,"Computer Vision:Algorithms and Applications",Springer,2010.* 2. *Forsyth/Ponce,"ComputerVision:AModernApproach",PearsonEducationIndia;2edition(2015)*	3. *S.Nagabhushana,"ComputerVisionandImageProcessing",NewAgeInternationalPvtLtd;First edition(2005)* 4. *Rafael C. GonzaLez'"Digital Image Processing",Pearson Education; Fourth edition (2018)*

Learning Assessment											
	Bloom's Level of Thinking	Continuous Learning Assessment (50% weightage)								Final Examination (50% weightage)	
		CLA – 1 (10%)		CLA – 2 (15%)		CLA – 3 (15%)		CLA – 4 (10%)#			
		Theory	Practice	Theory	Practice	Theory	Practice	Theory	Practice	Theory	Practice
Level 1	Remember Understand	*40 %*	-	*30 %*	-	*30 %*	-	*30 %*	-	*30%*	-
Level 2	Apply Analyze	*40 %*	-	*40 %*	-	*40 %*	-	*40 %*	-	*40%*	-
Level 3	Evaluate Create	*20 %*	-	*30 %*	-	*30 %*	-	*30 %*	-	*30%*	-
	Total	100 %		100 %		100 %		100 %		100 %	

CLA – 4 can be from any combination of these: Assignments, Seminars, Tech Talks, Mini-Projects, Case-Studies, Self-Study, MOOCs, Certifications, Conf. Paper etc.,

Course Designers		
Experts from Industry	Experts from Higher Technical Institutions	Internal Experts
	Dr. A.P.Shanthi , CEG Campus Anna University	*1.Dr.V.Ganapathy,SRMIST*
		2.T.Senthil Kumar,SRMIST

Course Code	18CSE479T	Course Name	STATISTICAL MACHINE LEARNING	Course Category	E	Professional Elective	L	T	P	C
							3	0	0	3

Pre-requisite Courses	Nil	Co-requisite Courses	Nil	Progressive Courses	Nil
Course Offering Department	CSE	Data Book / Codes/Standards	Nil		

Course Learning Rationale (CLR):	The purpose of learning this course is to:
CLR-1 :	*Understand the Fuzzy Logic Basics*
CLR-2 :	*Gain knowledge on the Machine learning concepts*
CLR-3 :	*Gain knowledge on Fuzzy based clustering concepts*
CLR-4 :	*Acquire knowledge on Fuzzy Integrated classification*
CLR-5 :	*Understanding Neuro-Fuzzy Modeling concepts*
CLR-5 :	*Acquiring better understanding on Fuzzy logic usage*
CLR-6	*Understanding the fuzzylogics in Machine learning*

Course Learning Outcomes (CLO):	At the end of this course, learners will be able to:	Learning 1: Level of Thinking (Bloom)	Learning 2: Expected Proficiency (%)	Learning 3: Expected Attainment (%)	PLO 1: Engineering Knowledge	PLO 2: Problem Analysis	PLO 3: Design & Development	PLO 4: Analysis, Design, Research	PLO 5: Modern Tool Usage	PLO 6: Society & Culture	PLO 7: Environment & Sustainability	PLO 8: Ethics	PLO 9: Individual & Team Work	PLO 10: Communication	PLO 11: Project Mgt. & Finance	PLO 12: Life Long Learning	PLO 13: PSO - 1	PLO 14: PSO - 2	PLO 15: PSO – 3
CLO-1 :	*Acquire the knowledge on statistical machine learning techniques.*	1	80	85	H	-	-	-	-	-	-	-	-	-	-	H	H	-	-
CLO-2 :	*Acquire the ability to build model based on logistic regression and random forest techniques*	1	75	80	H	H	-	-	-	-	-	-	-	-	-	H	H	-	-
CLO-3 :	*Understand the basic ideas of probability and work on probabilistic approaches like Naïve Bayes, Bayes Theorem*	1	85	80	H	-	-	-	-	-	-	-	-	-	-	H	H	-	-
CLO-4 :	*Apply the knowledge of Kernel functions in practical applications*	3	80	75	H	H	H	H	-	-	-	-	-	-	-	H	H	M	H
CLO-5 :	*Apply the knowledge of K-means clustering on real world examples*	3	75	85	H	-	H	H	-	-	-	-	-	-	-	H	H	M	H
CLO-6 :	*Acquire the knowledge on using PCA and SVD with Scikit-learn*	2	80	85	H	-	H	H	-	-	-	-	-	-	-	H	H	M	H

Duration (hour)		9	9	9	9	9
S-1	SLO-1	*Statistical terminology for model building and validation-Machine Learning,Major differences between statistical modeling andmachine learning*	*Comparison between regression and machinelearning models*	*K-nearest neighbors-KNN voter example*	*Support Vector Machines and Neural Networks-Support vector machines working principles-Maximum margin classifier*	*K-means clustering-K-means working methodology from first principles*
	SLO-2		*Compensating factors in machine learning models*	*Curse of dimensionality-Curse of dimensionality with 1D, 2D, and 3D example*		
S-2	SLO-1	*Steps in machine learning model developmentand deployment*	*Assumptions of linear regression Steps applied in linearregression modeling*	*Curse of dimensionality with 3D example*	*Support vector classifier*	*Optimal number of clusters and cluster evaluation*
	SLO-2					
S-3	SLO-1	*Statistical fundamentals and terminology for model building and validation*	*Example of simple linear regression from first principles*	*KNN classifier with breast cancer Wisconsin data example*	*Support vector machines*	*The elbow method*
	SLO-2					
S-4	SLO-1	*Bias versus variance trade-off,Train and test data*	*Machine learning models - ridge and lasso regression-Example of ridge regression machine learning,Example of lasso regression machine learning model*	*Naive Bayes*	*Kernel functions*	*K-means clustering with the iris data example*
	SLO-2					
S-5	SLO-1	*Linear regression versus gradient descent Machine learning losses*	*Logistic Regression Versus Random Forest-Maximum likelihood estimation*	*Probability fundamentals-Joint probability*	*Artificial neural networks - ANN*	*Principal component analysis - PCA-PCA working methodology from first principles*
	SLO-2					
S-6	SLO-1	*When to stop tuning machine learning models*	*Terminology involved in logistic regression*	*Understanding Bayes theorem with conditional probability*	*Forward propagation and backpropagation*	*PCA applied on handwritten digitsusing scikit-learn*
	SLO-2		*Applying steps in logistic regression modeling*			
S-7	SLO-1	*Train, validation, and test data Cross-validation*	*Random forest-Example of random forest using German credit data*	*Naive Bayes classification*	*Optimization of neural networks-*	*Singular value decomposition - SVD*

	SLO-2		*Grid search on random forest*		*Stochastic gradient descent - SGD*	
S-8	SLO-1	*Grid Search*	*Variable importance plot*	*Laplace estimator*	*Introduction to deep learning-Solving methodology*	*SVD applied on handwritten digitsusing scikit-learn*
	SLO-2					
S-9	SLO-1	*Machine learning model overview*	*Comparison of logistic regression with random forest*	*Naive Bayes SMS spam classification example*	*Deep learning software*	*SVD applied on handwritten digitsusing scikit-learn*
	SLO-2					

Learning Resources	1. *Pratap Dangeti,"Statistics for Machine Learning":,Packt Publishing Ltd,,2017.* 2. *Masashi Sugiyama,"Introduction to Statistical Machine Learning",Elsevier,2016*	3. *Gareth James,Daniela Witten,Trevor Hastie and Robert Tibshirani, An Introduction to Statistical Learning with Applications in R, Springer,2015* 4. *Hastie Trevor, The Elements of Statistical Learning: Data Mining, Inference, and Prediction, Springer-Verlag New York Inc, February2009*

Learning Assessment											
	Bloom's Level of Thinking	Continuous Learning Assessment (50%								Final Examination (50% weightage)	
		CLA – 1 (10%)		CLA – 2 (15%)		CLA – 3 (15%)		CLA – 4 (10%)#			
		Theory	Practice	Theory	Practice	Theory	Practice	Theory	Practice	Theory	Practice
Level 1	Remember Understand	*40 %*	-	*30 %*	-	*30 %*	-	*30 %*	-	*30%*	-
Level 2	Apply Analyze	*40 %*	-	*40 %*	-	*40 %*	-	*40 %*	-	*40%*	-
Level 3	Evaluate Create	*20 %*	-	*30 %*	-	*30 %*	-	*30 %*	-	*30%*	-
	Total	100 %		100 %		100 %		100 %		100 %	

CLA – 4 can be from any combination of these: Assignments, Seminars, Tech Talks, Mini-Projects, Case-Studies, Self-Study, MOOCs, Certifications, Conf. Paper etc.,

Course Designers		
Experts from Industry	Experts from Higher Technical Institutions	Internal Experts
1. Dr.Harisekharan,CTO,Sri SeshaaTechnologies Pvt. Ltd., Chennai	*1. Dr.Bagavandas, Cetre for Statistics, SRMIST*	*1. Dr.G.Vadivu*
2. Mr. S. Sudarsun – Chief Scientist, Co-Founder, Buddhealth	*2. Dr. Sampath, Professor, Department of Statistics, Madras University*	*2. Dr.C.Lakshmi*
		3.Dr.G.Manju

Course Code	18CSE480T	Course Name	NATURE INSPIRED COMPUTING TECHNIQUES	Course Category	E	Professional Elective	L	T	P	C
							3	0	0	3

Pre-requisite Courses	Nil	Co-requisite Courses	Nil	Progressive Courses	Nil
Course Offering Department	Computer Science and Engineering	Data Book / Codes/Standards	Nil		

Course Learning Rationale (CLR):	*The purpose of learning this course is to:*
CLR-1 :	*To Understand the basics of Natural systems*
CLR-2 :	*To appreciate the concepts of Natural systems and its applications*
CLR-3 :	*To understand newBasic Natural systems functions(operations)*
CLR-4 :	*To understand the fundamentals of nature inspired techniques which influence computing*
CLR-5 :	*To understand an Integration of Hardware and software in Natural applications.*
CLR-6:	*To Understand practical implementation of Natural design considerations.*

Course Learning Outcomes (CLO):	*At the end of this course, learners will be able to:*	Learning 1: Level of Thinking (Bloom)	Learning 2: Expected Proficiency (%)	Learning 3: Expected Attainment (%)	PLO 1: Engineering Knowledge	PLO 2: Problem Analysis	PLO 3: Design & Development	PLO 4: Analysis, Design, Research	PLO 5: Modern Tool Usage	PLO 6: Society & Culture	PLO 7: Environment & Sustainability	PLO 8: Ethics	PLO 9: Individual & Team Work	PLO 10: Communication	PLO 11: Project Mgt. & Finance	PLO 12: Life Long Learning	PLO 13: PSO - 1	PLO 14: PSO - 2	PLO 15: PSO – 3
CLO-1 :	*Illustrate the basic concepts of Swarm Intelligenceprocesses*	3	80	70	L	H	L	H	L	L	M	L	L	L	M	L	L	L	L
CLO-2 :	*Examine the principle of Immuno computing techniques*	3	85	75	L	H	L	H	L	L	M	L	L	L	M	L	L	L	L
CLO-3 :	*Skills for planning, estimating, and resourcing for Natural design considerations*	3	75	70	L	H	L	H	L	L	M	L	L	L	M	L	L	L	L
CLO-4 :	*Manage the scope changes of nature inspired techniques which influence computing*	3	85	80	L	H	L	H	L	L	M	L	L	L	M	L	L	L	L
CLO-5 :	*Ability to identify optimization Techniques as a means to provide functionality and value to apply context in specific case studies*	3	85	75	L	H	L	H	L	L	M	L	L	L	M	L	L	L	L
CLO-6 :	*Ability to understand the needs and familiarize the DNA Computing*	3	80	70	L	H	L	H	L	L	M	L	L	L	M	L	L	L	L

Duration (hour)		9	9	9	9	9
S-1	SLO-1	*Introduction*	*Evolutionary Computing*	*Swarm Intelligence*	*Introduction to Immune System*	*DNA Computing*
	SLO-2	*Overview of Philosophy*		*Introduction*		
S-2	SLO-1	*Nature to Nature Computing*	*Hill Climbing*	*Ant Colony Optimization*	*Physiology and main components*	*DNA Molecule*
	SLO-2			*Ant Foraging Behavior*		
S-3	SLO-1	*A Brief Overview of Three Branches*	*Simulated Annealing*	*Ant Colony Optimization*	*Pattern Recognition and Binding*	*Adleman's experiment*
	SLO-2	*Individuals, Entities and agents*		*SACO algorithm*		
S-4	SLO-1	*Parallelism and Distributivity Interactivity*	*Simulated Annealing*	*Ant Colony Algorithm (ACA)*	*Immune Network Theory*	*PAM Model*
	SLO-2				*Danger Theory*	
S-5	SLO-1	*Adaptation- Feedback*	*Genetics Principles*	*scope of ACO algorithms*	*Immune Algorithms*	*Splicing Systems*
	SLO-2					
S-6	SLO-1	*Self-Organization*	*Standard Evolutionary Algorithm*	*Swarm Robotics*	*Genetic algorithms*	*From Classical to DNA Computing*
	SLO-2	*Complexity, Emergence*	*Genetic Algorithms*			
S-7	SLO-1	*Bottom-up Vs Top-Down Approach*	*Reproduction*	*Social Adaptation of Knowledge*	*Bone Marrow Models*	*Universal DNA Computers*
	SLO-2		*Crossover Mutation*			
S-8	SLO-1	*Determination*	*Evolutionary Programming*	*Particle Swarm Optimization*	*Forest's Algorithm*	*Scope of DNA Computing*
	SLO-2					
S-9	SLO-1	*Chaos and Fractals*	*Genetic Programming*	*Particle Swarm Optimization*	*Artificial Immune Networks*	*Lipton's Solution to SAT Problem*
	SLO-2					

Learning Resources	1. *LeandroNunesdeCastro,"FundamentalsofNaturalComputing,BasicConcepts,Algorithms andApplications",Chapman&Hall/CRC,TaylorandFrancisGroup,2007.* 2. *FloreanoD.andMattiussiC.,"Bio-InspiredArtificialIntelligence:Theories,Methods,and Technologies", MIT Press, Cambridge, MA,2008.*	3. *AlbertY.Zomaya,"HandbookofNature-InspiredandInnovativeComputing",Springer,2006* 4. *Marco Dorrigo,Thomas Stutzle," Ant Colony Optimization", PHI,2005.*

Learning Assessment

	Bloom's Level of Thinking	Continuous Learning Assessment (50%								Final Examination (50% weightage)	
		CLA – 1 (10%)		CLA – 2 (15%)		CLA – 3 (15%)		CLA – 4 (10%)#			
		Theory	Practice	Theory	Practice	Theory	Practice	Theory	Practice	Theory	Practice
Level 1	Remember Understand	*40 %*	-	*30 %*	-	*30 %*	-	*30 %*	-	*30%*	-
Level 2	Apply Analyze	*40 %*	-	*40 %*	-	*40 %*	-	*40 %*	-	*40%*	-
Level 3	Evaluate Create	*20 %*	-	*30 %*	-	*30 %*	-	*30 %*	-	*30%*	-
	Total	100 %		100 %		100 %		100 %		100 %	

CLA – 4 can be from any combination of these: Assignments, Seminars, Tech Talks, Mini-Projects, Case-Studies, Self-Study, MOOCs, Certifications, Conf. Paper etc.,

Course Designers

Experts from Industry	Experts from Higher Technical Institutions	Internal Experts
1.Mr.Lokesh Peta,Head Developer,OEConnection,Newbury-UK;Mail:peta.lokesh@gmail.com	*Prof. A. Amuthan, Professor, Pondicherry Engineering College, amuthan@pec.edu*	*Dr.G.Maragatham / Mr. C. SanthanaKrishnan* *Dr.C.Lakshmi*

Course Code	18CSE481T	Course Name	APPLIED MACHINE LEARNING	Course Category	E	Professional Elective	L	T	P	C
							3	0	0	3

Pre-requisite Courses	18CSE392T	Co-requisite Courses	Nil	Progressive Courses	Nil
Course Offering Department	CSE	Data Book / Codes/Standards	Nil		

Course Learning Rationale (CLR):	*The purpose of learning this course is to:*
CLR-1 :	*Analyze the text data using Machine Learning*
CLR-2 :	*Analyze the audio data using Machine Learning*
CLR-3 :	*Analyze Time series and Sequential data using Machine Learning*
CLR-4 :	*Analyze the Image Content using Machine Learning*
CLR-5 :	*Visualize the data*

Course Learning Outcomes (CLO):	*At the end of this course, learners will be able to:*	Learning 1: Level of Thinking (Bloom)	Learning 2: Expected Proficiency (%)	Learning 3: Expected Attainment (%)	PLO 1: Engineering Knowledge	PLO 2: Problem Analysis	PLO 3: Design & Development	PLO 4: Analysis, Design, Research	PLO 5: Modern Tool Usage	PLO 6: Society & Culture	PLO 7: Environment & Sustainability	PLO 8: Ethics	PLO 9: Individual & Team Work	PLO 10: Communication	PLO 11: Project Mgt. & Finance	PLO 12: Life Long Learning	PLO 13: PSO - 1	PLO 14: PSO - 2	PLO 15: PSO – 3
CLO-1 :	*Identifying patterns in text using topic modeling*	3	75	80	H	M	H	-	H	-	-	-	-	-	-	H	H	H	H
CLO-2 :	*Building a speech recognizer*	3	75	80	H	M	H	-	H	-	-	-	-	-	-	H	H	H	H
CLO-3 :	*Extracting statistics from time series data, Building Conditional Random Fields for sequential text data*	3	75	80	H	M	H	-	H	-	-	-	-	-	-	H	H	H	H
CLO-4 :	*Building an object recognizer*	3	75	80	H	M	H	-	H	-	-	-	-	-	-	H	H	H	H

Duration (hour)		9	9	9	9	9
S-1	SLO-1	*Text Feature Engineering Introduction*	*Speech Recognition Introduction*	*Dissecting Time Series and Sequential Data*	*Image Content Analysis*	*Biometric Face Recognition*
	SLO-2	*Cleaning text data*	*Reading audio data*	*Introduction*	*Computer Vision*	*Face detection from the image and video*
S-2	SLO-1	*Preprocessing data using tokenization*	*Plotting audio data*	*Transforming data into the time series format Pandas and Numpy to convert Time Series data*	*Operating on images using OpenCV- Python*	*Capturing and processing video from a webcam Resizing and Scaling*
	SLO-2	*Tagging and categorising words*	*Transforming audio signals into the frequency domain*	*Plotting time series data*	*Learn to extract and load the image*	*Building a face detector using Haar cascades*
S-3	SLO-1	*Sequential tagging, Backoff tagging*	*Apply Fourier transform signal and plot*	*Slicing time series data Operating on time series data*	*Detecting edges Histogram equalization*	*determine the location of a face in the video frames captured from the webcam*
	SLO-2	*Creating features from text data- Stemming,*	*Generating audio signals with custom parameters*	*Plotting sliced time series data*	*Sobel filter, Laplacian edge detector, Canny edge detector*	*Face detector on the grayscale image*
S-4	SLO-1	*Lemmatising*	*Generate the time axis*	*Operating on time series data*	*Histogram equalization*	*Building eye and nose detectors*
	SLO-2	*Bagging using random forests*	*Synthesizing music*	*Extracting statistics from time series data*	*Visualize gray scale image*	*Face cascade classifier*
S-5	SLO-1	*Implementing bag of words*	*Construct the audio sample -amplitude and frequency*	*Correlation coefficients*	*Detecting corners*	*Visualize eye and nose detector*
	SLO-2	*Testing prepared data*	*synthesizer function*	*Plotting and understanding correlations*	*Understand the output corner detection image*	*Performing Principal Components Analysis*
S-6	SLO-1	*Analyze the results*	*Extracting frequency domain features*	*Building Hidden Markov Models for sequential data*	*Detecting SIFT feature points*	*PCA in face recognition systems*
	SLO-2	*Building a text classifier*	*MFCC and filter bank features*	*Prepare the Time Series data*	*SIFT feature detection*	*Convert the dataset from a five-dimensional set to a two-dimensional set*
S-7	SLO-1	*Analyzing the sentiment of a sentence*	*Building Hidden Markov Models*	*Train Gaussian HMM*	*Visualize the feature detected image*	*Kernel Principal Components Analysis*
	SLO-2	*Implement the sentiment analysis of a sentence*	*HMM training and prediction*	*Visualizing the model*	*Building a Star feature detector*	*Perform Kernel PCA*

S-8	SLO-1	*Identifying patterns in text using topic modeling*	*Building a speech recognizer*	*Building Conditional Random Fields for sequential text data*	*Detect features using the Star feature detector*	*Plot the PCA-transformed data*
	SLO-2	*Implement identifying patterns in text using topic modeling*	*MFCC features*	*CRF Model*	*Visualize keypoints on the input image*	*Plot Kernel PCA-transformed data*
S-9	SLO-1	*Case study- Twitter Data*	*Case study*	*Analyzing stock market data using Hidden Markov Models*	*Creating features using visual codebook and vector quantization*	*Performing blind source separation*
	SLO-2	*Case study- Twitter Data*	*Case study*	*Train the HMM and visualize*	*Method to quantize the data points*	*Independent Components Analysis*

Learning Resources	1. *Prateek Joshiandco,Python:RealWorldMachineLearning,PacktPublishing,2016* 2. *Sebastian Raschka,Python Machine Learning,PacktPublishing,2013.*	3. *Richert Coelho,Building Machine Learning Systems with Python,PacktPublishing,2016* 4. *Michael Bowles,Machine Learning in Python,Wiley&Sons,2015*

Learning Assessment

	Bloom's Level of Thinking	Continuous Learning Assessment (50% weightage)								Final Examination (50% weightage)	
		CLA – 1 (10%)		CLA – 2 (15%)		CLA – 3 (15%)		CLA – 4 (10%)#			
		Theory	Practice	Theory	Practice	Theory	Practice	Theory	Practice	Theory	Practice
Level 1	Remember Understand	*40 %*	-	*30 %*	-	*30 %*	-	*30 %*	-	*30%*	-
Level 2	Apply Analyze	*40 %*	-	*40 %*	-	*40 %*	-	*40 %*	-	*40%*	-
Level 3	Evaluate Create	*20 %*	-	*30 %*	-	*30 %*	-	*30 %*	-	*30%*	-
	Total	100 %		100 %		100 %		100 %		100 %	

CLA – 4 can be from any combination of these: Assignments, Seminars, Tech Talks, Mini-Projects, Case-Studies, Self-Study, MOOCs, Certifications, Conf. Paper etc.,

Course Designers

Experts from Industry	Experts from Higher Technical Institutions	Internal Experts
Dr.Harisekharan,CTO,Sri SeshaaTechnologies Pvt. Ltd., Chennai	*Dr.J.Suresh, SSN College of Engineering*	1. *Dr.G.Vadivu*
Mr. S. Sudarsun – Chief Scientist, Co-Founder, Buddhealth	*Dr. Sharmila Shankar, Crescent Institute of Science and Technology*	2. *Mr.Karthik Nanmaran*
		3. *Dr.Renukadevi*

Course Code	18CSE482T	Course Name	COMPUTATIONAL NEUROSCIENCE	Course Category	E	Professional Elective	L	T	P	C
							3	0	0	3

Pre-requisite Courses	Nil	Co-requisite Courses	Nil	Progressive Courses	Nil
Course Offering Department	Computer Science & Engg	Data Book / Codes/Standards	Nil		

Course Learning Rationale (CLR):	*The purpose of learning this course is to:*
CLR-1 :	*Understand to knowWhat happens in your brain when you make a decision*
CLR-2 :	*Gain knowledge mathematical and computational models that are used in the field of theoretical neuroscience*
CLR-3 :	*Basics of adaptively and learning,*
CLR-4 :	*Acquire knowledge on Basic models of cognitive processing.*
CLR-5 :	*Acquire knowledge on implementation model for neuro models*
CLR-6 :	*Acquire knowledge on various computational algorithm*

		Learning			Program Learning Outcomes (PLO)														
		1	2	3	1	2	3	4	5	6	7	8	9	10	11	12	13	14	15
Course Learning Outcomes (CLO):	*At the end of this course, learners will be able to:*	Level of Thinking (Bloom)	Expected Proficiency (%)	Expected Attainment (%)	Engineering Knowledge	Problem Analysis	Design & Development	Analysis, Design, Research	Modern Tool Usage	Society & Culture	Environment & Sustainability	Ethics	Individual & Team Work	Communication	Project Mgt. & Finance	Life Long Learning	PSO - 1	PSO - 2	PSO – 3
CLO-1 :	*To Design Models of single neurons , and small networks*	3	80	70	L	H	L	H	H	-	-	-	L	L	-	H	L	H	H
CLO-2 :	*Implementation of all simple as well as more complex numerical computations with few neurons.*	3	85	75	H	H	L	M	L	-	-	-	M	L	-	H	L	H	H
CLO-3 :	*Analyse connected networks in the mean-field limit*	3	75	70	H	H	M	H	L	-	-	-	M	L	-	H	L	H	H
CLO-4 :	*Formalize biological facts into mathematical models*	3	85	80	M	H	M	H	L	-	-	-	M	L	-	H	L	H	H
CLO-5 :	*Understand a simple mathematical model of memory formation in the brain*	3	85	75	H	H	M	H	L	-	-	-	M	L	-	H	L	H	H
CLO-6 :	*Understand a simple mathematical model of decision processes*	3	80	70	L	H	-	H	L	-	-	-	L	L	-	H	L	H	H

Duration (hour)		9	9	9	9	9
S-1	SLO-1	*History of Computational Neuroscience*	*Four components of Neural Signaling*	*From artificial neural network to realistic neural networks - Introduction*	*Memory Classification Scheme – Declarative, Non-declarative*	*Hebbian Learning-Hebbian versus Perceptron Learning-*
	SLO-2	*Models in Computational Neuroscience*	*Four components of Neural Signaling*	*Modelling the ventral stream*	*Auto-associative network and hippo campus - Learning and retrieval phase*	*Learning by Error Minimization*
S-2	SLO-1	*Computational Theory of the Brain*	*Neurotransmission*	*Modelling the dorsa and auditory stream*	*Point-attractor neural networks - Network dynamics and training*	*Gradient Descent Learning*
	SLO-2	*Biological Background*	*Population dynamics*	*Mechanical behavior of ceramics-flexural strength -The Perceptron .*	*Signal-to-noise analysis - Noisy weights and diluted attractor networks*	*Stabilizing Hebbian Learning*
S-3	SLO-1	*Basic synaptic mechanisms and dendritic processing*	*Modeling the average behavior of neurons*	*Mapping function*	*Sparse attractor neural networks and correlated patterns-Sparse patterns and expansion recoding*	*Principal Component Analysis (PCA)-Eigenvectors-Eigenvalues-Covariance matrix*
	SLO-2	*The generation of action potentials*	*Hodgkin*	*Multi-layer Perceptron*	*Control of sparseness in attractor networks*	*Singular Value Decomposition*
S-4	SLO-1	*Stimulation and rising phase*	*Modeling the average behavior of neurons*	*Back-propagation – Initution , Derivation*	*Chaotic networks-Attractors*	*Limits and Extensions of PCA*
	SLO-2	*Peak and falling phase*	*Huxley Model*	*Back-propagation –Loss Function*	*Lyapunov functions - The Cohen-Grossberg theorem*	*Variations of Hebbian Learning*
S-5	SLO-1	*After hyperpolarization and Refractory Period*	*Spiking neuron models - Single*	*Back-propagation – Limitation*	*Asymmetrical networks*	*Nonlinear Hebbian learning*
	SLO-2	*Hodgkin and Huxley equations - Intro*	*Spiking neuron models - Detailed*	*Support Vector Machines - Introduction*	*Non-monotonic networks*	*Linsker's Model of the Visual System*
S-6	SLO-1	*Neuron - axons,dendritesetc, thefour components ofNeural Signaling*	*Spiking neuron models – 2D Model*	*Support Vector Machines - Classification*	*Complementary memory systems*	*Application of Lateral Inhibition*
	SLO-2	*Neurotransmission:neurotrasmitter,rec epto r, ionchannel, channelgating*	*Integrate and firing model -Leaky integrate-and-fire model*	*Support Vector Machines - Regression*	*Distributed model of working memory-Limited capacity of working memory*	*Lateral Geniculate Nucleus*

S-7	SLO-1	*Electrophysiology -Nernst potential,resting potential,Goldman-Hodgkin-Katz voltageequation, outline ofthe Hodgkin- Huxley model.*	*Integrate and firing model -Nonlinear integrate-and-fire model*	*Support Vector Machines – Kernel Function*	*The spurious synchronization hypothesis*	*Striate Cortex*
	SLO-2	*Modeling ion1 channel kinetics,activation andinactivation gates*	*Integrate and firing model -Stimulation by synaptic currents*	*Self-organizing Maps - Introduction*	*The interacting-reverberating-memory hypothesis*	*Linsker's model for orientation columns*
S-8	SLO-1	*Completeformulation ofHodgkin-Huxleymodel. Relationbetween outputfiring and constant input current.Discussion ofregimes. Softwaredemo.*	*noise in spikingneuron model – part I*	*Self-organizing Maps - Variable*	*Motor Learning and Control*	*Reinforcement Learning -Elements of Reinforcement Learning*
	SLO-2	*Compartmental models: Cable theory*	*noise in spikingneuron model – part II*	*Self-organizing Maps - Algorithm*	*Feedback controller*	*Markov decision process-Dynamic programming algorithms for solving MDPs*
S-9	SLO-1	*Compartmental models: Cable theory – Cable Equation*	*compartmental modeling - I*	*Self-organizing Maps – SOM Initialization*	*Forward and inverse model controller*	*Algorithms for large state spaces*
	SLO-2	*Physical Shape of Neurons and Neuron Simulators*	*compartmental modeling -II*	*Self-organizing Maps – Kohonen Algorithm*	*The cerebellum and motor control*	*Gradient temporal difference learning*

Learning Resources	1. *Thomas Trappenberg, "Fundamentals of Computational Neuroscience", Oxford University Press, January2010* 2. *Peter Dayan & LF Abbot, "Theoretical Neuroscience: Computational and Mathematical Modeling of Neural Systems", MIT Pres,2005*	3. *Richard S. Sutton and Andrew G. Barto, "Reinforcement Learning-An Introduction",2nd Edition,The MIT Press,2018*

Learning Assessment												
	Bloom's Level of Thinking	Continuous Learning Assessment (50% weightage)								Final Examination (50% weightage)	
		CLA – 1 (10%)		CLA – 2 (15%)		CLA – 3 (15%)		CLA – 4 (10%)#			
		Theory	Practice	Theory	Practice	Theory	Practice	Theory	Practice	Theory	Practice
Level 1	Remember Understand	*40 %*	-	*30 %*	-	*30 %*	-	*30 %*	-	*30%*	-
Level 2	Apply Analyze	*40 %*	-	*40 %*	-	*40 %*	-	*40 %*	-	*40%*	-
Level 3	Evaluate Create	*20 %*	-	*30 %*	-	*30 %*	-	*30 %*	-	*30%*	-
	Total	100 %		100 %		100 %		100 %		100 %	

CLA – 4 can be from any combination of these: Assignments, Seminars, Tech Talks, Mini-Projects, Case-Studies, Self-Study, MOOCs, Certifications, Conf. Paper etc.,

Course Designers		
Experts from Industry	Experts from Higher Technical Institutions	Internal Experts
1. *Mr.Venkatesan venkatesan.g@tcs.com* 2. *Ganesan, Associate Consultant Tata Consultancy Services Australia*	*Dr.Sarulatha.K , Pondicherry Engg college, charuladha@pec.edu.in /* *Prof. Godfrey Winster, Saveetha Engineering College, godfreywinster@saveetha.ac.in*	*1. Dr. G.Maragatham / Dr. C.Vijayakumaran*

Course Code	18CSE483T	Course Name	INTELLIGENT MACHINING	Course Category	E	Professional Elective	L	T	P	C
							3	0	0	3

Pre-requisite Courses	Nil	Co-requisite Courses	Nil	Progressive Courses	Nil
Course Offering Department	CSE	Data Book / Codes/Standards	Nil		

Course Learning Rationale (CLR):	*The purpose of learning this course is to:*
CLR-1 :	*Understand the fundamentals of Artificial Intelligence*
CLR-2 :	*Learn basics of Intelligent machining, sensors and machining process*
CLR-3 :	*Understand the design of Intelligent Systems - RTOS*
CLR-4 :	*Understand the computational methods, optimization and reasoning about physical system*
CLR-5 :	*Understand implications of Artificial Intelligence in various real time applications*

Course Learning Outcomes (CLO):	*At the end of this course, learners will be able to:*	Learning 1: Level of Thinking (Bloom)	Learning 2: Expected Proficiency (%)	Learning 3: Expected Attainment (%)	PLO 1: Engineering Knowledge	PLO 2: Problem Analysis	PLO 3: Design & Development	PLO 4: Analysis, Design, Research	PLO 5: Modern Tool Usage	PLO 6: Society & Culture	PLO 7: Environment & Sustainability	PLO 8: Ethics	PLO 9: Individual & Team Work	PLO 10: Communication	PLO 11: Project Mgt. & Finance	PLO 12: Life Long Learning	PLO 13: PSO - 1	PLO 14: PSO - 2	PLO 15: PSO – 3
CLO-1 :	*Acquire the knowledge on the fundamentals of Artificial intelligence and its problem solving approaches*	2	80	85	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-
CLO-2 :	*Acquire the knowledge on fundamentals of Intelligent Machining and machining process*	2	75	80	H	H	H	H	H	H	-	-	-	-	-	H	-	-	-
CLO-3 :	*Acquire knowledge on the design of Intelligent Systemsand RTOS*	2	85	80	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-
CLO-4 :	*Acquire knowledge on computational methods and optimization*	2	80	75	-	H	-	-	H	-	-	-	-	-	-	-	-	-	-
CLO-5 :	*Apply the knowledge on Real time applications*	2	75	85	-	H	-	-	H	-	-	-	-	-	-	-	-	-	-

Duration (hour)		9	9	9	9	9
S-1	SLO-1	*Introduction to Artificial Intelligence and it's techniques*	*Introduction Intelligent Machining, Basics*	*Representation of Intelligent systems*	*Computational methods and optimization*	*Case Study - Autonomous Vehicle (Driver Less Car)*
	SLO-2	*Problem Solving with Artificial Intelligence*	*Open Architecture Machine Control*	*Control for the Evolution of VLSI Designs*		
S-2	SLO-1	*AI Models, Data acquisition and learning aspects of AI*	*Manufacturing Automation Protocol*	*An Object-Oriented Approach*	*Neural Network Modelling*	*Case Study - Defect Prediction , Wear and Tear Prediction in Mechanical devices*
	SLO-2	*Problem Solving - Problem Solving Process, Formulating Problems*	*The Evolution of Intelligent Machining*			
S-3	SLO-1	*Problem types and Characteristics*	*MOSAIC - NGC*	*Tools and Techniques for Conceptual Design*	*Fuzzy set theory*	*Case Study - Flying Drones*
	SLO-2	*Problem Space and Search*	*OSACA - SERCOS*	*Design Compilers*		
S-4	SLO-1	*Intelligent Agent*	*Components of Intelligent Machining*	*Labelled Interval Calculus*	*Machining Optimization*	*Case Study -Cogito*
	SLO-2	*Rationality and Rational agent with performance measures*	*Introduction sensors - Machining Process*	*Knowledge Representations for Design Improvisation*		
S-5	SLO-1	*Flexibility and Intelligent Agents*	*Sensing and Monitoring*	*A knowledge-based Framework for Design*	*Objective Functions and Constraints*	*Case Study - Alexa , SIRI*
	SLO-2	*Task Environment and its Properties*	*Signal Processing*		*Optimization Techniques*	
S-6	SLO-1	*Types of Agents*	*Transforming Data into Information - Examples*	*Introduction to RTOS - Hardware Components*	*Reasoning about physical system*	*Case Study - Smarter Home robots*
	SLO-2	*Other aspects of agents*	*Machining Process Control*			
S-7	SLO-1	*Constraint satisfaction problem (CSP)*	*Practical Uses of Machine Learning*	*Design Principles of RTOS - Interupt Processing - task Management*	*Temporal Qualitative Analysis*	*Case Study -Application of AI in CAD/CAM*
	SLO-2	Crypto Arithmetic puzzles	Machine Learning Process Control Strategies			

S-8	SLO-1	*CSP as a search problem-constraints and representation*	*Programmable Logic Controllers (PLC)*	*Task Scheduling -Synchronization tools*	*Reasoning about Geometry*	*Case Study - Streamlining Drug Discovery*
	SLO-2	*CSP- backtracking and Role of heuristic*	*Closed Loop Process Control Systems*	*Task Communication - Memory Management*		
S-9	SLO-1	*CSP - Froward Checking and constraint propogation*	*Introduction to Adaptive Control*	*File System*	*Study of Heuristic knowledge for automatic configuration Generation and Innovation*	*Case Study - Betterment (Financial Advisor)*
	SLO-2	*CSP-Intelligent backtracking*	*Commercially Available Software*	*Tracing and Debugging*		

Learning Resources	1. *Farid Meziane, Sunil Vadera, Khiary Kobbacy and Nathan Proudlove, "Intelligent Systems in Manufacturing: Current Developments and Future Prospects", (unit 1)* 2. *How Netflix Uses Analytics To Select Movies, Create Content, and Make Multimillion Dollar Decisions Author: Zach Bulygo(unit 1)* 3. *Digital Signal Processing: A Practical Guide for Engineers and Scientists, Steven Smith (unti 2)* 4. *4. Artifical Intelligent in Engineering Design: Volume 1 , Gerard Meurant, Springer (Chapter 2,3,5,6,9 - unit3)*	5. *K.C.Wang, " Embedded and Real-Time Operating Systems (Chapter 10.6- Unit 3)* 6. *Sam Siewert, John Pratt," Real-Time Embedded Components and Systems with Linux and RTOS", David Pallai Publisher, 2016. (Chapter 8- Unit 3)* 7. *Machining: Fundamentals and Recent Advances, J. Paulo Davim, Springer. (Chapter 12-unit 4)* 8. *8.Artifical Intelligent in Engineering Design: Volume 2 , Gerard Meurant, Springer (Chapter 10-14 - unit 5)*

Learning Assessment

	Bloom's Level of Thinking	Continuous Learning Assessment (50% weightage)								Final Examination (50% weightage)	
		CLA – 1 (10%)		CLA – 2 (15%)		CLA – 3 (15%)		CLA – 4 (10%)#			
		Theory	Practice	Theory	Practice	Theory	Practice	Theory	Practice	Theory	Practice
Level 1	Remember Understand	*40 %*	-	*30 %*	-	*30 %*	-	*30 %*	-	*30%*	-
Level 2	Apply Analyze	*40 %*	-	*40 %*	-	*40 %*	-	*40 %*	-	*40%*	-
Level 3	Evaluate Create	*20 %*	-	*30 %*	-	*30 %*	-	*30 %*	-	*30%*	-
	Total	100 %		100 %		100 %		100 %		100 %	

CLA – 4 can be from any combination of these: Assignments, Seminars, Tech Talks, Mini-Projects, Case-Studies, Self-Study, MOOCs, Certifications, Conf. Paper etc.,

Course Designers

Experts from Industry	Experts from Higher Technical Institutions	Internal Experts
Dr, Mariappan, Engineering Leader, Amazon, India	*Khanna Nehemiah H, Professor, Ramanujam Computing Center, Anna University*	*1.Dr.C.Lakshmi, SRMIST*
		2. Dr.S Prabakaran, SRMIST
		3. Dr. M. Thenmozhi, SRMIST

Course Code	18CSE484T	Course Name	DEEP LEARNING	Course Category	E	Professional Elective	L	T	P	C
							3	0	0	3

Pre-requisite Courses	Nil	Co-requisite Courses	Nil	Progressive Courses	Nil
Course Offering Department	Computer Science and Engineering	Data Book / Codes/Standards	Nil		

Course Learning Rationale (CLR):	*The purpose of learning this course is to:*
CLR-1 :	*Understand the concepts of Neural Networks and Deep Learning*
CLR-2 :	*Understand Deep neural network and layered learning approach*
CLR-3 :	*Study and understand CNN and RNN for deep learning*
CLR-4 :	*Learn and understand Auto Encoders and its applications*
CLR-5 :	*Understand concept of transfer learning and its applications with keras*

Course Learning Outcomes (CLO):	*At the end of this course, learners will be able to:*	Learning 1: Level of Thinking (Bloom)	2: Expected Proficiency (%)	3: Expected Attainment (%)	PLO 1: Engineering Knowledge	2: Problem Analysis	3: Design & Development	4: Analysis, Design, Research	5: Modern Tool Usage	6: Society & Culture	7: Environment & Sustainability	8: Ethics	9: Individual & Team Work	10: Communication	11: Project Mgt. & Finance	12: Life Long Learning	13: PSO - 1	14: PSO - 2	15: PSO – 3
CLO-1 :	*Apply basic mathematical concepts in Deep Learning*	2	80	85	H	L	-	-	H-	-	-	-	-	-	-	H	H	-	-
CLO-2 :	*Work with powerful framework for supervised learning*	3	75	80	H	H	-	-	H	-	-	-	-	-	-	H	H	H	M
CLO-3 :	*Deal with Convolution Neural Networks*	2	85	80	H	H	H	-	H	-	-	-	-	-	-	H	H	H	H
CLO-4 :	*Analyze various types efficient data encoders*	2	80	75	H	H	-	-	H	-	-	-	-	-	-	H	H	H	H
CLO-5 :	*Apply various network models in deep learning*	3	75	85	H	H	H	H	H	-	-	-	-	-	-	H	H	H	H

Duration (hour)		9	9	9	9	9
S-1	SLO-1	*Historical trends in deep learning – Machine Learning basics*	*Introduction to Simple DNN*	*Convolution Neural Networks Introduction*	*Encoder*	*Deep Architectures in Vision*
	SLO-2	*Learning algorithms – Supervised and Unsupervised Training*	*Platform for Deep Learning*	*Convolution Operation*	*Decoder*	*AlexNet to ResNet*
S-2	SLO-1	*Linear Algebra for machine learning*	*Deep Learning Software Libraries*	*Motivation*	*Auto Encoders Introduction*	*Transfer Learning*
	SLO-2	*Testing - Cross Validation*	*Deep Feed Forward Networks Introduction*	*Pooling*	*Auto Encoders*	
S-3	SLO-1	*Dimensionality Reduction*	*Learning XOR*	*Normalization*	*Under Complete Auto Encoder*	*Siamese Networks*
	SLO-2	*Over fitting /Under Fitting*	*Gradient-Based Learning*	*Applications in Computer Vision - ImageNet*	*Regularized Auto Encoder*	
S-4	SLO-1	*Hyper parameters and validation sets*	*Various Activation Functions, ReLU, Sigmoid – Error Functions*	*Sequence Modelling –VGGNet, LeNet*	*Stochastic Auto Encoder*	*Metric Learning*
	SLO-2	*Estimators – Bias - Variance*	*Architecture Design*	*Recurrent Neural Networks*	*Denoising Auto Encoder*	*Ranking / Triplet Loss*
S-5	SLO-1	*Loss Function-- Regularization*	*Differentiation Algorithms*	*RNN topologies- Difficulty in Training RNN*	*Contractive Auto Encoder*	*RCNNs with keras*
	SLO-2	*Biological Neuron – Idea of Computational units*	*Regularization methods for Deep Learning*		*Auto Encoder Applications*	
S-6	SLO-1	*McCulloch-Pitts units and Thresholding logic*	*Early Stopping*	*Long Short Term Memory*	*Dimensionality Reduction and Classification using Auto encoders*	*CNN-RNN*
	SLO-2	*Linear Perceptron*	*Drop Out*		*Recommendation*	
S-7	SLO-1	*Perceptron Learning Algorithm*	*Difficulty of training deep neural networks*	*Bidirectional LSTMs*	*Optimization for Deep Learning-Optimizers–RMS prop for RNNs*	*Applications in captioning and Video tasks*
	SLO-2	*Convergence theorem for Perceptron Learning Algorithm*				
S-8	SLO-1	*Linear Separability*	*Greedy layer wise training*	*Bidirectional RNNs*	*SGD for CNNs*	*3D CNNs*
	SLO-2	*Multilayer perceptron –The first example of network with Keras code*				
S-9	SLO-1	*Backprobagation*	*Optimization methods for Neural Networks-Adagrad, Adam*	*Application case study -Handwritten digits recognition using deep learning, LSTM with Keras – sentiment Analysis*	*Application case study – Image dimensionality reduction using encoders LSTM with Keras – sentiment Analysis*	*Application case study – Image recognition using RCNN and transfer learning*
	SLO-2					

Learning Resources	1. *IanGoodfellow,YoshuaBengio,AaronCourville,"DeepLearning",MITPress,2016.* 2. *KevinP.Murphy,"MachineLearning:AProbabilisticPerspective",MITPress,2012.*	3. *Neural Networks: A Systematic Introduction, RaulRojas, 1996.* 4. *ChristopherandM.Bishop,"PatternRecognitionandMachineLearning",SpringerScienceBusinessMedia, 2006.* 5. *JasonBrownlee,"DeepLearningwithPython",ebook,2016.*

Learning Assessment											
	Bloom's Level of Thinking	Continuous Learning Assessment (50% weightage)								Final Examination (50% weightage)	
		CLA – 1 (10%)		CLA – 2 (15%)		CLA – 3 (15%)		CLA – 4 (10%)#			
		Theory	Practice	Theory	Practice	Theory	Practice	Theory	Practice	Theory	Practice
Level 1	Remember Understand	*40 %*	-	*30 %*	-	*30 %*	-	*30 %*	-	*30%*	-
Level 2	Apply Analyze	*40 %*	-	*40 %*	-	*40 %*	-	*40 %*	-	*40%*	-
Level 3	Evaluate Create	*20 %*	-	*30 %*	-	*30 %*	-	*30 %*	-	*30%*	-
	Total	100 %		100 %		100 %		100 %		100 %	

CLA – 4 can be from any combination of these: Assignments, Seminars, Tech Talks, Mini-Projects, Case-Studies, Self-Study, MOOCs, Certifications, Conf. Paper etc.,

Course Designers		
Experts from Industry	Experts from Higher Technical Institutions	Internal Experts
1.	*1.*	*1. Dr.E.Poovammal*
2.	*2.*	*2. Dr.G.Vadivu*
		3. Mr.Joseph James

Course Code	18CSE485T	Course Name	ROBOTICS: COMPUTATIONAL MOTION PLANNING	Course Category	E	Professional Elective	L	T	P	C
							3	0	0	3

Pre-requisite Courses	Nil	Co-requisite Courses	Nil	Progressive Courses	Nil
Course Offering Department	Computer Science and Engineering	Data Book / Codes/Standards	Nil		

Course Learning Rationale (CLR):	*The purpose of learning this course is to:*
CLR-1 :	*Acquire knowledge of Bug algorithms and configuration Space*
CLR-2 :	*Acquire knowledge of Potential functions and Navigations*
CLR-3 :	*Acquire knowledge of Sampling Algorithms*
CLR-4 :	*Gain knowledge of filtering techniques*
CLR-5 :	*Gain knowledge about Trajectory and Motion Planning*
CLR-6 :	*Design motion plan for Robot in the path specified*

Course Learning Outcomes (CLO):	*At the end of this course, learners will be able to:*	Learning 1: Level of Thinking (Bloom)	Learning 2: Expected Proficiency (%)	Learning 3: Expected Attainment (%)	PLO 1: Engineering Knowledge	PLO 2: Problem Analysis	PLO 3: Design & Development	PLO 4: Analysis, Design, Research	PLO 5: Modern Tool Usage	PLO 6: Society & Culture	PLO 7: Environment & Sustainability	PLO 8: Ethics	PLO 9: Individual & Team Work	PLO 10: Communication	PLO 11: Project Mgt. & Finance	PLO 12: Life Long Learning	PLO 13: PSO - 1	PLO 14: PSO - 2	PLO 15: PSO – 3
CLO-1 :	*Apply knowledge of Bug algorithms and configuration Space*	3	80	70	M	H	-	H	L	-	-	-	L	L	-	H	-	-	-
CLO-2 :	*Apply knowledge of Potential functions and Navigations*	3	85	75	M	H	L	M	L	-	-	-	M	L	-	H	-	-	-
CLO-3 :	*Apply knowledge of Sampling Algorithms*	3	75	70	M	H	M	H	L	-	-	-	M	L	-	H	-	-	-
CLO-4 :	*Gain knowledge of filtering techniques*	3	85	80	M	H	M	H	L	-	-	-	M	L	-	H	-	-	-
CLO-5 :	*Gain knowledge about Trajectory and Motion Planning*	3	85	75	H	H	M	H	L	-	-	-	M	L	-	H	-	-	-

Duration (hour)		9	9	9	9	9
S-1	SLO-1	*Over view of Motion Planning*	*Potential Function: Addictive Attractive/Repulsive Potential*	*Sampling - Based Algorithms-Probabilistic Road Maps: Basic PRM*	*Linear Kalman Filtering*	*Trajectory Planning : Preliminaries*
	SLO-2	*Bug1 And Bug 2*	*Gradient Descent*	*Implementation of basic PRM*		
S-2	SLO-1	*Tangent Bug*	*Computing Distance From Implementation In The Plane*	*PRM sampling Strategies*	*Kalman Filter : Example*	*Decoupled Trajectory Planning*
	SLO-2	*Implementation: The Tangent Line*		*PRM connection Strategies*		
S-3	SLO-1	*Distance On Gradient*	*Local Minima Problem*	*Single-Query Sampling Based Planners: Expensive Spaces Trees*	*Bayesian Methods : Localization*	*Direct Trajectory Planning: Optimal Control*
	SLO-2	*Continuation Method*	*Wave-Front Planner*	*Rapidly Exploring Random Trees*	*Basic Idea Probabilistic Localization*	*Nonlinear Ptimization*
S-4	SLO-1	*Robot Configuration Specification*	*Navigation Potential Function: Sphere- Space*	*Connection Strategies and SBL Planner*	*Probabilistic Localization As Recursive Bayesian Filtering*	*Grid-Based Search*
	SLO-2		*Star-Space*			
S-5	SLO-1	*Circular Mobile Robot*	*Potential Functions for Rigid-Body Robots*	*Integration Of Planners Sampling Based Roadmap*	*Derivation Of Probabilistic Localization*	*Nonholonomic And Underactuated Systems : preliminaries*
	SLO-2	*Two joint planer arm*	*Path Planning for Articulated Bodies*			*Control Systems*
S-6	SLO-1	*Dimension Of The Configuration Space*	*Visibility Graph*	*Analysis Of PRM*	*Representation Of Posterior*	*Controllability*
	SLO-2					
S-7	SLO-1	*Topology of configuration space: Homeomorphisms and Diffeomorphisms*	*Deformation Retracts : Generalized Voronoi Diagram*	*Control based Planning*	*Sensor Model*	*Motion Planning: Optimal Control*
	SLO-2			*Multiple Robots*		
S-8	SLO-1	*Differentiable Manifolds*	*Retract -Like Structure: Generalized Voronoi Graph*	*Manipulation Planning*	*Mapping:: Mapping with known locations*	*Steering Chained -Form Systems Using Sinusoids*
	SLO-2					
S-9	SLO-1	*Examples*	*Piecewise Retracts: The Rod Hierarchical Generalized Voronoi GraphSilhouette Methods*	*Assembly Planning*	*Bayesian Simultaneous Localization and Mapping*	*Nonlinear Optimization*
	SLO-2					

Learning Resources	1. *HowieM.Choset,Seth Hutchinson, Kevin M.Lynch, George Kantor, Wolf ram Burgard, LydiaE. Kavraki, Sebastian Thrun, "Principles of Robot Motion: Theory, Algorithms, and Implementation"* 2. *Jean-ClaudeLatombe,"RobotMotionPlanning",SpringerScience&BusinessMedia,2012*	3. *http://robotics.stanford.edu/~latombe/cs326/2009/schedule.htm*

Learning Assessment											
	Bloom's Level of Thinking	Continuous Learning Assessment (50%								Final Examination (50% weightage)	
		CLA – 1 (10%)		CLA – 2 (15%)		CLA – 3 (15%)		CLA – 4 (10%)#			
		Theory	Practice	Theory	Practice	Theory	Practice	Theory	Practice	Theory	Practice
Level 1	Remember Understand	*40 %*	-	*30 %*	-	*30 %*	-	*30 %*	-	*30%*	-
Level 2	Apply Analyze	*40 %*	-	*40 %*	-	*40 %*	-	*40 %*	-	*40%*	-
Level 3	Evaluate Create	*20 %*	-	*30 %*	-	*30 %*	-	*30 %*	-	*30%*	-
	Total	100 %		100 %		100 %		100 %		100 %	

CLA – 4 can be from any combination of these: Assignments, Seminars, Tech Talks, Mini-Projects, Case-Studies, Self-Study, MOOCs, Certifications, Conf. Paper etc.,

Course Designers		
Experts from Industry	Experts from Higher Technical Institutions	Internal Experts
		Dr.R.Annie Uthra
		Dr.P. Supraja

Course Code	18CSE486T	Course Name	ADVANCED ALGORITHMS	Course Category	E	Professional Elective	L	T	P	C
							3	0	0	3

Pre-requisite Courses	18CS201J	Co-requisite Courses	Nil	Progressive Courses	Nil
Course Offering Department	Computer Science and Engineering	Data Book / Codes/Standards	Nil		

Course Learning Rationale (CLR):	*The purpose of learning this course is to:*
CLR-1 :	*Understand different asymptotic notations to analyze an algorithms*
CLR-2 :	*Utilize various data structures in developing applications*
CLR-3 :	*Utilize stack and queues in processing data for real-time applications*
CLR-4 :	*Understand various data structures to handle graph theory related real-time applications*
CLR-5 :	*Understand various probabilistic algorithms and randomized algorithms for real-time programming applications*
CLR-6 :	*Understand various Complexity classes like P-Type, NP-Type, NP-Complete, NP-Hard problems*

Course Learning Outcomes (CLO):	*At the end of this course, learners will be able to:*	Learning 1: Level of Thinking (Bloom)	2: Expected Proficiency (%)	3: Expected Attainment (%)	PLO 1: Engineering Knowledge	2: Problem Analysis	3: Design & Development	4: Analysis, Design, Research	5: Modern Tool Usage	6: Society & Culture	7: Environment & Sustainability	8: Ethics	9: Individual & Team Work	10: Communication	11: Project Mgt. & Finance	12: Life Long Learning	13: PSO - 1	14: PSO - 2	15: PSO – 3
CLO-1 :	*Understand complexity of various algorithms*	3	80	70	L	H	-	H	L	-	-	-	L	L	-	H	-	-	-
CLO-2 :	*How efficiently a problem can be solved with respect to time and space*	3	85	75	M	H	L	M	L	-	-	-	M	L	-	H	-	-	-
CLO-3 :	*To find the appropriateness of Data structure for real time applications*	3	75	70	M	H	M	H	L	-	-	-	M	L	-	H	-	-	-
CLO-4 :	*Representation and Solving Graph algorithms*	3	85	80	M	H	M	H	L	-	-	-	M	L	-	H	-	-	-
CLO-5 :	*Understand approximation methods to solve very difficult problems*	3	85	75	H	H	M	H	L	-	-	-	M	L	-	H	-	-	-

Duration (hour)		9	9	9	9	9
S-1	SLO-1	*Introduction-Basic Terminology*	*Elementary data structures-Array*	*Graph algorithms-Representation of graphs*	*Approximation algorithms*	*Complexity classes-Introduction*
	SLO-2	*Complexity of algorithms- Space and time complexity issues- Growth of functions*	*Operations on Arrays – Insertion and Deletion*	*BFS-DFS*	*The vertex-cover problem*	*Various definitions*
S-2	SLO-1	*Introduction of various asymptotic notations like Θ,ω,O, Ω*	*Stack-Various ADT operations- Uses of stack-Various examples*	*Strongly connected components*	*The traveling-salesman problem*	*NP-Completeness and the classes of P and NP*
	SLO-2	*Designing algorithm-Analysis of Insertion sort-Best case, worst case, average case analysis*	*Queue ADT- Insertion-deletion and various operations on Queue*	*Minimum Spanning tree-Introduction Prim's algorithm*	*Example*	*Continued*
S-3	SLO-1	*Various Problem solving techniques*	*Linked List- Deletion and Search-Doubly linked list-Various operations on linked list*	*Kruskal algorithm*	*The set-covering problem –With an example*	*A Formal language framework-Polynomial time verification*
	SLO-2	*Divide and Conquer paradigm*	*Polynomial Arithmetic*	*Single source Shortest path problem*	*The subset-sum problem*	*Continued*
S 4-5	SLO-1 / SLO-2	*Recurrence relations-Construction of recurrence relation for various examples- Towers of Hanoi Problem, Fibannacci series*	*Hashing-Hash functions Open addressing-Perfect Hashing*	*The Bellman-Ford algorithm - Single-source shortest paths in directed acyclic graphs -Dijkstra's algorithm*	*String Matching- The naive string-matching algorithm*	*p-type and NP-type problems NP- Completeness-Various examples*
S-6	SLO-1	*Solution by Substitution method*	*Various hashing methods*	*Shortest paths and matrix multiplication*	*Example*	*NP-Completeness-reducibility*
	SLO-2	*Recursion Tree Method*	*Collision in hashing-Avoiding Collision – Various methods*	*The Floyd-Warshall algorithm*	*The Rabin-Karp algorithm*	*Continued*
S-7	SLO-1	*Mater Theorem-Proof*	*Binary search tree*	*An example*	*Continued*	*NP-Completeness-reducibility*
	SLO-2	*Simple examples*	*Insertion-Deletion-Finding max,min*	*Johnson's algorithm for sparse graphs*	*The Knuth-Morris-Pratt algorithm*	*Continued*
S-8	SLO-1	*Probabilistic analysis of an algorithm*	*Red Black tree*	*Example*	*An example*	*NP-completeness proofs Continued-Satisfiability of boolean formulas is NP-complete.*

	SLO-2	*Hiring assistant problem*	*Insertion-Deletion*	*Flow network-example*	*Computational Geometry- Finding Convex hull- Finding the closest pair of points*	*3-CNF satisfiability problem-NP Complete*
S-9	SLO-1	*Probabilistic analysis Quick sort with illustration*	*Properties of RBT*	*Continued*	*Continued*	*NP-Hard problem-Definition and various examples-continued*
	SLO-2					

Learning Resources	1. *Cormen,ThomasH.;Leiserson,CharlesE.;Rivest,RonaldL.;Stein,Clifford(2009) Introduction to Algorithms (3rd ed.). MIT Press and McGraw-Hill* 2. *Ananyleviton, Introduction to the Design and Analysis of Algorithms, Kindleedition 2017.* 3. *Harowitz,SahaniandSangudevarRajasekaran,Fundamentalsofcomputeralgorithm, Universities Press; Second edition2008*	4. *Mark Allen Weiz, Data structures and algorithm analysis, Pearson Education India 2012*

Learning Assessment											
	Bloom's Level of Thinking	Continuous Learning Assessment (50%								Final Examination (50% weightage)	
		CLA – 1 (10%)		CLA – 2 (15%)		CLA – 3 (15%)		CLA – 4 (10%)#			
		Theory	Practice	Theory	Practice	Theory	Practice	Theory	Practice	Theory	Practice
Level 1	Remember Understand	*40 %*	-	*30 %*	-	*30 %*	-	*30 %*	-	*30%*	-
Level 2	Apply Analyze	*40 %*	-	*40 %*	-	*40 %*	-	*40 %*	-	*40%*	-
Level 3	Evaluate Create	*20 %*	-	*30 %*	-	*30 %*	-	*30 %*	-	*30%*	-
	Total	*100 %*		*100 %*		*100 %*		*100 %*		*100 %*	

CLA – 4 can be from any combination of these: Assignments, Seminars, Tech Talks, Mini-Projects, Case-Studies, Self-Study, MOOCs, Certifications, Conf. Paper etc.,

Course Designers		
Experts from Industry	Experts from Higher Technical Institutions	Internal Experts
	1. Dr.Masila Mani.V IIITDM, Kancheepuram,noor@iiitdm.ac.in	*1. K..Senthil Kumar, SRMIST*
		2. Dr.Thenmozhi , SRMIST

Course Code	18CSE355T	Course Name	DATA MINING AND ANALYTICS	Course Category	E	Professional Elective	L	T	P	C
							3	0	0	3

Pre-requisite Courses	Nil	Co-requisite Courses	Nil	Progressive Courses	Nil
Course Offering Department	CSE	Data Book / Codes/Standards	Nil		

Course Learning Rationale (CLR):	The purpose of learning this course is to:
CLR-1 :	*Understand the concepts of Data Mining*
CLR-2 :	*Familiarize with Association rule mining*
CLR-3 :	*Familiarize with various Classification algortihms*
CLR-4 :	*Understand the concepts of Cluster Analysis*
CLR-5 :	*Familiarize with Outlier analysis techniques*
CLR-6 :	*Familiarize with applications of Data mining in different domains*

		Learning			Program Learning Outcomes (PLO)														
		1	2	3	1	2	3	4	5	6	7	8	9	10	11	12	13	14	15
Course Learning Outcomes (CLO):	*At the end of this course, learners will be able to:*	Level of Thinking (Bloom)	Expected Proficiency (%)	Expected Attainment (%)	Engineering Knowledge	Problem Analysis	Design & Development	Analysis, Design, Research	Modern Tool Usage	Society & Culture	Environment & Sustainability	Ethics	Individual & Team Work	Communication	Project Mgt. & Finance	Life Long Learning	PSO - 1	PSO - 2	PSO – 3
CLO-1 :	*Gain knowledge about the concepts of Data Mining*	*2*	*80*	*85*															
CLO-2 :	*Understand and Apply Association rule mining techniques*	*2*	*75*	*80*															
CLO-3 :	*Understand and Apply various Classification algortihms*	*2*	*85*	*80*															
CLO-4 :	*Gain knowledge on the concepts of Cluster Analysis*	*2*	*80*	*75*															
CLO-5 :	*Gain knowledge on Outlier analysis techniques*	*2*	*75*	*85*															
CLO-6 :	*Understand the importance of applying Data mining concepts in different domains*	*2*	*80*	*85*															

Duration (hour)		9	9	9	9	9
S-1	SLO-1	*Why Data mining? What is Data mining ?*	*Mining frequent patterns: Basic concepts*	*Classification: Basic concepts*	*Cluster Analysis: Introduction*	*Outliers: Introduction*
	SLO-2	*Kinds of data meant for mining*	*Market Basket Analysis*	*General approach to Classification*	*Requirements and overview of different categories*	*Challenges of outlier detection*
S-2	SLO-1	*Kinds of patterns that can be mined*	*Frequent itemsets, Closed itemsets*	*Decision tree induction*	*Partitioning method: Introduction*	*Outlier detection methods: Introduction*
	SLO-2	*Applications suitable for data mining*	*Association rules-Introduction*	*Algorithm for Decision tree induction*	*k-means*	*Supervized and Semi-supervized methods*
S-3	SLO-1	*Issues in Data mining*	*Apriori algorithm-theoritical approach*	*Numerical example for Decision tree induction*	*k-medoids*	*Unsupervized methods*
	SLO-2	*Data objects and Attribute types*	*Apply Apriori algorithm on dataset-1*	*Attribute selection measure*	*Hierarchical method: Introduction*	
S-4	SLO-1	*Statistical descriptions of data*	*Apply Apriori algorithm on dataset-2*	*Tree pruning*	*Agglomerative vs. Divisive method*	*Statistical and Proximity based methods*
	SLO-2		*Generating Association rules from frequent itemsets*	*Scalability and Decision tree induction*	*Distance measures in algorithmic methods*	
S-5	SLO-1	*Need for data preprocessing and data quality*	*Improving efficiency of Apriori*	*Bayes' Theorem*	*BIRCH technique*	*Statistical approaches*
	SLO-2			*Naïve Bayesian Classification*		
S-6	SLO-1	*Data cleaning*	*Pattern growth approach*	*IF-THEN rules for classification*	*DBSCAN technique*	*Statistical data mining*
	SLO-2	*Data integration*		*Rule extraction from a decision tree*		
S-7	SLO-1	*Data reduction*	*Mining frequest itemsets using Vertical data format*	*Metrics for evaluating classifier performance*	*STING technique*	*Data mining and recommender systems*
	SLO-2		*Strong rules vs. weak rules*	*Cross validation*		
S-8	SLO-1	*Data transformation*	*Association analysis to Correlation analysis*	*Bootstrap*	*CLIQUE technique*	*Data mining for financial data analysis*
	SLO-2			*Ensemble methods-Introduction*		
S-9	SLO-1	*Data cube and its usage*	*Comparison of pattern evaluation measures*	*Bagging and Boosting*	*Evaluation of clustering techniques*	*Data mining for Intrusion detection*
	SLO-2			*Random Forests: Introduction*		

Learning Resources	1. *Jiawei Han and Micheline Kamber, " Data Mining: Concepts and Techniques", 3rd Edition, Morgan Kauffman Publishers, 2011.*	

Learning Assessment											
	Bloom's Level of Thinking	Continuous Learning Assessment (50% weightage)								Final Examination (50% weightage)	
		CLA – 1 (10%)		CLA – 2 (15%)		CLA – 3 (15%)		CLA – 4 (10%)#			
		Theory	Practice	Theory	Practice	Theory	Practice	Theory	Practice	Theory	Practice
Level 1	Remember Understand	*40 %*	-	*30 %*	-	*30 %*	-	*30 %*	-	*30%*	-
Level 2	Apply Analyze	*40 %*	-	*40 %*	-	*40 %*	-	*40 %*	-	*40%*	-
Level 3	Evaluate Create	*20 %*	-	*30 %*	-	*30 %*	-	*30 %*	-	*30%*	-
	Total	100 %		100 %		100 %		100 %		100 %	

CLA – 4 can be from any combination of these: Assignments, Seminars, Tech Talks, Mini-Projects, Case-Studies, Self-Study, MOOCs, Certifications, Conf. Paper etc.,

Course Designers		
Experts from Industry	Experts from Higher Technical Institutions	Internal Experts
1. Mr.V.Selvakumar, Hexaware Technologies, selvakumarv@hexaware.com	*1. Dr.Latha Parthiba, Pondicherry University, lathaparthiban@yahoo.com*	*1. Mr.L.N.B.Srinivas, SRMIST*
2.	*2.*	*2. Mr.S.Karthick, SRMIST*
		3. Dr.V.V.Ramalingam, SRMIST

Course Code	18CSE391T	Course Name	BIG DATA TOOLS AND TECHNIQUES	Course Category	E	Professional Elective	L	T	P	C
							3	0	0	3

Pre-requisite Courses	Nil	Co-requisite Courses	Nil	Progressive Courses	Nil
Course Offering Department	Computer Science and Engineering	Data Book / Codes/Standards	Nil		

Course Learning Rationale (CLR):	The purpose of learning this course is to:
CLR-1 :	*Gain knowledge about the various tools and techniques used in big data analytics*
CLR-2 :	*Learn the fundamentals of Hadoop and the related technologies*
CLR-3 :	*Understand the basics of development of applications using MapReduce, HDFS, YARN*
CLR-4 :	*Learn the basics of Pig, Hive and Sqoop*
CLR-5 :	*Learn the basics of Apache Spark, Flink and understand the importance of NoSQL databases*
CLR-6 :	*Learn about Enterprise Data Science and data visualization tools*

Course Learning Outcomes (CLO):	At the end of this course, learners will be able to:	Learning 1: Level of Thinking (Bloom)	Learning 2: Expected Proficiency (%)	Learning 3: Expected Attainment (%)	PLO 1: Engineering Knowledge	PLO 2: Problem Analysis	PLO 3: Design & Development	PLO 4: Analysis, Design, Research	PLO 5: Modern Tool Usage	PLO 6: Society & Culture	PLO 7: Environment & Sustainability	PLO 8: Ethics	PLO 9: Individual & Team Work	PLO 10: Communication	PLO 11: Project Mgt. & Finance	PLO 12: Life Long Learning	PLO 13: PSO - 1	PLO 14: PSO - 2	PLO 15: PSO – 3
CLO-1 :	*Use the various tools and techniques in big data analytics*	2	80	85	L	-	H	-	H	-	-	-	-	-	-	-	-	-	-
CLO-2 :	*Apply Hadoop and related technologies to big data analytics*	2	75	80	L	H	H	M	H	-	-	-	-	-	-	-	-	-	-
CLO-3 :	*Apply MapReduce, HDFS and YARN develop big data applications*	2	85	80	L	-	H	-	H	-	-	-	-	-	-	-	-	-	-
CLO-4 :	*Develop applications using Pig, Hive and Sqoop*	2	80	75	L	H	H	-	H	-	-	-	-	-	-	-	-	-	-
CLO-5 :	*Apply Apache Spark and Flink to applications and understand the importance of NoSQL databases*	2	75	85	L	-	H	M	H	-	-	-	-	-	-	-	-	-	-
CLO-6 :	*Understand the applications of Enterprise Data Science and data visualization tools*	2	80	85	L	-	H	-	H	-	-	-	-	-	-	-	-	-	-

Duration (hour)		9	9	9	9	9
S-1	SLO-1	*Overview of Big Data Analytics*	*MapReduce*	*Setting up a Hadoop cluster*	*Introducing Oozie*	*Enterprise Data Science Overview*
	SLO-2	*Introduction to data analytics and big data*	*Analyzing data with Unix tools and Hadoop*	*Cluster specification and setup*		
S-2	SLO-1	*Big data mining*	*Scaling Out – Data Flow, Combiner Functions*	*Hadoop configuration*	*Apache Spark*	*Data Science Solutions in the enterprise*
	SLO-2	*Technical elements of the Big Data platform*	*Hadoop Streaming*	*YARN configuration*		
S-3	SLO-1	*Analytics Toolkit, Components of the analytics toolkit*	*HDFS*	*Introduction to Pig*	*Limitations of Hadoop and overcoming the limitations*	*Enterprise data science – Machine Learning and AI*
	SLO-2	*Distributed and Parallel Computing for Big Data*		*Installing and running pig*	*Core components and architecture of Spark*	*Enterprise Infrastructure solutions*
S-4	SLO-1	*Cloud computing and Big Data*	*Hadoop filesystems*	*Basics of Pig Latin*	*Introduction to Apache Flink*	*Visualizing Big Data*
	SLO-2		*Java Interface to Hadoop*		*Installing Flink*	
S-5	SLO-1	*In-Memory Computing Technology for Big Data*	*YARN*	*Introduction to Hive*	*Batch analytics using Flink*	*Using Python and R for visualization*
	SLO-2		*Job Scheduling*	*Installing and running Hive*		*Big Data Visualization Tools*
S-6	SLO-1	*Fundamentals of Hadoop*	*Hadoop I/O*	*Introduction to HiveQL*	*Big Data Mining with NoSQL*	*Data Visualization with Tableau*
	SLO-2	*Hadoop Ecosystem*				
S-7	SLO-1	*The core modules of Hadoop*	*Data Integrity*	*Introduction to Zookeeper*	*Why NoSQL?*	*Case Studies: Hadoop*
	SLO-2		*Compression*	*Installing and running Zookeeper*	*NoSQL databases*	
S-8	SLO-1	*Introduction to Hadoop MapReduce*	*Serialization*	*The Zookeeper Service*	*Introduction to HBase*	*Case Studies: Spark*
	SLO-2		*File based Data Structures*	*Flume Architecture*		
S-9	SLO-1	*Introduction to Hadoop YARN*	*Developing a MapReduce Application*	*Introduction to Sqoop*	*Introduction to MongoDB, Cassandra*	*Case Studies: NoSQL*
	SLO-2					

Learning Resources	1. *TomWhite,Hadoop:The Definitive Guide,3rdEdition,O'Reilly,2012.* 2. *Sridhar Alla,Big Data Analytics with Hadoop3,Packt,2018.*	3. *NatarajDasgupta,Practical Big Data Analytics,Packt,2018.* 4. *DTEditorialServices,Big Data:Black Book,2016.*

Learning Assessment

	Bloom's Level of Thinking	Continuous Learning Assessment (50%								Final Examination (50% weightage)	
		CLA – 1 (10%)		CLA – 2 (15%)		CLA – 3 (15%)		CLA – 4 (10%)#			
		Theory	Practice	Theory	Practice	Theory	Practice	Theory	Practice	Theory	Practice
Level 1	Remember Understand	*40 %*	-	*30 %*	-	*30 %*	-	*30 %*	-	*30%*	-
Level 2	Apply Analyze	*40 %*	-	*40 %*	-	*40 %*	-	*40 %*	-	*40%*	-
Level 3	Evaluate Create	*20 %*	-	*30 %*	-	*30 %*	-	*30 %*	-	*30%*	-
	Total	100 %		100 %		100 %		100 %		100 %	

CLA – 4 can be from any combination of these: Assignments, Seminars, Tech Talks, Mini-Projects, Case-Studies, Self-Study, MOOCs, Certifications, Conf. Paper etc.,

Course Designers		
Experts from Industry	Experts from Higher Technical Institutions	Internal Experts

Course Code	18CSE392T	Course Name	MACHINE LEARNING - I	Course Category	E	Professional Elective	L	T	P	C
							3	0	0	3

Pre-requisite Courses	Nil	Co-requisite Courses	Nil	Progressive Courses	Nil
Course Offering Department	CSE	Data Book / Codes/Standards	Nil		

Course Learning Rationale (CLR):	*The purpose of learning this course is to:*
CLR-1 :	*To provide basic concepts of machine learning*
CLR-2 :	*To provide deeper understanding of various tools and techniques for Machine learning Algorithms and outputs*
CLR-3 :	*Understand and Implement the major classification techniques*
CLR-4 :	*Understand and Implement the various Clustering Methods*
CLR-5 :	*Learn and Understand the Tree based machine Learning Algorithms*

Course Learning Outcomes (CLO):	*At the end of this course, learners will be able to:*	Learning 1: Level of Thinking (Bloom)	Learning 2: Expected Proficiency (%)	Learning 3: Expected Attainment (%)	PLO 1: Engineering Knowledge	PLO 2: Problem Analysis	PLO 3: Design & Development	PLO 4: Analysis, Design, Research	PLO 5: Modern Tool Usage	PLO 6: Society & Culture	PLO 7: Environment & Sustainability	PLO 8: Ethics	PLO 9: Individual & Team Work	PLO 10: Communication	PLO 11: Project Mgt. & Finance	PLO 12: Life Long Learning	PLO 13: PSO - 1	PLO 14: PSO - 2	PLO 15: PSO – 3
CLO-1 :	*Understand the concepts of machine learning*	2	80	85	H	-	-	-	-	-	-	-	-	-	-	-	-	-	-
CLO-2 :	*Learn and understand machine tools and libraries of machine learning*	2	75	80	H	H	H	-	H	-	-	-	-	-	-	-	-	-	-
CLO-3 :	*Learn and understand the linear learning models and classification in machine learning*	2	85	80	H	H	-	-	H	-	-	-	-	-	-	-	-	-	-
CLO-4 :	*Understand the clustering techniques and their utilization in machine learning*	2	80	75	H	H	-	-	H	-	-	-	-	-	-	-	-	-	-
CLO-5 :	*Study the tree based machine learning techniques and to appreciate their capability*	2	75	85	H	H	-	H	H	-	-	-	-	-	-	-	-	-	-

Duration (hour)		9	9	9	9	9
S-1	SLO-1	*Machine Learning: What and Why?*	*Platform for machine learning*	*Ridge Regression*	*Measuring (dis)similarity*	*Decision tree representation*
	SLO-2	*Types of Machine Learning*	*Machine learning python libraries*		*Evaluating output of clustering methods*	
S-2	SLO-1	*Supervised Learning*	*Scikit-learn*	*Maximum likeliwood estimation (least squares)*	*Spectral clustering*	*Basic decision tree learning algorithm*
	SLO-2	*Unsupervised Learning*	*training data – testing data – validation data*		*Hierarchical clustering*	
S-3	SLO-1	*Reinforcement learning*	*k-fold cross validation*	*principal component analysis*	*Agglomerative clustering*	*Inductive bias in decision tree*
	SLO-2	*The Curse of dimensionality*	*Features*		*Divisive clustering*	
S-4	SLO-1	*Over fitting and under fitting*	*Performance metrics*	*Bayesian classifier*	*Choosing the number of clusters*	*Decision tree construction*
	SLO-2	*linear regression*	*MSE, accuracy, confusion matrix, precision*		*Clustering datapoints and features*	
S-5	SLO-1	*Bias and Variance tradeoff*	*recall, F- score*	*Support vector machine*	*Bi-clustering*	*Issues in decision tree*
	SLO-2	*Testing – cross validation*				
S-6	SLO-1	*Regularization*	*Linear Regression with multiple variables*	*Support vector machine + kernels*	*Multi-view clustering*	*Classification and regression trees (CART)*
	SLO-2	*Learning Curve*				
S-7	SLO-1	*Classification*	*Logistic Regression*	*Multi class classification*	*K-Means clustering*	*Random Forest*
	SLO-2	*Error and noise*				*Random Forest with scikit-learn*
S-8	SLO-1	*Parametric vs. non-parametric models*	*spam filtering with logistic regression*	*K nearest neighbour classification*	*K-meloids clustering*	*Multivariate adaptive regression trees (MART)*
	SLO-2					*Introduction to Artificial Neural Networks*
S-9	SLO-1	*Linear Algebra for machine learning*	*Naive Bayes with scikit-learn*	*Application: face recognition with PCA*	*Application: image segmentation using K-means clustering*	*Perceptron learning*
	SLO-2					

Learning Resources	1. *Kevin P. Murphy, "Machine Learning: A Probabilistic Perspective", MIT Press, 2012.* 2. *Ethem Alpaydin, "Introduction to Machine Learning", Prentice Hall of India, 2005* 3. *Tom Mitchell, "Machine Learning", McGraw-Hill, 1997.*	4. *Sebastian Raschka, Vahid Mirjilili,"Python Machine Learning and deep learning", 2nd edition, kindle book, 2018* 5. *Carol Quadros,"Machine Learning with python, scikit-learn and Tensorflow", Packet Publishing, 2018.* 6. *Gavin Hackeling," Machine Learning with scikit-learn", Packet publishing, O'Reily, 2018.*

Learning Assessment											
	Bloom's Level of Thinking	Continuous Learning Assessment (50% weightage)								Final Examination (50% weightage)	
		CLA – 1 (10%)		CLA – 2 (15%)		CLA – 3 (15%)		CLA – 4 (10%)#			
		Theory	Practice	Theory	Practice	Theory	Practice	Theory	Practice	Theory	Practice
Level 1	Remember Understand	*40 %*	-	*30 %*	-	*30 %*	-	*30 %*	-	*30%*	-
Level 2	Apply Analyze	*40 %*	-	*40 %*	-	*40 %*	-	*40 %*	-	*40%*	-
Level 3	Evaluate Create	*20 %*	-	*30 %*	-	*30 %*	-	*30 %*	-	*30%*	-
	Total	100 %		100 %		100 %		100 %		100 %	

CLA – 4 can be from any combination of these: Assignments, Seminars, Tech Talks, Mini-Projects, Case-Studies, Self-Study, MOOCs, Certifications, Conf. Paper etc.,

Course Designers		
Experts from Industry	Experts from Higher Technical Institutions	Internal Experts
		Dr.G.Vadivu *Dr. UshaKiruthika* *Mr.S.Joseph James*

Course Code	18CSE393T	Course Name	TEXT MINING	Course Category		Professional Elective	L	T	P	C
							3	0	0	3

Pre-requisite Courses	Nil	Co-requisite Courses	Nil	Progressive Courses	Nil
Course Offering Department	CSE	Data Book / Codes/Standards	Nil		

Course Learning Rationale (CLR):	*The purpose of learning this course is to:*
CLR-1 :	*Understand the fundamentals of text mining*
CLR-2 :	*Utilize text for prediction techniques*
CLR-3 :	*Understand the relevance between information retrieval and text mining*
CLR-4 :	*Understand the goals of information extraction*
CLR-5 :	*Analyze different case studies related to text mining*

Course Learning Outcomes (CLO):	*At the end of this course, learners will be able to:*	Learning			Program Learning Outcomes (PLO)														
		1	2	3	1	2	3	4	5	6	7	8	9	10	11	12	13	14	15
		Level of Thinking (Bloom)	Expected Proficiency (%)	Expected Attainment (%)	Engineering Knowledge	Problem Analysis	Design & Development	Analysis, Design, Research	Modern Tool Usage	Society & Culture	Environment & Sustainability	Ethics	Individual & Team Work	Communication	Project Mgt. & Finance	Life Long Learning	PSO - 1	PSO - 2	PSO – 3
CLO-1 :	*Acquire knowledge on fundamentals of text mining*	*2*	*80*	*85*	*H*	-	-	-	-	-	-	-	-	-	-	-	-	-	-
CLO-2 :	*Perform prediction from text and evaluate it*	*2*	*80*	*80*	*H*	-	-	-	-	-	-	-	-	-	-	-	-	-	-
CLO-3 :	*Perform document matching*	*2*	*80*	*75*	*H*	*M*	-	-	-	-	-	-	-	-	-	-	-	-	-
CLO-4 :	*Identify patterns and entities from text*	*2*	*75*	*85*	*H*	-	*M*	-	*M*	-	-	-	-	-	-	-	-	-	-
CLO-5 :	*Understand how text mining is implemented*	*2*	*80*	*85*	*H*	-	-	-	-	-	-	-	-	-	*L*	-	-	-	-

Duration (hour)		9	9	9	9	9
S-1	SLO-1	*Overview of text mining*	*Labels for the Right Answers*	*Linear scoring Methods*	*Clustering Documents by similarity*	*Ideal Model of Data*
	SLO-2	*Special about Text Mining*	*Feature selection by attribute ranking*	*Evaluation of Performance*	*Similarity of composite documents*	*Practical Data Sourcing*
S-2	SLO-1	*Structured Data*	*Sentence Boundary Determination*	*Estimating current and future performance*	*K-means Clustering*	*Prototypical Examples*
	SLO-2	*Unstructured Data*	*Part of speech Tagging*	*Getting the most from a Learning Method*	*Hierarchical Clustering*	*Hybrid Example*
S-3	SLO-1	*Is text different from numbers*	*Word Sense Disambiguation*	*Errors and Pitfalls in Big data Evaluation*	*The EM Algorithm*	*Mixed Data in Standard Table Format*
	SLO-2	*Types of Problem can be solved.*	*Phrase Recognition*	*Graph models for social Networks*	*Goals for Information Extraction*	*Case study: Market Intelligence from the web*
S-4	SLO-1	*Document Classification*	*Named Entity Recognition*	*Information Retrieval and Text Mining*	*Finding Patterns and Entities from Test*	*Case Study: Lightweight Document Matching for Digital Libraries*
	SLO-2	*Informational Retrieval*	*Parsing*	*Keyword search*	*Entity Extraction as Sequential Tagging*	*Generating Model cases for Help desk Application: case study*
S-5	SLO-1	*Prediction and Evaluation*	*Feature Generation*	*Nearest- Neighbor Methods*	*Tag Prediction as Classification*	*Assigning topics to news articles: Case study*
	SLO-2	*From Textual Information to Numerical Vectors*	*Using text for prediction*	*Measuring Similarity*	*The maximum Entropy method*	*E-mail Filtering: Case study*
S-6	SLO-1	*Collecting Documents*	*Recognizing that document Fit a pattern*	*Shared Word Count*	*Linguistic Features and Encoding*	*SearchEngines : case study*
	SLO-2	*Document Standardization*	*Document Classification*	*Word count and Bonus*	*Local Sequence Prediction Models*	*Extracting Named Entities from Documents*
S-7	SLO-1	*Tokenization*	*Learning to Predict from Text*	*Cosine Similarity*	*Global sequence Prediction Models*	*Mining Social Media*
	SLO-2	*Lemmatization*	*Similarity and Nearest-Neighbor Method*	*Web based Document Search*	*Coreference and relationship Extraction*	*Customized Newspapers*
S-8	SLO-1	*Inflectional Stemming*	*Document Similarity*	*Link Analysis*	*Template Filling And Database Construction*	*Emerging Directions*
	SLO-2	*Stemming to a Root*	*Decision Rules*	*Document Matching*	*Commercial Extraction System: Application*	*Different ways of collecting samples*
S-9	SLO-1	*Vector Generation for Prediction*	*Decision trees*	*Inverted List*	*Criminal Justice : Application*	*Learning to Unlabeled data*
	SLO-2	*Multiword Features*	*Scoring by Probabilities*	*Evaluation of Performance*	*Intelligence Applicaton*	*Distributed Text Mining*

Learning Resources	1. *By Sholom M. Weiss, Nitin Indurkhya, Tong Zhang.,Fundamentals of Predictive Text Mining*	

Learning Assessment											
	Bloom's Level of Thinking	Continuous Learning Assessment (50% weightage)								Final Examination (50% weightage)	
		CLA – 1 (10%)		CLA – 2 (15%)		CLA – 3 (15%)		CLA – 4 (10%)#			
		Theory	Practice	Theory	Practice	Theory	Practice	Theory	Practice	Theory	Practice
Level 1	Remember Understand	*40 %*	-	*30 %*	-	*30 %*	-	*30 %*	-	*30%*	-
Level 2	Apply Analyze	*40 %*	-	*40 %*	-	*40 %*	-	*40 %*	-	*40%*	-
Level 3	Evaluate Create	*20 %*	-	*30 %*	-	*30 %*	-	*30 %*	-	*30%*	-
	Total	100 %		100 %		100 %		100 %		100 %	

CLA – 4 can be from any combination of these: Assignments, Seminars, Tech Talks, Mini-Projects, Case-Studies, Self-Study, MOOCs, Certifications, Conf. Paper etc.,

Course Designers		
Experts from Industry	Experts from Higher Technical Institutions	Internal Experts
		Dr.E.Poovammal, SRMIST
		Mr.L.N.B.Srinivas, SRMIST
		Mr.D.Vivek, SRMIST

Course Code	18CSE394T	Course Name	BUSINESS INTELLIGENCE AND ANALYTICS	Course Category	E	Professional Elective	L	T	P	C
							3	0	0	3

Pre-requisite Courses	Nil	Co-requisite Courses	Nil	Progressive Courses	Nil
Course Offering Department	CSE	Data Book / Codes/Standards	Nil		

Course Learning Rationale (CLR):	*The purpose of learning this course is to:*	Learning			Program Learning Outcomes (PLO)														
		1	2	3	1	2	3	4	5	6	7	8	9	10	11	12	13	14	15
CLR-1 :	*Familiarize with Business Intelligence, Analytics and Decision Support*																		
CLR-2 :	*Understand the technologies for Decision making*																		
CLR-3 :	*Familiarize with predictive modeling techniques*																		
CLR-4 :	*Familiarize with sentiment analysis techniques*																		
CLR-5 :	*Understand about Multi-criterai Decision making systems*																		
CLR-6 :	*Familiarize with Automated decision systems*																		
Course Learning Outcomes (CLO):	*At the end of this course, learners will be able to:*	Level of Thinking (Bloom)	Expected Proficiency (%)	Expected Attainment (%)	Engineering Knowledge	Problem Analysis	Design & Development	Analysis, Design, Research	Modern Tool Usage	Society & Culture	Environment & Sustainability	Ethics	Individual & Team Work	Communication	Project Mgt. & Finance	Life Long Learning	PSO - 1	PSO - 2	PSO – 3
CLO-1 :	*Gain knowledge on Business Intelligence, Analytics and Decision Support*	*2*	*80*	*85*															
CLO-2 :	*Understand the technologies for Decision making*	*2*	*75*	*80*															
CLO-3 :	*Apply predictive modeling techniques*	*2*	*85*	*80*															
CLO-4 :	*Apply sentiment analysis techniques*	*2*	*80*	*75*															
CLO-5 :	*Gain knowledge on Multi-criterai Decision making systems*	*2*	*75*	*85*															
CLO-6 :	*Gain knowledge on Automated decision systems*	*2*	*80*	*85*															

Duration (hour)		9	9	9	9	9
S-1	SLO-1	*Information Systems Support for Decision Making*	*Decision Making:*	*Basic Concepts of Neural Networks*	*Decision Support Systems modeling*	*Automated Decision Systems*
	SLO-2		*Introduction and Definitions*	*Developing Neural Network*	*Structure of mathematical models for decision support*	*The Artificial Intelligence field*
S-2	SLO-1	*An Early Framework for Computerized Decision Support*	*Phases of the Decision*	*Based Systems*	*Decision making under certainty*	*Basic concepts of Expert Sysytems*
	SLO-2		*Making Process*	*Illuminating the Black Box of ANN with Sensitivity*	*Uncertainty and Risk*	
S-3	SLO-1	*The Concept of Decision Support Systems*	*The Intelligence Phase*	*Support Vector Machines*	*Decision modeling with spreadsheets*	*Applications of Expert Sysytems*
	SLO-2			*A Process*		
S-4	SLO-1	*A Framework for Business Intelligence*	*Design Phase*	*Based Approach to the Use of SVM*	*Mathematical programming optimization*	*Structure of Expert Sysytems*
	SLO-2			*Nearest Neighbor Method for Prediction*		
S-5	SLO-1	*Business Analytics Overview*	*Choice Phase*	*Sentiment Analysis Overview*	*Decision analysis-introduction*	*Knowledge Engineering*
	SLO-2					
S-6	SLO-1	*Brief Introduction to Big Data Analytics*	*Implementation Phase*	*Sentiment Analysis Applications*	*Decision tables*	*Development of Expert Sysytems*
	SLO-2					
S-7	SLO-1	*Clickstream Analysis*	*Decision Support SystemsCapabilities*	*Sentiment Analysis Process*	*Decision Trees*	*Location based Analytics*
	SLO-2	*Metrics*				
S-8	SLO-1	*Clickstream Analysis*	*Decision Support SystemsClassification*	*Sentiment Analysis*	*Multi-criteria decision making*	*Cloud Computing*
	SLO-2	*Practical Solutions*				
S-9	SLO-1	*Competitive Intelligence Analysis*	*Decision Support SystemsComponents*	*Speech Analytics*	*Pairwise comparisons*	*Business Intelligence*
	SLO-2					

Learning Resources	1. *Ramesh Sharda, Dursun Delen, EfraimTurban, J.E.Aronson,Ting-Peng Liang, David King, "Business Intelligence and Analytics: System for Decision Support", 10th Edition, Pearson Global Edition, 2013.*	

Learning Assessment											
	Bloom's Level of Thinking	Continuous Learning Assessment (50% weightage)								Final Examination (50% weightage)	
		CLA – 1 (10%)		CLA – 2 (15%)		CLA – 3 (15%)		CLA – 4 (10%)#			
		Theory	Practice	Theory	Practice	Theory	Practice	Theory	Practice	Theory	Practice
Level 1	Remember Understand	*40 %*	-	*30 %*	-	*30 %*	-	*30 %*	-	*30%*	-
Level 2	Apply Analyze	*40 %*	-	*40 %*	-	*40 %*	-	*40 %*	-	*40%*	-
Level 3	Evaluate Create	*20 %*	-	*30 %*	-	*30 %*	-	*30 %*	-	*30%*	-
	Total	100 %		100 %		100 %		100 %		100 %	

CLA – 4 can be from any combination of these: Assignments, Seminars, Tech Talks, Mini-Projects, Case-Studies, Self-Study, MOOCs, Certifications, Conf. Paper etc.,

Course Designers		
Experts from Industry	Experts from Higher Technical Institutions	Internal Experts
1. Mr.V.Selvakumar,Hexaware Technologies, selvakumarv@hexaware.com	*1.*	*1. Mr.L.N.B.Srinivas, SRMIST*
2.	*2.*	*2. Ms.S.Nagadevi, SRMIST*

Course Code	18CSE395T	Course Name	WEB INTELLIGENCE	Course Category	E	Professional Elective	L	T	P	C
							3	0	0	3

Pre-requisite Courses	Nil	Co-requisite Courses	Nil	Progressive Courses	Nil
Course Offering Department	CSE	Data Book / Codes/Standards	Nil		

Course Learning Rationale (CLR):	*The purpose of learning this course is to:*
CLR-1 :	*Understand the topics of Web Intelligence*
CLR-2 :	*Study models of information retrieval, semantic webs, search engines, and web mining.*
CLR-3 :	*Gain knowledge on the algorithmic aspect of Web Intelligent systems*
CLR-4 :	*Acquire knowledge on Data mining techniques*
CLR-5 :	*Understand the impact of Social Network Design for Web Intelligence*
CLR-6 :	*Gain Knowledge on different approaches required for studying the impact of social network for Web Intelligence*

Course Learning Outcomes (CLO):	*At the end of this course, learners will be able to:*	Learning 1: Level of Thinking (Bloom)	2: Expected Proficiency (%)	3: Expected Attainment (%)	PLO 1: Engineering Knowledge	2: Problem Analysis	3: Design & Development	4: Analysis, Design, Research	5: Modern Tool Usage	6: Society & Culture	7: Environment & Sustainability	8: Ethics	9: Individual & Team Work	10: Communication	11: Project Mgt. & Finance	12: Life Long Learning	13: PSO - 1	14: PSO - 2	15: PSO – 3
CLO-1 :	*Acquire the knowledge on topics and benefits of Web Intelligence*	*2*	*80*	*85*	*H*	-	-	-	-	-	-	-	-	-	-	*H*	*H*	*H*	-
CLO-2 :	*Acquire the ability to build models of information retrieval, semantic webs, search engines, and web mining.*	*2*	*75*	*80*	*H*	*H*	*H*	-	*H*	-	-	-	-	-	-	*H*	*H*	*H*	*M*
CLO-3 :	*Understand the basic ideas of Multimedia Information Retrieval*	*2*	*85*	*80*	*H*	-	-	-	-	*H*	-	-	-	-	-	*H*	*H*	*H*	*H*
CLO-4 :	*Acquire knowledge to use web crawlers and fetch relevant information*	*2*	*80*	*75*	*H*	*H*	*H*	*M*	*M*	-	-	-	-	-	-	*H*	*H*	*H*	*H*
CLO-5 :	*Acquire knowledge to refine the social network design approached used for developing intelligent web*	*2*	*75*	*85*	*H*	-	-	*H*	*H*	-	-	-	-	-	-	*H*	*H*	*H*	*H*
CLO-6 :	*Apply the knowledge of different web intelligence based algorithms in practical applications*	*2*	*80*	*85*	*H*	-	*H*	-	-	*H*	-	-	-	-	-	*H*	*H*	*H*	*H*

Duration (hour)		9	9	9	9	9
S-1	SLO-1 SLO-2	*Introduction to Web Intelligence What is Web Intelligence? Benefits of Intelligent Web:What applications can benefit from web intelligence*	*Information Retrieval-Introduction, Document Representation*	*Data Mining Techniques-Classification*	*Web Content Mining-Web Crawlers*	*Social Network Design for Web Intelligence:Introduction: Social Network Design for Web Intelligence*
S-2	SLO-1 SLO-2	*Wisdom Web*	*Retrieval Models*	*Data Mining Techniques-Clustering and Association*	*Web Crawlers*	*Overview of Social Intelligence Design: Groups and Communities, Issues of Social Intelligence Design, Applications of Social Intelligence Design*
S-3	SLO-1 SLO-2	*Ingredients of Intelligent Web*	*Retrieval Models*	*Data Mining Techniques- Association*	*Search Engines*	*The Travelling Conversation Model*
S-4	SLO-1 SLO-2	*Topics of Web Intelligence*	*Evaluation of Retrieval Performance*	*Web Usage Mining- Web-Log processing*	*Personalization of Web Content*	*A Broadcast-Based Approach*
S-5	SLO-1 SLO-2	*How can I build intelligence in my own application?*	*Semantic Web-Introduction, The Layered-Language Model*	*Web Usage Mining -Analyzing Web Logs*	*Multimedia Information Retrieval*	*A Conversational Agent-Based Approach*
S-6	SLO-1 SLO-2	*Examples of intelligent web applications*	*Metadata and Ontologies*	*Applications of Web Usage Mining Clustering of Web Users*	*Web Structure Mining- Modeling Web Topology*	*Smart Environment based approach*
S-7	SLO-1 SLO-2	*Fallacies of Intelligent applications*	*Ontology Languages for the Web*	*Applications of Web Usage Mining-Classification Modeling of Web Users*	*PageRank Algorithm*	*Psychological Evaluation, Technical Issues*
S-8	SLO-1 SLO-2	*Related Technologies*	*Tool Environment for the Ontology RDFferret-Full Text Search and RDF Querying.Onto Share-Community support Onto Edit-Ontology Development*	*Applications of Web Usage Mining-Association Mining of Web Usages*	*Hyperlink-Induced Topic Search (HITS)*	*Case Study-Putting it all together : an intelligent news portal*
S-9	SLO-1 SLO-2	*Related Technologies*	*OntoView-Change Management for Ontologies Sesame-Repositories for Ontologies and Data CORPORIUM-Information Extraction*	*Sequence-Pattern Analysis of Web Logs*	*Random Walks on the Web*	*Case Study-Applying Web Intelligence for Business Intelligence*

Learning Resources	1. *Akerkar, R. & Lingras, P. (2008). Building an Intelligent Web: Theory and practice. Jones and Bartlett Publishers, Sudbury, Massachusetts. ISBN-13: 978-0- 7637-4137-2* 2. *Marmanis & Babenko: Algorithms of the Intelligent Web, Manning Publications, 2009, ISBN:978-1933988665* 3. *Witten, Ian H. & Frank, E. (2005). Data Mining: Practical Machine Learning Tools and Techniques. 2nd Edition, Morgan Kaufman. ISBN 0120884070, 9780120884070*	4. *Bing Liu: Web Data Mining, Springer, 2nd ed. 2011 (view online or download fromSpringerlink)* 5. *Manning, Raghavan and Schuetze: Introduction to Information Retrieval, CambridgeUniversityPress,2008(bookavailableonline)* *N. Zhong, J.M. Liu, Y.Y. Yao, Web Intelligence (Springer, 2003)*

Learning Assessment											
	Bloom's Level of Thinking	Continuous Learning Assessment (50% weightage)								Final Examination (50% weightage)	
		CLA – 1 (10%)		CLA – 2 (15%)		CLA – 3 (15%)		CLA – 4 (10%)#			
		Theory	Practice	Theory	Practice	Theory	Practice	Theory	Practice	Theory	Practice
Level 1	Remember Understand	*40 %*	-	*30 %*	-	*30 %*	-	*30 %*	-	*30%*	-
Level 2	Apply Analyze	*40 %*	-	*40 %*	-	*40 %*	-	*40 %*	-	*40%*	-
Level 3	Evaluate Create	*20 %*	-	*30 %*	-	*30 %*	-	*30 %*	-	*30%*	-
	Total	100 %		100 %		100 %		100 %		100 %	

CLA – 4 can be from any combination of these: Assignments, Seminars, Tech Talks, Mini-Projects, Case-Studies, Self-Study, MOOCs, Certifications, Conf. Paper etc.,

Course Designers		
Experts from Industry	Experts from Higher Technical Institutions	Internal Experts
1. Dr.B.Sathiya, Data Scientist,SPi Global - Analytics & AI,Adyar, Chennai	*1. Dr.S.RenugaDevi, Assistant Professor(Sl.Gr.),College of Engineering,Guindy,AnnaUniversity,Chennai*	*1. Dr.G.Manju*
		2.Mr.K.Vijayakumar
		3.Mr.LNB.Srinivas

Course Code	18CSE396T	Course Name	DATA SCIENCE	Course Category	E	Professional Elective	L	T	P	C
							3	0	0	3

Pre-requisite Courses	Nil	Co-requisite Courses	Nil	Progressive Courses	Nil
Course Offering Department	Computer Science and Engineering	Data Book / Codes/Standards	Nil		

Course Learning Rationale (CLR):	*The purpose of learning this course is to:*
CLR-1 :	*Able to apply fundamental algorithmic ideas to process data*
CLR-2 :	*Understand the Data Analytics lifecycle*
CLR-3 :	*Able to construct predictive models to classify new data set*
CLR-4 :	*Learn to apply hypotheses and data into actionable predictions*
CLR-5 :	*Document and communicate the results effectively to different stakeholders*
CLR-6 :	*Effectively communicate the findings using visualization techniques*

Course Learning Outcomes (CLO):	*At the end of this course, learners will be able to:*	Learning 1: Level of Thinking (Bloom)	2: Expected Proficiency (%)	3: Expected Attainment (%)	PLO 1: Engineering Knowledge	2: Problem Analysis	3: Design & Development	4: Analysis, Design, Research	5: Modern Tool Usage	6: Society & Culture	7: Environment & Sustainability	8: Ethics	9: Individual & Team Work	10: Communication	11: Project Mgt. & Finance	12: Life Long Learning	13: PSO - 1	14: PSO - 2	15: PSO – 3
CLO-1 :	*Able to comprehend basic methods of processing data from real world problems*	2	85	80	L	M	L	L	H	L	L	L	L	L	M	M	H	M	L
CLO-2 :	*Able to convert data into actionable insights*	2	80	75	M	H	L	M	M	L	L	M	M	M	M	H	M	M	M
CLO-3 :	*Build clustering and classification models using R environment*	3	85	80	H	M	H	H	H	L	L	M	H	M	H	M	M	H	M
CLO-4 :	*Apply statistical techniques for evaluation*	3	75	70	M	H	H	H	H	L	M	M	H	H	H	H	M	H	H
CLO-5 :	*Analyze and validate the models using appropriate performance metrics*	4	80	75	H	H	M	H	M	L	M	M	H	M	H	H	M	H	H
CLO-6 :	*Present the results using effective visualization techniques*	4	85	80	M	M	M	H	H	M	L	H	H	H	H	H	M	M	H

Duration (hour)		9	9	9	9	9
S-1	SLO-1	*Data science process*	*Approaching Analytics Problems*	*Introduction to R*	*Choosing and evaluating models*	*Documentation*
	SLO-2	*The roles in a data science project*	*Key roles for successful Analytics project*	*R Graphical user interfaces*	*Schematic model construction and evaluation*	*Knitr package*
S-2	SLO-1	*Stages in data science project*	*Discovery*	*Data Import and Export*	*Mapping problems to machine learning*	*Deploying models*
	SLO-2	*Define, Collect, Build, Evaluate, Present and Deploy*	*Business domain, Resources, Problem framing, Key stakeholders, Analytics sponsors, Initial hypotheses, Data sources*	*Attributes and Data Types*	*Solving classification problems, working without known targets*	*Deploying R HTTP services and exporting*
S-3	SLO-1	*Working with data from files*	*Data Preparation*	*Vectors*	*Evaluating classification models*	*Presenting your results to the project sponsor*
	SLO-2	*Structured data, other data formats and Transforming data in R*	*Learning about the data, conditioning*	*Arrays and Matrices*	*Accuracy, precision, Recall, sensitivity and specificity*	*Summarizing the project goals and stating the results*
S-4	SLO-1	*Working with relational databases and NoSQL databases*	*Model Planning*	*Data Frames*	*Evaluating clustering models*	*Presenting your model to end user*
	SLO-2	*Staging and Curating the data*	*Data exploration, Model selection*	*Lists*	*Intracluster distance, cross cluster distance*	*Presenting your work to other data scientist*
S-5	SLO-1	*Exploring data*	*Model Building*	*Factors*	*Validating models*	*Introduction to data analysis*
	SLO-2	*Using summary statistics to spot problems*	*Common tools for model building*	*Contingency Tables*	*Overfitting, Quantifying model soundness, Ensuring model quality*	*Visualization before Analysis*
S-6	SLO-1	*Managing data*	*Communicate Results*	*Descriptive statistics*	*Memorization methods*	*Dirty data*
	SLO-2	*Cleaning data*	*Analysis over the different models*	*Model building, Evaluation and Deployment*	*Using single variable and multi variable*	*Visualizing a single variable*
S-7	SLO-1	*Sampling for modeling and validation*	*Operationalize*	*Hypotheses Testing*	*Linear regression*	*Examining multiple variables*

	SLO-2	*Training and test set split, Sample group column, Record grouping, Data provenance*	*Moving the model to deployment environment*	*Null hypotheses and Alternative hypotheses*	*Building a linear regression model and predicting*	*Dotchart and Barplot*
S-8	SLO-1	*Data Structures*	*Analytics Plan*	*Difference of means*	*Logistic regression*	*Box and Whisker plot*
	SLO-2	*Structured, Semi-structured, Quasi-structured and Unstructured data*		*Student t-test, Welch's t-test*	*Building a logistic regression model and predicting*	*Hexbinplot for large datasets*
S-9	SLO-1	*Drivers of big data*	*Key deliverables of analytics project*	*Wilcoxon Rank-Sum test*	*Unsupervised methods*	*Scatterplot matrix*
	SLO-2	*Devices – Mobile, smart devices*	*Presentation: Project sponsors, Analysts, Code, Technical specifications*	*Type I and II errors*	*Cluster analysis*	*Analyzing a variable over time*

Learning Resources	1. *David Dietrich, Barry Heller, Beibei Yang, "Data Science and Big Data Analytics" , EMC Education Services,2015* 2. *NinaZumel,JohnMount,"PracticalDataSciencewithR",ManningPublications,2014* 3. *JureLeskovec,AnandRajaraman,JeffreyD.Ullman,"MiningofMassiveDatasets",Cambridge University Press,2014*	4. *MarkGardener,"BeginningR-TheStatisticalProgrammingLanguage",JohnWiley&Sons,Inc,2012* 5. *W.N.Venables,D.M.SmithandtheRCoreTeam,"AnIntroductiontoR",2013* 6. *Tony Ojeda, Sean Patrick Murphy, Benjamin Bengfort, Abhijit Dasgupta, "Practical Data Science Cookbook", Packt Publishing Ltd.,2014*

Learning Assessment

	Bloom's Level of Thinking	Continuous Learning Assessment (50% weightage)								Final Examination (50% weightage)	
		CLA – 1 (10%)		CLA – 2 (15%)		CLA – 3 (15%)		CLA – 4 (10%)#			
		Theory	Practice	Theory	Practice	Theory	Practice	Theory	Practice	Theory	Practice
Level 1	Remember Understand	*40 %*	-	*30 %*	-	*30 %*	-	*30 %*	-	*30%*	-
Level 2	Apply Analyze	*30 %*	-	*40 %*	-	*30 %*	-	*40 %*	-	*40%*	-
Level 3	Evaluate Create	*30 %*	-	*30 %*	-	*40 %*	-	*30 %*	-	*30%*	-
	Total	100 %		100 %		100 %		100 %		100 %	

CLA – 4 can be from any combination of these: Assignments, Seminars, Tech Talks, Mini-Projects, Case-Studies, Self-Study, MOOCs, Certifications, Conf. Paper etc.,

Course Designers

Experts from Industry	Experts from Higher Technical Institutions	Internal Experts
1. Dr. Pethuru Raj, Reliance Jio Infocomm Ltd, peterindia@gmail.com	*1. Prof. P.Marikkannu, IT HOD, Anna University Regional centre, Coimbatore, pmarikkannu@gmail.com*	*1. Dr. G. Vadivu, SRMIST*
	2. Prof. E.Ilavarasan, Pondicherry University, eilavarasan@pec.edu	*2. Dr.B.Baranidharan, SRMIST*
		3. Mr.D.Vivek, SRMIST

Course Code	18CSE487T	Course Name	DATA WAREHOUSING AND ITS APPLICATIONS	Course Category	E	Professional Elective	L	T	P	C
							3	0	0	3

Pre-requisite Courses	Nil	Co-requisite Courses	Nil	Progressive Courses	Nil
Course Offering Department	Computer Science and Engineering	Data Book / Codes/Standards	Nil		

Course Learning Rationale (CLR):	The purpose of learning this course is to:
CLR-1 :	*Understand the basic idea of data warehouse*
CLR-2 :	*To learn step by step approach to design a data warehouse*
CLR-3 :	*Understand ETL Process*
CLR-4 :	*To learn building process of data warehouse and implementation of data mart*
CLR-5 :	*Identify the Data mining concepts with various domains*
CLR-6 :	*To learn case studies to bring out practical aspects of data warehouse*

Course Learning Outcomes (CLO):	At the end of this course, learners will be able to:	Learning 1: Level of Thinking (Bloom)	2: Expected Proficiency (%)	3: Expected Attainment (%)	PLO 1: Engineering Knowledge	2: Problem Analysis	3: Design & Development	4: Analysis, Design, Research	5: Modern Tool Usage	6: Society & Culture	7: Environment & Sustainability	8: Ethics	9: Individual & Team Work	10: Communication	11: Project Mgt. & Finance	12: Life Long Learning	13: PSO - 1	14: PSO - 2	15: PSO – 3
CLO-1 :	*Acquire the knowledge, Architecture and schema and OLAP Tool concepts.*	2	80	85	H	-	-	-	-	-	-	-	-	-	-	-	-	-	-
CLO-2 :	*Acquire knowledge to design a data warehouse.*	2	75	80	H		-	-	-	-	-	-	-	-	-	-	-	-	-
CLO-3 :	*Implement ETL Process in various data warehouse applications.*	2	85	80	H		-	-	-	-	-	-	-	-	-	-	-	-	-
CLO-4 :	*Acquire knowledge to implement a data warehouse.*	2	80	75	H		-		-	-	-	-	-	-	-	-	-	-	-
CLO-5 :	*Implement the various concepts and applications of data mining rules and technology.*	2	75	85	H	-	-	H	-	-	-	-	-	-	-	-	-	-	-
CLO-6 :	*To Implement the data warehouse concepts in various organizations.*	2	80	85	H	-	-	-	-	-	-	-	-	-	-	-	-	-	-

Duration (hour)		9	9	9	9	9
S-1	SLO-1	*Introduction to dataware housing*	*Data Warehouse Schema-Introduction*	*Building a data warehouse - Introduction*	*DATA MINING-introduction – Data – Types of Data – Data Mining Functionalities*	*Data Warehouse in Tamil Nadu government*
	SLO-2	*Introduction to data ware housing*	*Dimensional Modeling*	*Critical success factor*	*Integrating Data Mining with Data Warehouse*	*Data warehouse for ministry of commerce*
S-2	SLO-1	*Data warehousing Components*	*The Star Schema*	*Requirement Analysis*	*Data Mining Task Primitives*	*Data warehouse for the government of Andhra Pradesh*
	SLO-2	*Need for Data warehousing*	*The Snowflake Schema*	*Planning for the data warehouse*	*Data Preprocessing*	*Data warehouse for the government of Andhra Pradesh*
S-3	SLO-1	*Benefits and application of data warehouse*	*Aggregate Tables*	*Data warehouse design stage*	*Association rule mining and classification*	*Data warehouse in Hewlett Packard*
	SLO-2	*Data Warehouse Architecture Goals*	*DBMS Schemas for Decision Support*	*Building and implementing data marts*	*Frequent pattern Mining*	*Data warehouse in Hewlett Packard*
S-4	SLO-1	*Data Warehouse Architecture and Characteristics*	*Data Extraction*	*Building data warehouse*	*Apriori algorithm*	*Data warehouse in Levi Strauss*
	SLO-2	*Data Warehouse Architecture and Characteristics*	*Data transformation: Basic tasks*	*Backup and Recovery*	*Frequent pattern Mining without candidate generation*	*Data warehouse in Levi Strauss*
S-5	SLO-1	*Data Mart*	*Major transformation types*	*Establish the data recovery quality framework*	*Mining Multilevel Association Rules*	*Data warehouse in World Bank*
	SLO-2	*Data Mart*	*OLAP definition,*	*Operating the warehouse*	*Mining Multidimensional Association Rule, Correlation Analysis Rule*	*Data warehouse in World Bank*
S-6	SLO-1	*Classification of data mart, Implementation*	*Dimensional Analysis*	*Recipe for a successful data warehouse*	*Classification: Decision Tree*	*HARBOR-A highly available data warehouse*
	SLO-2	*Classification of data mart, Implementation*	*Hypercube*	*Data warehouse pitfalls*	*Bayesian Classification-Naïve Bayes Classification*	*HARBOR-A highly available data warehouse*
S-7	SLO-1	*Gathering the business requirement*	*OLAP operations*	*Meta Data – Introduction*	*SVM Linear and Non linear data*	*A Typical Business Data Warehouse for a trading company*

	SLO-2	Planning and project management-Project principles	Drill down	Meta Data – Data Management	Text Mining Temporal Data Mining and Spatial Data mining	A Typical Business Data Warehouse for a trading company
S-8	SLO-1	Data ware house readiness assessment, project team	Roll up	Meta Data – Query Generation	Cluster Analysis-Introduction	Customer Data warehouse of world's first and largest online bank in united kingdom
	SLO-2	Selecting the operating system	Slice	Meta Data – Query Generation	K-means– Partitioning Methods	Customer Data warehouse of world's first and largest online bank in united kingdom
S-9	SLO-1	Selecting the database software	OLAP models	Meta Data and Tools	Hierarchical Methods	A German supermarket Edeka's Data warehouse
	SLO-2	Selecting the tools	MOLAP	Meta Data and Tools	Data Mining Applications	A German supermarket Edeka's Data warehouse

Learning Resources	1. *PaulrajPonniah,—DataWarehousing:FundamentalsforITProfessionals,WileyIndia.,2001.* 2. *Reema Theraja "Data Warehousing" by Oxford UniversityPress-2011.* 3. *DataMiningandDataWarehousingbyMs.KhushbooSaxena,Mr.Sandeepsaxena,Dr.AkashSaxenafirst edition 2015,BPBpublication,India*	4. *Prabhu CSR ,Data Warehousing Concepts, Technique, Product and application, PHI Learning private Ltd, Third Edition,2013.* 5. *SamAnahory,DennisMurray,DataWarehousingintheRealWorld,Pearsonpublication-2009*

Learning Assessment											
	Bloom's Level of Thinking	Continuous Learning Assessment (50%								Final Examination (50% weightage)	
		CLA – 1 (10%)		CLA – 2 (15%)		CLA – 3 (15%)		CLA – 4 (10%)#			
		Theory	Practice	Theory	Practice	Theory	Practice	Theory	Practice	Theory	Practice
Level 1	Remember Understand	*40 %*	-	*30 %*	-	*30 %*	-	*30 %*	-	*30%*	-
Level 2	Apply Analyze	*40 %*	-	*40 %*	-	*40 %*	-	*40 %*	-	*40%*	-
Level 3	Evaluate Create	*20 %*	-	*30 %*	-	*30 %*	-	*30 %*	-	*30%*	-
	Total	100 %		100 %		100 %		100 %		100 %	

CLA – 4 can be from any combination of these: Assignments, Seminars, Tech Talks, Mini-Projects, Case-Studies, Self-Study, MOOCs, Certifications, Conf. Paper etc.,

Course Designers		
Experts from Industry	Experts from Higher Technical Institutions	Internal Experts
K Selvanayagam, System Analyst, project Lead, Preludesys, Siruseri, Kancheepuram Dist.	*V.Masillamani, Asst Prof,IIITDM, Kancheepuram ,chennai*	*1.A.M.J Muthu Kumaran*
		2. S.A Saranya

Course Code	18CSE488T	Course Name	FUNCTIONAL PROGRAMMING	Course Category	E	Professional Elective	L	T	P	C
							3	0	0	3

Pre-requisite Courses	Nil	Co-requisite Courses	Nil	Progressive Courses	Nil
Course Offering Department	Computer Science and Engineering	Data Book / Codes/Standards	Nil		

Course Learning Rationale (CLR):	*The purpose of learning this course is to:*
CLR-1 :	*Understand the basic building blocks of stream processing*
CLR-2 :	*Explore the data ingestion options into stream processing engines*
CLR-3 :	*Process streaming data in real time*
CLR-4 :	*Utilize NOSQL storage options to store real time data*
CLR-5 :	*Deliver stream processing results to end users*

Course Learning Outcomes (CLO):	*At the end of this course, learners will be able to:*	Learning 1: Level of Thinking (Bloom)	2: Expected Proficiency (%)	3: Expected Attainment (%)	PLO 1: Engineering Knowledge	2: Problem Analysis	3: Design & Development	4: Analysis, Design, Research	5: Modern Tool Usage	6: Society & Culture	7: Environment & Sustainability	8: Ethics	9: Individual & Team Work	10: Communication	11: Project Mgt. & Finance	12: Life Long Learning	13: PSO - 1	14: PSO - 2	15: PSO – 3
CLO-1 :	*Comprehend the usage of basic constructs of a functional programming language*	3	80	70	L	H	H	H	H	-	-	-	L	L	-	H	-	-	-
CLO-2 :	*Create the different types of functions and evaluate its operations*	3	85	75	M	H	L	M	M	-	-	-	M	L	-	H	-	-	-
CLO-3 :	*Create patterns and match the same with traits and case classes*	3	75	70	M	H	M	H	H	-	-	-	M	L	-	H	-	-	-
CLO-4 :	*Create lists and collections, evaluate its operations*	3	85	80	M	H	M	H	H	-	-	-	M	L	-	H	-	-	-
CLO-5 :	*Construct functional design for real world applications using common structures*	3	85	75	H	H	M	H	M	-	-	-	M	L	-	H	-	-	-

Duration (hour)		9	9	9	9	9
S-1	SLO-1	*Programming Paradigms*	*Modules, Objects and Namespaces*	*Traits – Purpose and Syntax*	*Lists – Java vs Scala Lists*	*Functors - Purpose and Use*
	SLO-2	*Different types of programming paradigms, Functional vs OOP*	*Demo - Modules, Objects and Namespaces*	*Define a trait*	*Lists definitions and usage demo*	*Writing a simple functor*
S-2	SLO-1	*Scala Language Basics - Variables,*	*Anonymous Functions*	*Interface types*	*Working with Lists*	*Functor Laws*
	SLO-2	*Expressions*	*Polymorphic Functions, Nested Functions*	*Interface types examples*	*Constructing Lists*	*Applicatives – Concepts and use*
S-3	SLO-1	*Functions*	*Demo – Anonymous , Polymorphic and Nested Functions*	*Thick Interfaces*	*Basic operations on lists*	*Defining an applicative*
	SLO-2	*Recursion*	*Closures*	*Thin Interfaces*	*head, tail, isEmpty demo, List Patterns*	*Demo of Applicatives*
S-4	SLO-1	*Call By Name*	*Demo - Closures*	*Comparison - Thick vs Thin Interfaces*	*Lists - First Order methods*	*Traversable functors*
	SLO-2	*Call By Value*	*Repeated Parameters*	*Ordered trait*	*Examples of First Order Methods*	*Example – Traversable Functors*
S-5	SLO-1	*Conditionals*	*Tail Recursion*	*Demo – Ordered trait, Trait Comparisons*	*Lists - Higher Order methods*	*Monads*
	SLO-2	*Looping – for each and for*	*Demo – Tail Recursion*	*Traits for modifying interfaces*	*Examples of Higher Order Methods*	*Defining Monads*
S-6	SLO-1	*Significance of vals*	*Define a tail recursive function*	*Stacking modifications*	*Sequences – Overview and operations*	*Monad Laws*
	SLO-2	*Classes*	*Tracing tail-recursive functions*	*Recap – Traits and operations*	*Demo - Sequences*	*Demo – Monads and Monad Laws*
S-7	SLO-1	*Types*	*Demo – Tracing tail-recursive functions*	*Mixin – Purpose & Composition*	*Tuples - Overview and operations*	*Monoid – Concept, Purpose and Use*
	SLO-2	*Fields*	*Limits of tail-recursive functions*	*Mixin Example*	*Demo - Tuples*	*Examples of Monoid*
S-8	SLO-1	*Methods*	*Curried Functions*	*Case Classes – Use, Definition*	*Sets and Maps – Overview and operations*	*Recap with more examples -Monads and Functors*
	SLO-2	*Variable scope*	*Demo - Curried Functions*	*Pattern Matching, Example*	*Demo – Sets and Maps*	*Recap with more examples -Applicatives*
S-9	SLO-1	*Objects*	*Higher Order Functions - Definition and Uses*	*Sealed Classes, Option Type*	*Recap – Lists and Collections*	*Applications – Functors, Monads*
	SLO-2	*Singleton object, Variables of objects*	*Higher Order Functions Example*	*Applications – Sealed Classes and Option Type*	*Examples – Lists and Collections*	*Applciations - Monads*

Learning Resources	1. *Chiusano.P,BjarnasonR,FunctionalProgramminginScala,ManningPublications,2015* 2. *OderskeyM,SpoonL,VennersB,"ProgramminginScala",Thirdedition.*	3. *Hortsmann, C., Scala for the Impatient, 2nd ed., Addison-Wesley,2016.* 4. *Raychaudhuri R, Scala in Action, 1st ed. Manning Publications,2013.*

Learning Assessment											
	Bloom's Level of Thinking	Continuous Learning Assessment (50%								Final Examination (50% weightage)	
		CLA – 1 (10%)		CLA – 2 (15%)		CLA – 3 (15%)		CLA – 4 (10%)#			
		Theory	Practice	Theory	Practice	Theory	Practice	Theory	Practice	Theory	Practice
Level 1	Remember Understand	*40 %*	-	*30 %*	-	*30 %*	-	*30 %*	-	*30%*	-
Level 2	Apply Analyze	*40 %*	-	*40 %*	-	*40 %*	-	*40 %*	-	*40%*	-
Level 3	Evaluate Create	*20 %*	-	*30 %*	-	*30 %*	-	*30 %*	-	*30%*	-
	Total	100 %		100 %		100 %		100 %		100 %	

CLA – 4 can be from any combination of these: Assignments, Seminars, Tech Talks, Mini-Projects, Case-Studies, Self-Study, MOOCs, Certifications, Conf. Paper etc.,

Course Designers		
Experts from Industry	Experts from Higher Technical Institutions	Internal Experts
		Ms. K.Sornalakshmi
		Mr.R.Rajkumar

Course Code	18CSE489T	Course Name	STREAMING ANALYTICS	Course Category	E	Professional Elective	L	T	P	C
							3	0	0	3

Pre-requisite Courses	Nil	Co-requisite Courses	Nil	Progressive Courses	
Course Offering Department	Computer Science and Engineering	Data Book / Codes/Standards	Nil		

Course Learning Rationale (CLR):	The purpose of learning this course is to:
CLR-1 :	*Understand the basic building blocks of stream processing*
CLR-2 :	*Explore the data ingestion options into stream processing engines*
CLR-3 :	*Process streaming data in real time*
CLR-4 :	*Utilize NOSQL storage options to store real time data*
CLR-5 :	*Deliver stream processing results to end users*

Course Learning Outcomes (CLO):	At the end of this course, learners will be able to:	Learning 1 Level of Thinking (Bloom)	Learning 2 Expected Proficiency (%)	Learning 3 Expected Attainment (%)	PLO 1 Engineering Knowledge	PLO 2 Problem Analysis	PLO 3 Design & Development	PLO 4 Analysis, Design, Research	PLO 5 Modern Tool Usage	PLO 6 Society & Culture	PLO 7 Environment & Sustainability	PLO 8 Ethics	PLO 9 Individual & Team Work	PLO 10 Communication	PLO 11 Project Mgt. & Finance	PLO 12 Life Long Learning	PLO 13 PSO - 1	PLO 14 PSO - 2	PLO 15 PSO – 3
CLO-1 :	*Comprehend the concepts and terminologies in stream processing*	3	80	70	L	H	H	H	H	-	-	-	L	L	-	H	-	-	-
CLO-2 :	*Create the data ingestion pipeline for a stream processing application*	3	85	75	M	H	L	M	M	-	-	-	M	L	-	H	-	-	-
CLO-3 :	*Create stream processing applications using Apache Storm and Spark Streaming*	3	75	70	M	H	M	H	H	-	-	-	M	L	-	H	-	-	-
CLO-4 :	*Store real time data using NoSQL databases*	3	85	80	M	H	M	H	H	-	-	-	M	L	-	H	-	-	-
CLO-5 :	*Construct stream data visualizations for users*	3	85	75	H	H	M	H	M	-	-	-	M	L	-	H	-	-	-
		3	80	70	L	H	H	H	H	-	-	-	L	L	-	H	-	-	-

Duration (hour)		9	9	9	9	9
S-1	SLO-1	*Introduction to Stream Processing*	*Getting Started with Kafka*	*Apache Storm – Introduction*	*Apache Spark Streaming Introduction*	*NoSQL Data Bases*
	SLO-2	*Batch vs Stream Processing, Examples of stream processing*	*Why Kafka ? Publish Subscribe messaging model*	*Features of Storm*	*Spark's Memory Usage*	*Introduction to MongoDB*
S-2	SLO-1	*Map Reduce, Scalability and Fault Tolerance*	*Kafka Architecture*	*Storm Components*	*Understanding Resilience and Fault Tolerance in a Distributed System*	*MongoDB's Key Feature*
	SLO-2	*Applications of stream processing*	*Messages and Batches, Schemas*	*Nimbus, Supervisor Nodes*	*Spark's cluster manager*	*Data Model, Adhoc queries*
S-3	SLO-1	*Stateful Stream Processing*	*Topics and Partitions,*	*Zookeeper cluster*	*Data Delivery Semantics in Spark*	*Indexes, Querying*
	SLO-2	*Stream Processing Model*	*Producers and consumers*	*Storm Data Model*	*Data Delivery Semantics in Spark Applications*	*Replication, Speed and Durability*
S-4	SLO-1	*Data Sources, Stream processing pipelines, Sinks*	*Brokers and Clusters*	*Definition of a Storm topology, Operation modes in Storm*	*Microbatching*	*Scaling, MongoDB Change Streams*
	SLO-2	*Transformations and Aggregation*	*Multiple Clusters, Data Ecosystem*	*Storm – Prerequisites and Setting up a storm cluster, Developing a hello world example*	*Dynamic Batch Interval*	*Real-time data changes with Change Streams*
S-5	SLO-1	*Window Aggregations*	*Sending messages with producers*	*Storm topology options, Demo of Hello world in Storm*	*Structured Stream processing model*	*Visualizing Streaming data – Events, Logs, Records*
	SLO-2	*Stateless and stateful processing*	*Steps & Example - Sending messages with producers*	*Introduction to Storm UI*	*Spark Streaming Resilience Model*	*Dashboards*
S-6	SLO-1	*Effect of time in stream processing*	*Receiving messages with consumers*	*Cluster, Nimbus, Supervisor, Topology Summary. Nimbus Configuration*	*Data Structures in Spark – RDDs and DStreams*	*Visual Elements and Properties*
	SLO-2	*Lambda Architecture*	*Steps & Example - Receiving messages with consumers*	*Storm Scheduler*	*Spark Fault Tolerance Guarantees*	*Data Density*
S-7	SLO-1	*Kappa Architecture*	*Developing Kafka Streams Application*	*Types of schedulers*	*First Steps in Structured Streaming*	*Dividing time, Time to Live, Context*
	SLO-2	*Examples – Lambda & Kappa Architectures*	*Phases in a Kafka Streams Applciation Development*	*Applications of schedulers*	*Streaming Analytics Phases*	*Examples of Streaming Data Visualization*

S-8	SLO-1	*Streaming vs Batch Algorithms*	*Constructing a topology*	*Storm Cluster Monitoring*	*Acquiring streaming data*	*Visual Distractions and Visual Deception*
	SLO-2	*Applications – Streaming and Batch Algorithms*	*Streams and State – Applying stateful operations*	*Integration of Storm with Kafka*	*Transforming streaming data*	*Example – Stream processing visualization dashboards*
S-9	SLO-1	*Use of a Batch-Processing Component in a Streaming Application*	*Example application development with Kafka Streams*	*Integration of Storm with Kafka example*	*Output the resulting data*	*Streaming Visualization Techniques*
	SLO-2	*Recap – Stream Processing Fundamentals*	*Demo – Kafka Streams*	*Recap – Storm in Stream Processing*	*Demo – Stream Processing with Spark Streaming*	*Demo – Stream Processing visualizaton*

Learning Resource s	1. *Ellis B, Real-Time Analytics – Techniques to analyze and visualize streaming data, 1st ed., John Wiley & Sons Inc,2014* 2. *Andrade.H.C, Gedik B, Turaga D.S, "Fundamentals of Stream Processing: Application Design, Systems, and Analytics", 1st ed., Cambridge University Press,2014.* 3. *Narkhede N, Shapira .G, and Palino T., Kafka: The Definitive Guide - Real-Time Data and Stream Processing at Scale, 1st ed., O'Reilly Media, Inc.,2017.*	4. *Bejeck Jr. W.P., Kafka Streams in Action- Real-time apps and microservices with the Kafka Streams API, ", 1st ed., Manning Publications,2018* 5. *Jain.A, Mastering Apache Storm, 1st ed., Packt Publishing,2017.* 6. *Garillot F and Mass. G.., Stream Processing with Apache Spark, 1st ed., O'Reilly Media, Inc.,2019.* 7. *https://docs.mongodb.com/manual/changeStreams/* 8. *Banker K., Bakkum P., Verch S., Garret D., Hawkins T., MongoDb in Action, ", 1st ed., Manning Publications, 2016* 9. *Arageus A, Visualizing Streaming Data, 1st ed., O'Reilly Media, Inc.,2018.*

Learning Assessment

	Bloom's Level of Thinking	Continuous Learning Assessment (50% weightage)								Final Examination (50% weightage)	
		CLA – 1 (10%)		CLA – 2 (15%)		CLA – 3 (15%)		CLA – 4 (10%)#			
		Theory	Practice	Theory	Practice	Theory	Practice	Theory	Practice	Theory	Practice
Level 1	Remember Understand	*40 %*	-	*30 %*	-	*30 %*	-	*30 %*	-	*30%*	-
Level 2	Apply Analyze	*40 %*	-	*40 %*	-	*40 %*	-	*40 %*	-	*40%*	-
Level 3	Evaluate Create	*20 %*	-	*30 %*	-	*30 %*	-	*30 %*	-	*30%*	-
	Total	100 %		100 %		100 %		100 %		100 %	

CLA – 4 can be from any combination of these: Assignments, Seminars, Tech Talks, Mini-Projects, Case-Studies, Self-Study, MOOCs, Certifications, Conf. Paper etc.,

Course Designers

Experts from Industry	Experts from Higher Technical Institutions	Internal Experts
		Ms.K.Sornalakshmi
		Ms.A.Saranya, Dr.Manju

Course Code	18CSE490T	Course Name	BIG DATA VISUALIZATION	Course Category	E	Professional Elective	L	T	P	C
							3	0	0	3

Pre-requisite Courses	Nil	Co-requisite Courses	Nil	Progressive Courses	Nil
Course Offering Department	Computer Science and Engineering	Data Book / Codes/Standards	Nil		

Course Learning Rationale (CLR):	*The purpose of learning this course is to:*
CLR-1 :	*Understand the key techniques used in visualization which includes data models, graphical perception and techniques specifically for visual encoding and interaction*
CLR-2 :	*Obtain an exposure to common data domains and the corresponding analysis tasks which includes multivariate data and text*
CLR-3 :	*Get hands-on experience in building and evaluating visualization systems*
CLR-4 :	*Gain knowledge in data visualization aides*
CLR-5 :	*Understand the significance of data by placing it in a visual context*
CLR-6 :	*Utilize the knowledge by reading and discussing research papers from the visualization literature*

		Learning			Program Learning Outcomes (PLO)														
		1	2	3	1	2	3	4	5	6	7	8	9	10	11	12	13	14	15
Course Learning Outcomes (CLO):	*At the end of this course, learners will be able to:*	Level of Thinking (Bloom)	Expected Proficiency (%)	Expected Attainment (%)	Engineering Knowledge	Problem Analysis	Design & Development	Analysis, Design, Research	Modern Tool Usage	Society & Culture	Environment & Sustainability	Ethics	Individual & Team Work	Communication	Project Mgt. & Finance	Life Long Learning	PSO - 1	PSO - 2	PSO – 3
CLO-1 :	*Design and exploring the result with data visualizations*	*3*	*75*	*70*	*L*	*M*	*M*	*M*	*L*	-	-	-	*M*	*L*	*M*	*M*			
CLO-2 :	*Conducting exploratory data analysis using visualization techniques and tools.*	*3*	*75*	*70*	*M*	*H*	*M*	*M*	*M*	-	-	-	*M*	*L*	*M*	*M*			
CLO-3 :	*Visual presentations of data for effective Communication.*	*3*	*80*	*75*	*M*	*M*	*H*	*H*	*M*	*M*	-	-	*M*	*M*	*H*	*H*			
CLO-4 :	*Designing and evaluating color palettes for visualization based on principles of perception.*	*3*	*85*	*80*	*M*	*M*	*M*	*H*	*H*	-	-	-	*M*	*M*	*H*	*H*			
CLO-5 :	*Using the knowledge of perception and cognition to evaluate visualization design alternatives*	*3*	*85*	*80*	*M*	*H*	*M*	*H*	*H*	-	-	-	*M*	*M*	*H*	*H*			
CLO-6 :	*Identifying opportunities for the application of data visualization in various domains.*	*3*	*85*	*80*	*M*	*H*	*H*	*H*	*H*	-	-	-	*M*	*M*	*H*	*H*			

Duration (hour)		9	9	9	9	9
S-1	SLO-1	*Introduction to Big Data Visualization*	*Definitions and explanations of visualization categories*	*An Introduction to Visualization tools*	*Introduction to D3*	*Case Studies: 1: Color considerations with a dark background*
	SLO-2	*Challenges of Big Data Visualization*	*Exploring R In big data*	*Visualization tools and big data*	*D3 and big data*	
S-2	SLO-1	*Categorization*	*Example with Patient Medical History*	*Example 1 – Sales transactions*	*Basic Examples*	*2: Leveraging animation in thevisuals you present*
	SLO-2	*Visualization Philosophies*	*Digging in with R*	*Adding more context*	*Getting started with D3*	
S-3	SLO-1	*Approaches to Big Data Visualization*	*No looping*	*Wrangling the data*	*D3 visualization sample templates*	*3: Logic in order*
	SLO-2	*Quality of Visualization*	*Comparisons and Contrasts*	*Trifacta Script panel*	*Big data visualization using D3*	
S-4	SLO-1	*Infographics versus Data Visualization*	*Tendencies*	*A visualization dashboard*	*Displaying Results Using D3*	*4: Strategies for avoiding thespaghetti graph*
	SLO-2	*Exploration versus Explanation*	*Dispersion*	*Experimenting with the data and build the visualization*	*Create a summary file for visualization*	
S-5	SLO-1	*Informative versus Persuasive versus Visual Art*	*Data quality categorized*	*Data pane_core details*	*Visualization using HTML document*	*5: Alternatives to pies*
	SLO-2	*Ingredients of Successful Visualizations*	*Data Manager*	*Constructing Dashboards*	*Data visualization showing the stacked view*	
S-6	SLO-1	*Choose Appropriate Visual Encodings-Natural Ordering, Distinct Values*	*Data Manager and big data*	*Saving and Presenting the work*	*Visual transitions*	*Final Thought*
	SLO-2	*Redundant Encoding ,Defaults versus Innovative Formats ,Readers' Context*	*Example-Reformatting-A little Setup*	*Visualization re-coloring, resizing, adding or changing labels*		
S-7	SLO-1	*Compatibility with Reality ,Patterns and Consistency*	*Adding Script Code*	*Filters and Measure Names*	*Multiple donuts*	*Where to go from here*
	SLO-2	*Selecting Structure*	*Executing the scene*	*Example-Promotion Spend Effect on Sales*	*Another twist on bar chart visualizations with examples*	
S-8	SLO-1	*Position: Layout and Axes*	*Status and relevance*	*Sales and spend*		*Building storytelling with data*

	SLO-2	*The Meaning of Placement and Proximity*	*Naming the nodes*	*Sales v Spend and Spend as % of Sales Trend*	*D3 Stacked Area via Nest template*	*competency in yourteam or organization*
S-9	SLO-1	*Patterns of Organization-Specific Graphs, Layouts, and Axis Styles*	*Consistency ,Reliability ,Appropriateness*	*ables and indicators*	*Adopting the sample*	
	SLO-2	*Appropriate Use of Circles and Circular Layouts*	*Accessibility and Other Output nodes*		*Visualization changes format*	

Learning Resources	1. *Big Data Visualization,James D. Miller,Copyright © 2017 Packt Publishing* 2. *Designing Data Visualizations,by Noah Iliinsky and Julie Steele,Copyright © 2011 Julie Steele and Noah Iliinsky. All rights reserved.Printed in the United States of America*	3. *Storytelling with data - a data visualization guide for business professionals by cole nussbaumer knaflic, Wiley publications* 4. *Tableau Your Data! by Daniel G. Murray and the InterWorks BI Team, Wiley publications*

Learning Assessment

	Bloom's Level of Thinking	Continuous Learning Assessment (50% weightage)								Final Examination (50% weightage)	
		CLA – 1 (10%)		CLA – 2 (15%)		CLA – 3 (15%)		CLA – 4 (10%)#			
		Theory	Practice	Theory	Practice	Theory	Practice	Theory	Practice	Theory	Practice
Level 1	Remember Understand	*40%*	-	*30%*	-	*30%*	-	*30%*	-	*30%*	-
Level 2	Apply Analyze	*40%*	-	*40%*	-	*40%*	-	*40%*	-	*40%*	-
Level 3	Evaluate Create	*20%*	-	*30%*	-	*30%*	-	*30%*	-	*30%*	-
	Total	100 %		100 %		100 %		100 %		100 %	

CLA – 4 can be from any combination of these: Assignments, Seminars, Tech Talks, Mini-Projects, Case-Studies, Self-Study, MOOCs, Certifications, Conf. Paper etc.,

Course Designers

Experts from Industry	Experts from Higher Technical Institutions	Internal Experts
Valiyullasha, Bugtreat Technologies, UK, ceo@bugtreat.com	*Prof.Shiv ram Dubey, IIIT Sricity, srdubey@iiits.in*	*Dr.Mangalraj,SRMIST,*
Saravanakarthick,Hewlett-Packard, India, saravanakarthick.chinniah@dxc.com	*Prof. Bhawana Rudra, NITK suratkal,bhawanarudra@nitk.edu.in*	*Dr.K.P.Vijayakumar,SRMIST*

Course Code	18CSE491T	Course Name	MACHINE LEARNING - II	Course Category	E	Professional Elective	L	T	P	C
							3	0	0	3

Pre-requisite Courses	18CSE392T	Co-requisite Courses	Nil	Progressive Courses	Nil
Course Offering Department	CSE	Data Book / Codes/Standards	Nil		

Course Learning Rationale (CLR):	*The purpose of learning this course is to:*
CLR-1 :	*Understand the Fundamentals of machine Learning Experiments*
CLR-2 :	*Design and implement Ensemble learning methods*
CLR-3 :	*To provide deeper understanding of Reinforcement Learning and its Elements*
CLR-4 :	*Understand and Implement Neural Network Algorithms*
CLR-5 :	*Understand the concepts of Deep Learning Algorithms*

Course Learning Outcomes (CLO):	*At the end of this course, learners will be able to:*	Learning			Program Learning Outcomes (PLO)														
		1	2	3	1	2	3	4	5	6	7	8	9	10	11	12	13	14	15
		Level of Thinking (Bloom)	Expected Proficiency (%)	Expected Attainment (%)	Engineering Knowledge	Problem Analysis	Design & Development	Analysis, Design, Research	Modern Tool Usage	Society & Culture	Environment & Sustainability	Ethics	Individual & Team Work	Communication	Project Mgt. & Finance	Life Long Learning	PSO - 1	PSO - 2	PSO – 3
CLO-1 :	*Design and Analyze Machine Learning Experiments*	*2*	*80*	*85*	*H*	-	-	-	-	-	-	-	-	-	-	-	-	-	-
CLO-2 :	*Learn and Understand Graphical Model Learning and ensemble learning*	*2*	*75*	*80*	*H*	*H*	-	-	*H*	-	-	-	-	-	-	-	-	-	-
CLO-3 :	*Understand the concept of Reinforcement learning*	*2*	*85*	*80*	*H*	*H*	-	-	-	-	-	-	-	-	-	-	-	-	-
CLO-4 :	*Study the neural network systems for machine learning*	*2*	*80*	*75*	*H*	*H*	-	-	*H*	-	-	-	-	-	-	-	-	-	-
CLO-5 :	*Learn and Implement Deep Learning algorithms*	*2*	*75*	*85*	*H*	*H*	-	*H*	*H*	-	-	-	-	-	-	-	-	-	-

Duration (hour)		9	9	9	9	9
S-1	SLO-1	*Introduction to machine learning*	*Graphical Models*	*Reinforcement Learning*	*Neural Networks representations*	*Feature selection*
	SLO-2	*Basic probability theory*	*Bayesian belief networks*	*K-Armed Bandit*	*McCulloch-Pitts units*	*Feature extraction*
S-2	SLO-1	*linear algebra*	*Markov random fields*	*Elements of reinforcement learning*	*Thresholding logic*	*Deep Learning*
	SLO-2			*Model based learning*	*Perceptron*	*Deep learning python libraries*
S-3	SLO-1	*Factors*		*Value iteration*	*Feed forward networks*	*Simple DNN*
	SLO-2	*Response and strategy of Experimentation*	*Naïve Bayes classifiers*	*policy iteration*	*Multi-layer perceptron*	*Activation functions*
S-4	SLO-1	*Randomization, Replication and Blocking*	*Markov models*	*Temporal difference learning*	*Back propagation algorithms*	*Regularization methods*
	SLO-2	*Guidelines for machine learning Experiments*	*Hidden Markov models*	*Exploration strategies*		
S-5	SLO-1	*Cross validation and resampling methods*	*Ensemble learning methods*	*Deterministic and Non-deterministic rewards and actions*	*Convergence and Hidden layer representation in back propagation*	*Convolutional Neural Networks*
	SLO-2	*Measuring classifier performance*	*Voting, Boosting, Adaboost*		*Optimization Algorithms*	
S-6	SLO-1	*Interval estimation*	*Gradient Boosting*	*Semi-supervised learning*	*Gradient Decent*	*Recurrent Neural Networks*
	SLO-2	*Hypothesis testing*	*Bagging*		*Stochastic gradient*	
S-7	SLO-1	*Assessing a Classification Algorithm's performance*	*Random Forest*	*Computational learning theory*	*Adam, Adagrad*	*LSTM*
	SLO-2	*Comparing two classification Algorithms*			*RMSProp*	*Sentiment analysis with LSTM keras code*
S-8	SLO-1	*Comparing multiple Algorithms*	*Fine Tuning Ensemble*	*VC dimension*	*Drop out*	*Auto encoders*
	SLO-2		*Cascading*		*Batch Normalization*	
S-9	SLO-1	*Comparison over multiple Datasets*	*Application Face recognition using Ensemble techniques*	*PAC learning*	*Application Face recognition using Neural Networks*	*Dimensionality reduction using Auto Encoders*
	SLO-2					

Learning Resources	1. *KevinP.Murphy,"MachineLearning:AProbabilisticPerspective",MITPress,2012.* 2. *EthemAlpaydin,"IntroductiontoMachineLearning",PrenticeHallofIndia,2005* 3. *Tom Mitchell, "Machine Learning", McGraw-Hill,1997.*	4. *Sebastian Raschka, VahidMirjilili,"Python Machine Learning and deep learning", 2nd edition, kindle book,2018* 5. *IanGoodfellow,Yoshua Bengio ,Aaron Courville,"DeepLearning",MITPress,2016.* 6. *JasonBrownlee,"DeepLearningwithPython",ebook,2016.*

Learning Assessment											
	Bloom's Level of Thinking	Continuous Learning Assessment (50%								Final Examination (50% weightage)	
		CLA – 1 (10%)		CLA – 2 (15%)		CLA – 3 (15%)		CLA – 4 (10%)#			
		Theory	Practice	Theory	Practice	Theory	Practice	Theory	Practice	Theory	Practice
Level 1	Remember Understand	*40 %*	-	*30 %*	-	*30 %*	-	*30 %*	-	*30%*	-
Level 2	Apply Analyze	*40 %*	-	*40 %*	-	*40 %*	-	*40 %*	-	*40%*	-
Level 3	Evaluate Create	*20 %*	-	*30 %*	-	*30 %*	-	*30 %*	-	*30%*	-
	Total	100 %		100 %		100 %		100 %		100 %	

CLA – 4 can be from any combination of these: Assignments, Seminars, Tech Talks, Mini-Projects, Case-Studies, Self-Study, MOOCs, Certifications, Conf. Paper etc.,

Course Designers		
Experts from Industry	Experts from Higher Technical Institutions	Internal Experts
		1. Dr.G.Vadivu
		2. DrUshaKrithika *3. Mr. S. JosephJames*

Course Code	18CSE341T	Course Name	COMMUNICATION SYSTEMS ENGINEERING	Course Category	E	Professional Elective	L	T	P	C
							3	0	0	3

Pre-requisite Courses	Nil	Co-requisite Courses	Nil	Progressive Courses	Nil
Course Offering Department	Computer Science and Engineering	Data Book / Codes/Standards	Nil		

Course Learning Rationale (CLR):	*The purpose of learning this course is to:*
CLR-1 :	*Understand the principles of Communication systems engineering*
CLR-2 :	*Gain knowledge on the basics of Communication system components*
CLR-3 :	*Acquire knowledge on encoding, decoding techniques*
CLR-4 :	*Understand the fundamentals of Fiber Optic Communication*
CLR-5 :	*Understand the basics of Satellite Communication*
CLR-6 :	

Course Learning Outcomes (CLO):	*At the end of this course, learners will be able to:*	Learning 1 Level of Thinking (Bloom)	Learning 2 Expected Proficiency (%)	Learning 3 Expected Attainment (%)	PLO 1 Engineering Knowledge	PLO 2 Problem Analysis	PLO 3 Design & Development	PLO 4 Analysis, Design, Research	PLO 5 Modern Tool Usage	PLO 6 Society & Culture	PLO 7 Environment & Sustainability	PLO 8 Ethics	PLO 9 Individual & Team Work	PLO 10 Communication	PLO 11 Project Mgt. & Finance	PLO 12 Life Long Learning	PLO 13 PSO - 1	PLO 14 PSO - 2	PLO 15 PSO – 3
CLO-1 :	*Understand the basic ideas about Communication and its types*	*1*	*80*	*85*	*H*	-	-	-	-	-	-	-	-	-	-	-	-	-	-
CLO-2 :	*Acquire the knowledge on applications of Communication systems*	*2*	*75*	*80*	*H*	*H*	-	-	-	-	-	-	-	-	-	-	-	-	-
CLO-3 :	*Gain knowledge on information sources and source coding algorithms*	*2*	*85*	*80*	*H*	-	-	-	-	-	-	-	-	-	-	-	-	-	-
CLO-4 :	*Understand the concepts of coding for reliable Communication*	*2*	*80*	*75*	*H*	*H*	-	-	-	-	-	-	-	-	-	-	-	-	-
CLO-5 :	*Ability to apply/appreciate the skills learnt during the design and integration of the fibre optic mode of Communication in any system under development*	*2*	*75*	*85*	*H*	-	-	*H*	-	-	-	-	-	-	-	-	-	-	-
CLO-6 :	*Ability to apply/appreciate the skills learnt during the design and integration of the satellite mode of Communication in any system under development*	*2*	*80*	*85*	*H*	-	-	*H*	-	-	-	-	-	-	-	-	-	-	-

Duration (hour)		9	6	9	9	9
S-1	SLO-1	Significance of human Communication, Communication systems, transmitter	Introduction to information sources and source coding	Coding for reliable Communication	Fibre Optic Communication: Introduction Through Optical Fiber	Satellite Communication: Introduction
	SLO-2	Communication channel, Receivers, Transceivers	Modeling of information sources	Tight bound on error probability of orthogonal signals	Electromagnetic Spectrum	Basic Satellite Transponder Kepler's Laws Kepler's First Law Kepler's Second Law Kepler's Third Law
S-2	SLO-1	Attenuation, Noise	Measure of Information	The promise of coding	Types of Optical Fibres	Satellite Orbits: Low Earth Orbit Satellite Medium Earth Orbit Satellite
	SLO-2	Types of electronic Communication, simplex	Joint and Conditional Entropy	Linear block codes	Propagation of Light	Satellite Orbital Patterns Inclined Orbits Equatorial Orbit, Polar Orbits
S-3	SLO-1	Full duplex, half duplex	Source coding theorem	Theorem on Linear code	Single Mode Fibre	Geostationary Satellites
	SLO-2	Analog signals, Digital signals	Source coding algorithms	Hamming Codes	Multimode Fibre	Geosynchronous Satellite—Advantages and Disadvantages
S-4	SLO-1	Modulation and multiplexing, Baseband transmission	The Huffman source coding algorithm	Decoding and performance of linear block codes	Losses Within an Optical Fibre: Attenuation Loss	Power Systems
	SLO-2	Broadband transmission	Huffman Encoding Algorithm	Soft decision decoding	Absorption Loss	Altitude Control: Spin Stabilized
S-5	SLO-1	Multiplexing	Examples on Huffman Encoding Algorithm	Hard decision decoding	Radiation Loss	Spun/de-spun Stabilization Method
	SLO-2	Electromagnetic spectrum	The Lempel-Ziv source coding algorithm	Error detection and Error correction	Dispersion Loss	Three-axis Stabilized Method
S-6	SLO-1	Frequency and wavelength	Rate distortion theory	Burst error correcting codes	Rayleigh Scattering Loss	Altitude Control Components: Sensors, Actuators

	SLO-2	Optical spectrum	Mutual information	Cyclic codes, The structure of cyclic codes	Modal Dispersion Loss	Satellite System Parameters
S-7	SLO-1	Bandwidth	Differential Entropy	The generator matrix, Encoding of cyclic codes	Coupling Losses	Equivalent Noise
	SLO-2	Channel bandwidth	Rate distortion function	BCH Codes, Reed-Solomon Codes	Fibre Optic Transmission System: Fibre Optic Cable Light Sources	Temperature Carrier-to-Noise Density Ratio
S-8	SLO-1	Spectrum management	Examples on Rate distortion function	Convolutional Codes	Types of Fibre Optic Transmitters, Optical Detectors, Optical Repeater	Energy of Bit-to-Noise Density Ratio
	SLO-2	Standards	Digital audio transmission and digital audio recording	Basic properties of convolutional codes, Encoding, The transfer function	Optical Point-to-point Communication System:	Satellite System Link Models
S-9	SLO-1	Communication applications survey - Simplex	Digital audio in telephone transmission systems	Catastrophic codes	Single Channel System Amplified Single Channel System	Satellite System Link Equation 636 Uplink Power Budget Calculation
	SLO-2	Communication applications survey - Duplex	Digital audio recording	Optimum decoding of convolutional codes - The Viterbi algorithm	Wavelength Division Multiplexing (WDM) Systems	Satellite Radio Navigation

Learning Resources	1. *Louis E. Frenzel, Principles of Electronic Communication Systems, 4th Edition, Tata McGraw Hill Education, 2019. (Unit -I)* 2. *John G. Proakis, Masoud Salehi , Communication Systems Engineering, 2nd edition, Pearson Education International, 2015. (Unit - II & Unit -III)*	3. *Communication Systems , V. Chandra Sekar, Oxford University Press, 2015(Unit - IV &Unit-V)*

Learning Assessment											
	Bloom's Level of Thinking	Continuous Learning Assessment (50%								Final Examination (50% weightage)	
		CLA – 1 (10%)		CLA – 2 (15%)		CLA – 3 (15%)		CLA – 4 (10%)#			
		Theory	Practice	Theory	Practice	Theory	Practice	Theory	Practice	Theory	Practice
Level 1	Remember Understand	*40 %*	-	*30 %*	-	*30 %*	-	*30 %*	-	*30%*	-
Level 2	Apply Analyze	*40 %*	-	*40 %*	-	*40 %*	-	*40 %*	-	*40%*	-
Level 3	Evaluate Create	*20 %*	-	*30 %*	-	*30 %*	-	*30 %*	-	*30%*	-
	Total	100 %		100 %		100 %		100 %		100 %	

CLA – 4 can be from any combination of these: Assignments, Seminars, Tech Talks, Mini-Projects, Case-Studies, Self-Study, MOOCs, Certifications, Conf. Paper etc.,

Course Designers		
Experts from Industry	Experts from Higher Technical Institutions	Internal Experts
Mr. Ramesh Somasundaram,Director & Head, IT Sourcing Management & Supplier Governance, Energica, Chennai	*Dr.M.P Chitra, HOD/ECE, Panimalar Institute of Science and Technology*	*Dr.Annapurani.K, Dr.M.Prakash*
Mr. Umakanthan Velayutham, Senior Partner & Head, Transform Advisory Services, Energica, Chennai	*Dr.Dhalia Sweetlin, Asst.Prof(Sr.G), IT Dept, MIT,Chennai*	*Mrs.Kayalvizhi Jeyavel*

Course Code	18CSE342T	Course Name	DIGITAL COMMUNICATION SYSTEMS	Course Category	E	Professional Elective	L	T	P	C
							3	0	0	3

Pre-requisite Courses	Nil	Co-requisite Courses	Nil	Progressive Courses	Nil
Course Offering Department	Computer Science and Engineering	Data Book / Codes/Standards	Nil		

Course Learning Rationale (CLR):	*The purpose of learning this course is to:*
CLR-1 :	*Understand the model of digital Communication system.*
CLR-2 :	*Gain the knowledge about digital coding, signal compression and its application*
CLR-3 :	*Gain knowledge on digital modulation , baseband and band-pass modulation*
CLR-4 :	*To know the fundamentals of error control coding*
CLR-5 :	*To learn the importance of Multiplexing and Multiple Access*

Course Learning Outcomes (CLO):	*At the end of this course, learners will be able to:*	Learning 1 Level of Thinking (Bloom)	2 Expected Proficiency (%)	3 Expected Attainment (%)	PLO 1 Engineering Knowledge	2 Problem Analysis	3 Design & Development	4 Analysis, Design, Research	5 Modern Tool Usage	6 Society & Culture	7 Environment & Sustainability	8 Ethics	9 Individual & Team Work	10 Communication	11 Project Mgt. & Finance	12 Life Long Learning	13 PSO - 1	14 PSO - 2	15 PSO – 3
CLO-1 :	*Acquire the knowledge on digital Communication, signals and systems*	*1*	*80*	*85*	*H*	-	-	-	-	-	-	-	-	-	-	-	-	-	-
CLO-2 :	*Acquire the knowledge on sampling, Quantization, encoding and Signal Compression*	*2*	*75*	*80*	*H*	*H*	-	-	-	-	-	-	-	-	-	-	-	-	-
CLO-3 :	*Understand the various digital modulation techniques*	*2*	*85*	*80*	*H*	-	-	-	-	-	-	-	-	-	-	-	-	-	-
CLO-4 :	*To understand the error Detection and Correction codes*	*2*	*80*	*75*	*H*	*H*	-	-	-	-	-	-	-	-	-	-	-	-	-
CLO-5 :	*Understand the behavior of various multiplexing techniques*	*2*	*75*	*85*	*H*	-	-	*H*	-	-	-	-	-	-	-	-	-	-	-
CLO-6 :		*2*	*80*	*85*	*H*	-	-	-	-	-	-	-	-	-	-	-	-	-	-

Duration (hour)		9	9	9	9	9
S-1	SLO-1	*Introduction Digital Communication System, advantages of Digital Communication*	*Introduction to digital coding*	*Introduction to Digital Modulation*	*Introduction-Types and Measure of Error- Shannon-Hartley Capacity Theorem*	*Introduction to Multiplexing-Types*
	SLO-2	*Regeneration of Digital Signals, Power Efficiency of Digital Modulators*	*Digitizing Analog Signals*	*Baseband Modulation*	*Methods of Error Control-Classification of Error Correcting Codes*	*Frequency Division Multiplexing*
S-2	SLO-1	*Bandwidth Compression, Multimedia: Unification of Signals*	*Sampling*	*Pulse Modulation Systems*	*Linear Block Codes-Hamming Distance, Weight, Error Detection, Correction*	*Time Division Multiplexing*
	SLO-2	*Performance, Technology*	*Quantization*	*Baseband Signaling*	*Linear Block Codes-Generator Matrix, Systematic codes, Parity Check Matrix*	*Frame Synchronization*
S-3	SLO-1	*Time and Frequency Representation*	*Encoding*	*Correlative Coding: Duo-Binary Coding*	*Standard Array - Implementing the decoder*	*Primary Multiplexing in Digital Telephony*
	SLO-2	*Fourier Series, Fourier Transform*	*Signal Compression,*	*Modified Duo-Binary Coding*	*Cyclic Codes-Generator Polynomial for cyclic code*	*Higher Order Multiplexing*
S-4	SLO-1	*Discrete-time Fourier Transform*	*Signal Statistics and Redundancy*	*Digital Phase Modulation(Phase Shift Keying): Bi-phase shift keying modulation*	*Systematic Cyclic code*	*Multiple Access-Frequency Division Multiple Access*
	SLO-2	*Discrete Fourier Transform*	*Companded PCM*	*Differential coding in Bi-phase shift keying*	*Polynomial Multiplication and division*	*Time Division Multiple Access*
S-5	SLO-1	*Convolution*	*Predictive Coding*	*Scarmbling*	*Importance of Block Codes-Hamming Codes*	*Code Division Multiple Access*
	SLO-2	*Correlation*	*Transform Coding*	*Bi-phase shift keying modulator, Quadrature and Offset Quadrature phase shift keying*	*Problem solving session*	*Random Access*
S-6	SLO-1	*Hilbert Transform*	*Parametric Coding*	*Digital Frequency Modulation(Frequency Shift Keying)*	*Golay-Reed Solomon Codes*	*Carrier Sense Multiple access/Collision Detection*
	SLO-2	*Problem solving session*	*Perceptual Coding*	*Minimum Shift Keying*	*Convolutional codes, Convolutional Encoder*	*Fixed Assignment Multiple Access*
S-7	SLO-1	*Low-pass and Band-pass Representations,*	*Application of Digital Coding-Digital*	*Minimum Shift Keying Modulator, Gaussian*	*Convolutional Decoding, Maximum*	*Demand Assignment Multiple Access*
		Band-pass Signals and Systems	*Speech*	*Minimum Shift Keying, Continuous Phase*	*like hood Decoding*	

				Modulation		
	SLO-2	*Analytic Signals*	*Adaptive Delta Modulation Codec*	*Power Spectral Density of Baseband Signals*	*Viterbi algorithm*	*Introduction to Pseudo-Noise Sequence*
S-8	SLO-1	*Low-pass Equivalent Signals*	*Pulse Code modulation Codec*	*Power Spectral Density of Band-pass Signals*	*Sequential Decoding and Fano Algorithm*	*Properties of PN Sequences*
	SLO-2	*Problem solving session*	*Digital Audio: MP3 Coding*	*Problem solving session*	*Practical Applications of Error Correcting codes*	*Direct Sequence Spread Spectrum Transmitter and Receiver, Interface Rejection*
S-9	SLO-1	*Signal Space Representations: Vector Space*	*Digital Video: Run Length Coding, variable Length Coding*	*Comparison of Basic Modulations*	*Deep Space Communication*	*Frequency hopping Spread Spectrum, Frequency hopping Spread Spectrum Transmitter and receiver*
	SLO-2	*Problem solving session*	*MPEG1*	*Orthogonal Frequency Division Multiplexing*	*Satellite Communication*	*Spread Spectrum Applications*

Learning Resources	1. *R.N. Mutagi, Digital Communication – Theory, Techniques and Applications, 2nd Edition, Oxford University Press,2014.* 2. *John R. Barry, Edward A. Lee, David G. Messerschmitt, Digital Communication, 3rd Edition, Springer International Edition, Springer,2011* 3. *JohnG.Proakis,MasoudSalehi,DigitalCommunications,5thEdition,McGrawHillEducation,2015*

Learning Assessment

	Bloom's Level of Thinking	Continuous Learning Assessment (50%								Final Examination (50% weightage)	
		CLA – 1 (10%)		CLA – 2 (15%)		CLA – 3 (15%)		CLA – 4 (10%)#			
		Theory	Practice	Theory	Practice	Theory	Practice	Theory	Practice	Theory	Practice
Level 1	Remember Understand	*40 %*	-	*30 %*	-	*30 %*	-	*30 %*	-	*30%*	-
Level 2	Apply Analyze	*40 %*	-	*40 %*	-	*40 %*	-	*40 %*	-	*40%*	-
Level 3	Evaluate Create	*20 %*	-	*30 %*	-	*30 %*	-	*30 %*	-	*30%*	-
	Total	100 %		100 %		100 %		100 %		100 %	

CLA – 4 can be from any combination of these: Assignments, Seminars, Tech Talks, Mini-Projects, Case-Studies, Self-Study, MOOCs, Certifications, Conf. Paper etc.,

Course Designers		
Experts from Industry	Experts from Higher Technical Institutions	Internal Experts
Mr. Ramesh Somasundaram,Director & Head, IT Sourcing Management & Supplier Governance, Energica, Chennai	*Dr.M.P Chitra, HOD/ECE, Panimalar Institute of Science and Technology*	*Dr.Annapurani.K, Dr.M.Prakash*
Mr. Umakanthan Velayutham, Senior Partner & Head, Transform Advisory Services, Energica, Chennai	*Dr.Dhalia Sweetlin, Asst.Prof(Sr.G), IT Dept, MIT,Chennai*	*Mrs. M. Safa, Mrs. D. Anitha*

Course Code	18CSE378T	Course Name	PRINCIPLES OF CLOUD COMPUTING	Course Category	E	Professional Elective	L	T	P	C
							3	0	0	3

Pre-requisite Courses	Nil	Co-requisite Courses	Nil	Progressive Courses	Nil
Course Offering Department	Computer Science and Engineering	Data Book / Codes/Standards	Nil		

Course Learning Rationale (CLR):	The purpose of learning this course is to:
CLR-1 :	*Understand the fundamental ideas behind Cloud Computing, the evolution of the paradigm, its applicability; benefits, as well as current and future challenges*
CLR-2 :	*Learn cloud enabling technologies and get exposure to advanced clouds*
CLR-3 :	*Explore cloud storage technologies and relevant distributed file systems, NoSQL databases and object storage;*
CLR-4 :	*Understand the cloud security threats and protective mechanism for cloud computing*
CLR-5 :	*Participate in team-based peer reviews to analyze the security development life cycle and mitigate risks and vulnerabilities*

Course Learning Outcomes (CLO):	At the end of this course, learners will be able to:	Learning 1: Level of Thinking (Bloom)	2: Expected Proficiency (%)	3: Expected Attainment (%)
CLO-1 :	*Explain terms used in secured software development and life cycle process*	3	80	70
CLO-2 :	*Apply fundamental concepts in cloud infrastructures to understand the cloud system, network and virtualization and outline their role in enabling the cloud computing system model.*	3	85	75
CLO-3 :	*Illustrate the fundamental concepts of cloud storage and demonstrate their use in storage systems such as Amazon S3 and HDFS*	3	75	70
CLO-4 :	*Evaluate the security issues related to cloud computing and handle the security threats and construct different cloud delivery design models.*	3	85	80
CLO-5 :	*Analyze various cloud programming models and apply them to solve problems on the cloud.*	3	85	75

Program Learning Outcomes (PLO)	1 Engineering Knowledge	2 Problem Analysis	3 Design & Development	4 Analysis, Design, Research	5 Modern Tool Usage	6 Society & Culture	7 Environment & Sustainability	8 Ethics	9 Individual & Team Work	10 Communication	11 Project Mgt. & Finance	12 Life Long Learning	13 PSO - 1	14 PSO - 2	15 PSO – 3
CLO-1	H	H	H	H	H	-	-	-	L	L	-	H	-	-	-
CLO-2	M	H	L	M	H	M	-	-	M	L	-	H	-	-	-
CLO-3	M	H	M	M	H	-	-	-	M	L	-	H	-	-	-
CLO-4	M	H	L	H	M	-	-	-	M	L	-	H	-	-	-
CLO-5	H	H	M	H	H	M	-	-	M	M	-	H	-	-	-

Duration (hour)		9	9	9	9	9
S-1	SLO-1	*Introduction to Cloud Computing*	*Cloud enabling technologies- Broadband networks and Internet architecture*	*Introduction to Cloud Data Storage, The evaluation of storage technology*	*Fundamental Cloud Security*	*Cloud Application Development and Architectural Styles*
	SLO-2	*Evolution of cloud computing*			*Basic Terms and Concepts*	
S-2	SLO-1	*Network-Centric Computing*	*Data Center Technology*	*Storage Models*	*Threat Agents, Cloud Security Threats*	*MapReduce Programming Model*
	SLO-2	*Network-Centric Content*				
S-3	SLO-1	*Origin of Cloud Computing, Basic Concepts and Terminology*	*Web Technology*	*File Systems and databases*	*Cloud Security Mechanisms*	*Case Study: the GrepTheWeb Application*
	SLO-2		*Multitenant Technology*			
S-4	SLO-1	*Goals and Benefits*	*Service Technology Virtualization Technology*	*Distributed File Systems Google File System*	*Encryption Hashing*	*Hadoop: Yarn and Tez*
	SLO-2	*Risks and Challenges, Roles and Boundaries, Cloud Characteristics*				
S-5	SLO-1	*Cloud Service Models*	*Virtual Machines*	*HDFS*	*Digital Signature, Public Key Infrastructure*	*SQL on Hadoop: Pig, Hive, and Impala*
	SLO-2	*Cloud Deployment Models*		*NoSQL Databases*		
S-6	SLO-1	*Cloud Service Providers and the Cloud Ecosystem*	*Full Virtualization and Para-virtualization*	*Cloud Databases (HBase, MongoDB, Cassandra, DynamoDB)*	*Identity and Access Management, Single Sign-On: Kerberos authentication*	*Current Cloud Applications and New Opportunities*
	SLO-2					
S-7	SLO-1	*Amazon Web Services(AWS), Google Clouds,*	*Hardware Support for Virtualization*	*Cloud Object Storage (Amazon S3,*	*One-time password, Basic cloud data*	*Design approaches with Case Study*

	SLO-2	*Microsoft Azure Cloud*		*OpenStack Swift, Ceph)*	*security mechanisms*	
S-8	SLO-1	*SLA Management in Cloud Computing: A Service Providers Perspective*	*Kernel-Based Virtual Machine, Hypervisors*	*Data Storage for Online Transaction Processing Systems*	*Virtual Machine Security, Security of Virtualization, A Trusted Hypervisor*	*Design methodology for IaaS Service Model*
	SLO-2					
S-9	SLO-1	*Case Study on Open Source & Commercial Clouds: Eucalyptus, OpenStack, Aneka*	*Containers; Docker Containers, Kubernetes*	*Disk Locality versus Data Locality in Computer Clouds*	*Mobile Devices and Cloud Security*	*Google API, AWS EC2 Instances.*
	SLO-2					

Learning Resources	*1.Dan C. Marinescu," Cloud Computing Theory and Practice", Second Edition Copyright © 2018 Elsevier Inc. All.https://www.sciencedirect.com/book/9780128128107/cloud-computing* *2.Rajkumar Buyya, James Broberg, AndrzejGoscinski, Cloud Computing Principles and Paradigms, Wiley Publications, 2017.* *3. Thomas Erl, ZaighamMahmood, and RichardoPuttini, "Cloud Computing: Concepts, Technology & Architecture", Prentice Hall/PearsonPTR, Fourth Printing, 2014, ISBN: 978013338752.*	*4.K. Chandrasekaran, "Essentials of Cloud Computing", Chapman and Hall/CRC Press, 2014, ISBN 9781482205435* *5.Arshdeep Bahga, Vijay Madisetti, "Cloud Computing: A Hands-On Approach", University Press, 2016, ISBN-13: 978-0996025508.*

Learning Assessment

	Bloom's Level of Thinking	Continuous Learning Assessment (50% weightage)								Final Examination (50% weightage)	
		CLA – 1 (10%)		CLA – 2 (15%)		CLA – 3 (15%)		CLA – 4 (10%)#			
		Theory	Practice	Theory	Practice	Theory	Practice	Theory	Practice	Theory	Practice
Level 1	Remember Understand	40%	-	30%	-	30%	-	30%	-	30%	-
Level 2	Apply Analyze	40%	-	40%	-	40%	-	40%	-	40%	-
Level 3	Evaluate Create	20%	-	30%	-	30%	-	30%	-	30%	-
	Total	100 %		100 %		100 %		100 %		100%	

CLA – 4 can be from any combination of these: Assignments, Seminars, Tech Talks, Mini-Projects, Case-Studies, Self-Study, MOOCs, Certifications, Conf. Paper etc.,

Course Designers

Experts from Industry	Experts from Higher Technical Institutions	Internal Experts
SuriyadeepanRamamoorthy *Research Engineer at Saama Technology* *Puducherry, Puducherry, India* *Information Technology and Services*	*Dr.E. Ilavarasan* *Professor,CSE* *Pondicherry Engineering college.*	*1.Mrs Krishnaveni,SRMIST,KTR-SWE*
		2.Dr.S.Ramamooorthy,SRMIST,KTR-CSE
		3.Mr.K. Venkatesh,SRMIST,KTR-IT
		4.Mr. S.VidhyaSagar,SRMIST,Vadapalani campus

Course Code	18CSE377T	Course Name	DATA CENTRIC NETWORKS	Course Category	E	Professional Elective	L	T	P	C
							3	0	0	3

Pre-requisite Courses	Nil	Co-requisite Courses	Nil	Progressive Courses	Nil
Course Offering Department	Computer Science and Engineering	Data Book / Codes/Standards	Nil		

Course Learning Rationale (CLR):	*The purpose of learning this course is to:*
CLR-1 :	*Critically discuss data center networking technologies*
CLR-2 :	*Evaluate key concepts in modern Layer 2 & Layer 3 data center networks*
CLR-3 :	*Concepts related to networking technologies in modern data centers.*
CLR-4 :	*Design, build and configure complex routed and switched networks*
CLR-5 :	*Expose to implementing the networking solutions in a virtualized environment*

		Learning			Program Learning Outcomes (PLO)														
		1	2	3	1	2	3	4	5	6	7	8	9	10	11	12	13	14	15
Course Learning Outcomes (CLO):	*At the end of this course, learners will be able to:*	Level of Thinking (Bloom)	Expected Proficiency (%)	Expected Attainment (%)	Engineering Knowledge	Problem Analysis	Design & Development	Analysis, Design, Research	Modern Tool Usage	Society & Culture	Environment & Sustainability	Ethics	Individual & Team Work	Communication	Project Mgt. & Finance	Life Long Learning	PSO - 1	PSO - 2	PSO – 3
CLO-1 :	*apply networking technologies in data centers*	*1*	*90*	*85*	*L*	-	-	*M*	-	-	-	-	-	-	-	*H*	*L*	-	-
CLO-2 :	*Design modern data centers which incorporate all dynamic routing protocols.*	*3*	*85*	*80*	*M*	*M*	*H*	*H*	*H*	-	-	-	-	-	-	*H*	*M*	*H*	-
CLO-3 :	*Design layer 2 and layer 3 protocols.*	*3*	*85*	*80*	*M*	*H*	*H*	*H*	*H*	-	-	-	-	-	-	*H*	*M*	*H*	-
CLO-4 :	*design and configure the data centers*	*3*	*80*	*75*	*M*	*H*	*H*	*H*	*H*	-	-	-	-	-	-	*H*	*H*	*H*	-
CLO-5 :	*implement various network solutions for data centers*	*3*	*80*	*75*	*H*	*H*	*H*	*H*	*H*	*H*	-	*M*	-	-	-	*H*	*M*	*H*	*H*

Duration (hour)		9	9	9	9	9
S-1	SLO-1 SLO-2	*Data centric networking from different perspectives*	*Introduction to data center architectures*	*Introduction to server Architectures*	*Introduction to Layer 2 Networks*	*Introduction to Layer 3 Networks*
S-2	SLO-1 SLO-2	*Content-Centric Networking (CCN)*	*Top of rack (TOR)network connectivity*	*Clustering in server architectures*	*IEEE 802.3ba standards*	*Layer 3 Data Center technologies*
S-3	SLO-1 SLO-2	*Content Distribution Networks (CDN)*	*End of rack(EOR) network connectivity*	*scaling in server architectures*	*40 Gbps and 100 Gbps Ethernet*	*LocatorIdentifier Separation Protocol (LISP)*
S 4-5	SLO-1 SLO-2	*Requirements for modern data centers*	*Solutions that reduce cabling in architecture*	*Optimization in server architectures*	*IEEE 802.1D Spanning Tree Protocol (STP)*	*Layer 3 Multicasting*
S-6	SLO-1 SLO-2	*Design for flexibility*	*Solutions that reduce power in architecture*	*Stand-alone blades*	*RSTP protocol*	*Protocols; IPv4, IPv6*
S-7	SLO-1	*Design for scalability*	*TIA/EIA-942. Structured cabling standards*	*Redundant Layer 2 and Layer 3 designs*	*PVST protocol*	*Protocols; MPLS, OSPF*
	SLO-2	*Design for environmental control*			*MSTP protocol*	
S-8	SLO-1	*Design for electrical power*	*Cable management*	*Limitation of traditional server deployments*	*TRILL protocols*	*Protocols; IS-IS, BGP*
	SLO-2	*Design for Backup*	*Bandwidth requirements*		*IEEE 802.1Qbg Edge Virtual Bridging*	
S-9	SLO-1 SLO-2	*Flooring in data centers*	*I/O connectivity*	*Case study*	*Fiber Channel over Ethernet (FCoE) vs Internet*	*OTV& VPLS layer 2 extension*

Learning Resources	1. *MouricioArregoces,"Data Centre Fundamentals",CiscoPress,2003* 2. *SilvanoGai,Claudio DeSanti,"I/O Consolidation in the Data Center" Cisco Press;1 edition [ISBN:9781587058882].2009.* 3. *KevinCorbin,Ron Fuller,DavidJansen,"NX-OSand CiscoNexus Switching:Next-Generation Data Center Architectures"CiscoPress;1 edition [ISBN:9781587058929],2010.* 4. *Silvano Gai,Tommi Salli,RogerAndersson,"Cisco Unified Computing System" CiscoPress;1edition,[ISBN:9781587141935],2010.*	5. *NashDarukhanawalla,Patrice Bellagamba,"Interconnecting Data Centers Using VPLS"CiscoPress;1edition,[ISBN:9781587059926],2009.* 6. *RobertW.Kembel,Roger Cummings(Introduction),"The Fibre Channel Consultant" Northwest Learning Assoc;3rdedition,[ISBN:0931836840],1998.* 7. *Robert W Kembal"FiberChannelSwitchedFabric"Northwest Learning Associates,inc.[ISBN:0931836719],2009.* 8. *JohnL.Hufferd,"ISCSI",Addison-WesleyBoston[ISBN:978-0201784190],2003*

Learning Assessment

	Bloom's Level of Thinking	Continuous Learning Assessment (50%								Final Examination (50% weightage)	
		CLA – 1 (10%)		CLA – 2 (15%)		CLA – 3 (15%)		CLA – 4 (10%)#			
		Theory	Practice	Theory	Practice	Theory	Practice	Theory	Practice	Theory	Practice
Level 1	Remember Understand	*40 %*	-	*30 %*	-	*30 %*	-	*30 %*	-	*30%*	-
Level 2	Apply Analyze	*40 %*	-	*40 %*	-	*40 %*	-	*40 %*	-	*40%*	-
Level 3	Evaluate Create	*20 %*	-	*30 %*	-	*30 %*	-	*30 %*	-	*30%*	-
	Total	100 %		100 %		100 %		100 %		100 %	

CLA – 4 can be from any combination of these: Assignments, Seminars, Tech Talks, Mini-Projects, Case-Studies, Self-Study, MOOCs, Certifications, Conf. Paper etc.,

Course Designers

Experts from Industry	Experts from Higher Technical Institutions	Internal Experts
Dr.M.S.Sricharan/Wipro Technologies		*Dr. B.Amutha, Professor and Head, Department of CSE, SRM IST*
		Dr. G.Vadivu, Professor and Head, Department of IT, SRM IST

Course Code	18CSE343T	Course Name	WEB APPLICATION DEVELOPMENT	Course Category	E	Professional Elective	L	T	P	C
							3	0	0	3

Pre-requisite Courses	Nil	Co-requisite Courses	Nil	Progressive Courses	Nil
Course Offering Department	Computer Science	Data Book / Codes/Standards	Nil		

Course Learning Rationale (CLR):	*The purpose of learning this course is to:*
CLR-1 :	*Generate web pages using HTML,CSS, AJAX, JQUERY*
CLR-2 :	*Design and implement dynamic web page with validation using JavaScript objects and by applying different event handling mechanisms.*
CLR-3 :	*Understand web site dynamic behavior and server side Programming*
CLR-4 :	*Generate dynamic web pages using databases*
CLR-5 :	*To understand the different web development frameworks*

Course Learning Outcomes (CLO):	*At the end of this course, learners will be able to:*	Learning 1: Level of Thinking (Bloom)	2: Expected Proficiency (%)	3: Expected Attainment (%)	PLO 1: Engineering Knowledge	2: Problem Analysis	3: Design & Development	4: Analysis, Design, Research	5: Modern Tool Usage	6: Society & Culture	7: Environment & Sustainability	8: Ethics	9: Individual & Team Work	10: Communication	11: Project Mgt. & Finance	12: Life Long Learning	13: PSO - 1	14: PSO - 2	15: PSO – 3
CLO-1 :	*Acquire the knowledge of HTML,CSS, AJAX, JQUERY*	*2*	*80*	*85*	*M*		*H*	-	-	-	-	-	-	-	-	-	-	-	-
CLO-2 :	*Design the dynamic web page with validation using JavaScript objects and by applying different event handling mechanisms*	*2*	*75*	*80*	*M*		*H*		-	-	-	-	-	-	-	-	-	-	-
CLO-3 :	*Acquire the knowledge of web site dynamic behavior and server side Programming*	*2*	*85*	*80*	*M*		*H*		*H*	-	-	-	-	-	-	-	-	-	-
CLO-4 :	*Develop the dynamic web pages using databases*	*2*	*80*	*75*	*M*		*H*	-	-	-	-	-	-	-	-	-	-	-	-
CLO-5 :	*Understand the web development frameworks*	*2*	*75*	*85*	*M*	-	*H*		*H*	-	-	-	-	-	-	-	-	-	-

Duration (hour)		11	9	9	7	9
S-1	SLO-1	*Introduction: Rich Internet Applications*	*Introduction Angular JS*	*Overview of JSP2*	*Struts Architecture*	*Web Services*
	SLO-2					
S-2	SLO-1	*Introduction to HTML*	*Expression*	*Overview of SERVLET*	*Struts classes , Action Forward*	*Consuming a RESTfull Web Service Java desktop application /JSP*
	SLO-2	*HTML5 : Responsive web design*			*Action Form*	*Building REST Service with spring*
S-3	SLO-1	*Introduction about CSS*	*Module ,Directive Databinding*	*Creating dynamic web pages using JSP*	*Action Servlet*	*Spring Security Architecture*
	SLO-2	*CSS types*			*Action classes*	
S-4	SLO-1	*Introduction to JavaScript*	*Controllers,Scope-Filter*	*Standard-Tag Library*	*Understanding struts*	*Accessing relational data using JDBC with spring*
	SLO-2			*Java Beans , Custom Tags*	*config.xml*	
S-5	SLO-1	*Control structure*	*Introduction to Mongo, DB-Documents*	*Relational Database*	*Understanding Action Mappings, Struts flow with an example application*	*Uploading Files using spring application*
	SLO-2			*Introduction to MYSQL*		
S-6	SLO-1	*Objects*	*Collection-Database*	*JBDC-Driver*	*Struts Tiles Framework*	*Validating form input*
	SLO-2					*Handling form submission*
S-7	SLO-1	*Events*	*Datatypes*	*Understanding JDBC ODBC Connection Management*	*Struts Validation Framework*	*Creation of Batch Service*
	SLO-2					*Securing web application*
S-8	SLO-1	*Basic AJAX, History of AJAX*	*Creating, Updating*	*Resultset, Statements*		*Integrating Data*
	SLO-2	*AJAX - using XMLHttpRequest object*				*Accessing data with MongoDB*
S-9	SLO-1	*XML- and DOM , creating a full scaled web design*	*Deleting documents-Querying*	*Prepared statement, Callable Statement.*		*Creating asynchronous method,*
	SLO-2	*AJAX- Enabled Application using JSON.*				*Using WebSocket to build an interactive web application*
S10	SLO-1	*JQuery basic*				

	SLO-2	*jQuery core, events, effects,*				
S11	SLO-1	*plugins- user interface using jQuery.*				
	SLO-2					

Learning Resources	1. *Deitel ,Deitel and Nieto, "Internet and World Wide Web – How to program",4th Edition, Pearson Education Publishers,2009* 2. *EricFreeman,Elisabeth Robson,"HTML5Programming",firstedition,O'ReillyPublishers, 2011.* 3. *RobinNixon,"LearningPHP,My SQL, JavaScript, CSS & HTML5 "ThirdEdition, O'REILLY, 2014.* 4. *Marty Hall, "Core Servlet &Java Sever Pages " SunMicrosystems,* 5. *JamesHolmes"Struts:TheCompleteReference,"2ndEdition2007McGrawHillProfessional.* 6. *Patrick Naughton, "COMPLETE REFERENCE: JAVA2", 7th edition,Tata McGraw-Hill, 2010.* 7. *ThomasApowell,"ThecompletereferenceHTML&CSS",5thEdition.* 8. *CraigWalls,"SpringinAction,4thEditionKindleEdition,ManningPublication,2015.*	9. *JobineshPurushothaman,"RESTfulJavaWebServices"SecondEdition,Packt Publishing,2015* 10. *https://www.w3schools.com/angular/angular_filters.asp* 11. *KristinaChodorow,MongoDB:TheDefinitiveGuide,2ndEdition,2013,OReilly.*

Learning Assessment

	Bloom's Level of Thinking	Continuous Learning Assessment (50%								Final Examination (50% weightage)	
		CLA – 1 (10%)		CLA – 2 (15%)		CLA – 3 (15%)		CLA – 4 (10%)#			
		Theory	Practice	Theory	Practice	Theory	Practice	Theory	Practice	Theory	Practice
Level 1	Remember Understand	40 %	-	30 %	-	30 %	-	30 %	-	30%	-
Level 2	Apply Analyze	40 %	-	40 %	-	40 %	-	40 %	-	40%	-
Level 3	Evaluate Create	20 %	-	30 %	-	30 %	-	30 %	-	30%	-
	Total	100 %		100 %		100 %		100 %		100 %	

CLA – 4 can be from any combination of these: Assignments, Seminars, Tech Talks, Mini-Projects, Case-Studies, Self-Study, MOOCs, Certifications, Conf. Paper etc.,

Course Designers

Experts from Industry	Experts from Higher Technical Institutions	Internal Experts
1. Mr.M.Prakash Team Lead(Associate Consultant) ,Virtusa ,Chennai, prakashpm@virtusa.com	*1. Dr.KHANNA NEHEMIAH , Professor, Ramanujan Computing, Anna University*	*1. Dr. M.UMA, Assistant Professor, SWE*
		2. Dr.Madhavan, Associate Professor/CSE
		3.K.Navin AP/IT

Course Code	18CSE344T	Course Name	CLOUD ARCHITECTURE	Course Category	E	Professional Elective	L	T	P	C
							3	0	0	3

Pre-requisite Courses	Nil	Co-requisite Courses	Nil	Progressive Courses	Nil
Course Offering Department	Computer Science and Engineering	Data Book / Codes/Standards	Nil		

Course Learning Rationale (CLR):	*The purpose of learning this course is to:*
CLR-1 :	*Observe the fundamentals of cloud architecture*
CLR-2 :	*Observe the Technologies used in cloud platforms*
CLR-3 :	*Understand the advanced cloud architecture and storage arrays*
CLR-4 :	*Understand the importance of cloud architecture design*
CLR-5 :	*Gain knowledge in virtualization architecture*
CLR-6 :	*Gain knowledge in future trends and technologies in cloud structures*

Course Learning Outcomes (CLO):	*At the end of this course, learners will be able to:*	Learning 1 Level of Thinking (Bloom)	Learning 2 Expected Proficiency (%)	Learning 3 Expected Attainment (%)	PLO 1 Engineering Knowledge	PLO 2 Problem Analysis	PLO 3 Design & Development	PLO 4 Analysis, Design, Research	PLO 5 Modern Tool Usage	PLO 6 Society & Culture	PLO 7 Environment & Sustainability	PLO 8 Ethics	PLO 9 Individual & Team Work	PLO 10 Communication	PLO 11 Project Mgt. & Finance	PLO 12 Life Long Learning	PLO 13 PSO - 1	PLO 14 PSO - 2	PLO 15 PSO – 3
CLO-1 :	*To understand the concept of basic cloud computing paradigms*	2	80	85	H	-	-	-	-	-	-	-	-	-	-	-	-	-	-
CLO-2 :	*To interpret the concepts of Cloud service structures*	2	75	80	H	H	-	-	-	-	-	-	-	-	-	-	-	-	-
CLO-3 :	*To Analyze the components of cloud computing showing how business agility in an organization can be created*	2	85	80	H	-	-	-	-	-	-	-	-	-	-	-	-	-	-
CLO-4 :	*To be familiar with the market service providers in cloud.*	2	80	75	H	H	-	-	-	-	-	-	-	-	-	-	-	-	-
CLO-5 :	*To understand the technologies of data center cloud structures.*	2	75	85	H	-	-	H	-	-	-	-	-	-	-	-	-	-	-
CLO-6 :	*To work with robust cloud architectural patterns*	2	80	85	H	-	-	-	-	-	-	-	-	-	-	-	-	-	-

Duration (hour)		9	9	9	9	9
S-1	SLO-1	*Introduction to cloud computing fundamentals*	*Service Oriented Architecture*	*Introduction to cloud storage infrastructures*	*Management Of Cloud Services*	*Introduction to Cloud Architecture patterns*
	SLO-2	*Cloud Computing definition*	*REST*	*Concept, planning and Design*	*Reliability, availability and security of services deployed from the cloud*	*Horizontally Scaling Compute Pattern- Cloud Significance*
S-2	SLO-1	*Cloud deployment models*	*Systems of Systems*	*Business continuity*	*Performance and scalability of services*	*Queue-Centric Workflow Pattern*
	SLO-2	*Private, Public , Hybrid, community cloud*	*Web Services*	*Basic concepts of information security*	*Tools and technologies used to manage cloud services deployment*	*Auto-Scaling Pattern*
S-3	SLO-1	*Cloud services:*	*Publish-Subscribe Model*	*Managing VDC and cloud environments and infrastructures*	*Cloud Economics*	*Eventual Consistency Prime*
	SLO-2	*IaaS, PaaS, SaaS*	*Basics of Virtualization*	*Securing storage in virtualized and cloud environments*	*Cloud Computing infrastructures available for implementing cloud based services*	*MapReduce Pattern*
S-4	SLO-1	*Enabling technologies of cloud computing*	*Types of Virtualization*	*Monitoring and management*	*Economics of choosing a Cloud platform for an organization*	*. Database Sharding Pattern*
	SLO-2	*Benefits and challenges of cloud computing*	*Implementation Levels of Virtualization*	*Security auditing and SIEM*	*Runtime Support Services*	*Node Failure Pattern*
S-5	SLO-1	*Business Agility:*	*Virtualization Structures*	*Storage Network Design*	*Resource Provisioning and Platform Deployment- Provisioning of Compute Resources (VMs)*	*Network Latency Primer*
	SLO-2	*Benefits and challenges to Cloud architecture.*	*Tools and Mechanisms*	*Architecture of storage, analysis and planning.*	*Resource Provisioning Methods*	*CDN Pattern.*
S-6	SLO-1	*Cloud Applications*	*Virtualization of CPU Memory*	*Storage network design considerations*	*NIST Cloud Computing Reference Architecture*	*Multisite Deployment Pattern*
	SLO-2	*Application availability*	*I/O Devices*	*NAS and FC SANs*	*Demand-Driven, Event-Driven Resource Provisioning*	*Network connectivity optimization evolution: Top of rack (TOR), end of rack (EOR), connectivity.*

S-7	SLO-1	*Performance*	*Virtualization Support and Disaster Recovery*	*Hybrid storage networking technologies*	*Popularity-Driven Resource Provisioning*	*Stand-alone, blades, stateless,*
	SLO-2	*Security and disaster recovery*	*Server Virtualization*	*iSCSI, FCIP, FCoE*	*Dynamic Resource Deployment*	*clustering*
S-8	SLO-1	*Next generation of Cloud Applications.*	*Parallel Processing*	*Design for storage virtualization in cloud computing*	*Storage-as-a-Service*	*scaling*
	SLO-2	*Virtualization*	*Vector Processing*	*host system design considerations*	*Advantages of Cloud Storage - Global Exchange of Cloud Resources*	*optimization, virtualization.*
S-9	SLO-1	*Types of virtualization in cloud computing*	*Symmetric Multiprocessing Systems*	*Cloud Applications*	*Application Development*	*Limitation of traditional server deployments*
	SLO-2	*Advantages and Disadvantages*	*Massively Parallel Processing Systems*	*Technologies and the processes required when deploying web services*	*Service creation environments to develop cloud based applications*	*Case studies*

Learning Resources	1. *GautamShroff,"EnterpriseCloudComputingTechnologyArchitectureApplications",Cambridge University Press; 1 edition, [ISBN: 978-0521137355],2010.* 2. *Toby Velte, Anthony Velte, Robert Elsenpeter, "Cloud Computing, A Practical Approach" McGraw-Hill Osborne Media; 1 edition [ISBN: 0071626948],2009* 3. *Greg Schulz, "Cloud and Virtual Data Storage Networking", Auerbach Publications [ISBN: 978- 1439851739],2011* 4. *EMC,"InformationStorageandManagement"Wiley;2edition[ISBN:978-0470294215],2012.* 5. *VolkerHerminghaus,AlbrechtScriba,"StorageManagementinDataCenters"Springer;editionN[ISBN: 978-3540850229].2009.*	6. *KlausSchmidt,"HighAvailabilityandDisasterRecovery"Springer;edition[ISBN:978-3540244608],2006.* 7. *Kai Hwang, Geoffrey C. Fox, Jack G. Dongarra, "Distributed and Cloud Computing, From Parallel ProcessingtotheInternetofThings",MorganKaufmannPublishers,2012.* 8. *Rittinghouse, John W., and James F. Ransome, —Cloud Computing: Implementation, Management and Security‖, CRC Press, 2017.* 9. *SilvanoGai,ClaudioDeSanti,"I/OConsolidationintheDataCenter"CiscoPress;1edition[ISBN: 9781587058882].2009.* 10. *2. Bill wilder, Cloud Architecture patterns,2012*

Learning Assessment

	Bloom's Level of Thinking	Continuous Learning Assessment (50%								Final Examination (50% weightage)	
		CLA – 1 (10%)		CLA – 2 (15%)		CLA – 3 (15%)		CLA – 4 (10%)#			
		Theory	Practice	Theory	Practice	Theory	Practice	Theory	Practice	Theory	Practice
Level 1	Remember Understand	*40 %*	-	*30 %*	-	*30 %*	-	*30 %*	-	*30%*	-
Level 2	Apply Analyze	*40 %*	-	*40 %*	-	*40 %*	-	*40 %*	-	*40%*	-
Level 3	Evaluate Create	*20 %*	-	*30 %*	-	*30 %*	-	*30 %*	-	*30%*	-
	Total	100 %		100 %		100 %		100 %		100 %	

CLA – 4 can be from any combination of these: Assignments, Seminars, Tech Talks, Mini-Projects, Case-Studies, Self-Study, MOOCs, Certifications, Conf. Paper etc.,

Course Designers

Experts from Industry	Experts from Higher Technical Institutions	Internal Experts
Mr. Anil Nayer, JPA solutions	*Dr. Kanagachidambaresan, Professor, PSG-Tech*	*Mr K. Venkatesh, SRMIST*
		Dr Ramamoorthy, SRMIST
		Mr Vinoth, SRMIST

Course Code	18CSE441T	Course Name	CLOUD APPLICATION DEVELOPMENT	Course Category	E	Professional Elective	L	T	P	C
							3	0	0	3

Pre-requisite Courses	Nil	Co-requisite Courses	Nil	Progressive Courses	Nil
Course Offering Department	Computer Science and Engineering	Data Book / Codes/Standards	Nil		

Course Learning Rationale (CLR):	*The purpose of learning this course is to:*
CLR-1 :	*Utilize the different types of cloud services*
CLR-2 :	*Utilize the different storage services*
CLR-3 :	*Utilize different algorithms for cloud computing*
CLR-4 :	*Utilize virtualization techniques*
CLR-5 :	*Utilize real-time cloud services from different vendors*
CLR-6 :	*Utilize and understand cloud services with real-time cloud applications*

		Learning			Program Learning Outcomes (PLO)														
		1	2	3	1	2	3	4	5	6	7	8	9	10	11	12	13	14	15
Course Learning Outcomes (CLO):	*At the end of this course, learners will be able to:*	Level of Thinking (Bloom)	Expected Proficiency (%)	Expected Attainment (%)	Engineering Knowledge	Problem Analysis	Design & Development	Analysis, Design, Research	Modern Tool Usage	Society & Culture	Environment & Sustainability	Ethics	Individual & Team Work	Communication	Project Mgt. & Finance	Life Long Learning	PSO - 1	PSO - 2	PSO – 3
CLO-1 :	*Understand different cloud architecture and models*	*3*	*80*	*70*	*L*	*H*	*-*	*H*	*L*	*-*	*-*	*-*	*L*	*L*	*-*	*H*	*-*	*-*	*-*
CLO-2 :	*Create the different types of cloud applications using different languages*	*3*	*85*	*75*	*M*	*H*	*L*	*M*	*L*	*-*	*-*	*-*	*M*	*L*	*-*	*H*	*-*	*-*	*-*
CLO-3 :	*Understand the concepts of virtualization*	*3*	*75*	*70*	*M*	*H*	*M*	*H*	*L*	*-*	*-*	*-*	*M*	*L*	*-*	*H*	*-*	*-*	*-*
CLO-4 :	*Create simple cloud applications and deploy*	*3*	*85*	*80*	*M*	*H*	*M*	*H*	*L*	*-*	*-*	*-*	*M*	*L*	*-*	*H*	*-*	*-*	*-*
CLO-5 :	*Understanding cloud application paradigms*	*3*	*85*	*75*	*H*	*H*	*M*	*H*	*L*	*-*	*-*	*-*	*M*	*L*	*-*	*H*	*-*	*-*	*-*
CLO-6 :	*Analyze different cloud technologies and its implementations*	*3*	*80*	*70*	*L*	*H*	*-*	*H*	*L*	*-*	*-*	*-*	*L*	*L*	*-*	*H*	*-*	*-*	*-*

Duration (hour)		9	9	9	9	9
S-1	SLO-1	*Introduction to cloud computing*	*Cloud Computing: Applications*	*Server virtualization*	*Amazon Web Services: EC2 Instances*	*Case studies – IaaS, PaaS, SaaS*
	SLO-2	*Cloud deployment models*	*Challenges for Cloud Computing*	*Hypervisor- based virtualization*	*Connecting Clients to Cloud Instances Through Firewalls*	*IaaS*
S-2	SLO-1	*business drivers for Cloud Computing*	*Existing Cloud Applications and New Application Opportunities*	*Techniques for Hypervisor*	*Security Rules for Application Layer Protocols in EC2*	*Storage as a Service*
	SLO-2	*cloud computing Delivery Models*	*Architectural Styles for Cloud Applications*	*Hardware support for Virtualization*	*Security Rules for Transport Layer Protocols in EC2*	*Storage as a Service – Amazon storage service S3*
S-3	SLO-1	*cloud computing Services*	*Workflows: Coordination of Multiple Activities*	*VMware virtualization software*	*How to Launch an EC2 Linux Instance and Connect to it*	*Compute as a service*
	SLO-2	*challenges of cloud computing*	*Coordination Based on a State Machine Model*	*XenServer Virtual Machine Monitor*	*How to Use S3 in Java*	*Compute as a service – Amazon EC2*
S-4	SLO-1 SLO-2	*Cloud Infrastructure : cloud computing at Amazon*	*The Zookeeper*	*Storage Virtualization*	*How to Manage SQS Services in C#*	*PaaS*
S-5	SLO-1	*Cloud computing The Google perspective*	*Scalable data storage techniques*	*File virtualization*	*How to Install the Simple Notification Service on Ubuntu*	*Microsoft Azure*
	SLO-2	*Microsoft Windows Azure*	*The MapReduce Programming Model*	*Example*	*Example*	*Google App Engine*
S-6	SLO-1	*Microsoft Windows Azure services*	*RIAs, simple Hello world example*	*Block Virtualization*	*How to Create an EC2 Placement Group*	*Apache hadoop*
	SLO-2	*Open-Source Software Platforms for Private Clouds*	*Client-server example , RSS Feed Reader*	*Examples*	*How to Use MPI*	*Yahoo Mashups*
S-7	SLO-1	*Cloud Storage Diversity, Cloud Storage Vendor lock-in*	*Advanced platform functionality*	*Grid Computing*	*Hadoop Ecosystem*	*SaaS : CRM as a Service*
	SLO-2	*Cloud Computing Inter-operability*	*Clouds for Science and Engineering*	*Grid Technologies*	*How to Install Hadoop on Eclipse on a*	*Salesforce.com*

					Windows System	
S-8	SLO-1	*The inter cloud , Responsibilities of User*	*High-Performance Computing on a Cloud , social Computing , Digital Content*	*comparing Grid and Cloud*	*Cloud-Based Simulation of a Distributed Trust Algorithm*	*Social Computing services : What Constitutes Social computing?, Case study - Facebook*
	SLO-2					
S-9	SLO-1	*Responsibilities of service provider*	*Cloud computing*	*Creating sample hello world application in OpenShift*	*A Cloud Service for Adaptive Data Streaming*	*Micro Blogger : Twitter*
	SLO-2	*Responsibility Sharing Between User and Cloud Service Provide*	*A Case Study: The GrepTheWeb Application*	*Example*	*Cloud-Based Optimal FPGA Synthesis*	*Document services*

Learning Resources	1. *Dinkar Sitaram, Geetha Manjunath, Moving To The Cloud: Developing Apps in the New World of Cloud Computing, Syngress,2013.* 2. *DanC.Marinescu,CloudComputing:TheoryandPractice.,MorganKaufman,2013*	3. *AMichael P. McGrath, Understanding PaaS: Unleash the Power of Cloud Computing, O'Reilly Media,2012.*

Learning Assessment

	Bloom's Level of Thinking	Continuous Learning Assessment (50%								Final Examination (50% weightage)	
		CLA – 1 (10%)		CLA – 2 (15%)		CLA – 3 (15%)		CLA – 4 (10%)#			
		Theory	Practice	Theory	Practice	Theory	Practice	Theory	Practice	Theory	Practice
Level 1	Remember Understand	*40 %*	-	*30 %*	-	*30 %*	-	*30 %*	-	*30%*	-
Level 2	Apply Analyze	*40 %*	-	*40 %*	-	*40 %*	-	*40 %*	-	*40%*	-
Level 3	Evaluate Create	*20 %*	-	*30 %*	-	*30 %*	-	*30 %*	-	*30%*	-
	Total	100 %		100 %		100 %		100 %		100 %	

CLA – 4 can be from any combination of these: Assignments, Seminars, Tech Talks, Mini-Projects, Case-Studies, Self-Study, MOOCs, Certifications, Conf. Paper etc.,

Course Designers		
Experts from Industry	Experts from Higher Technical Institutions	Internal Experts
Mr. Venkatesh Varalu, New YorkTimes, USA	*Dr. Balaraman Ravindran, Professor, IITM*	*Mr. Venkatesh, SRMIST* *Dr Pradeep Mohan Kumar, SRMIST* *Mrs Krishnaven, SRMISTi*

Course Code	18CSE442T	Course Name	CLOUD SECURITY	Course Category	E	Professional Elective	L	T	P	C
							3	0	0	3

Pre-requisite Courses	Nil	Co-requisite Courses	Nil	Progressive Courses	Nil
Course Offering Department	Computer Science and Engineering	Data Book / Codes/Standards	Nil		

Course Learning Rationale (CLR):	The purpose of learning this course is to:
CLR-1 :	*To understand the concept of cloud security*
CLR-2 :	*The issues related to virtualized infrastructure security*
CLR-3 :	*To have knowledge on the various issue in cloud security*
CLR-4 :	*To Learn the methods to improve virtualization security and technologies in security*
CLR-5 :	*Understand the cloud contracting Model and case study of commercial cloud*

Course Learning Outcomes (CLO):	At the end of this course, learners will be able to:	Learning 1: Level of Thinking (Bloom)	2: Expected Proficiency (%)	3: Expected Attainment (%)	Program Learning Outcomes (PLO) 1: Engineering Knowledge	2: Problem Analysis	3: Design & Development	4: Analysis, Design, Research	5: Modern Tool Usage	6: Society & Culture	7: Environment & Sustainability	8: Ethics	9: Individual & Team Work	10: Communication	11: Project Mgt. & Finance	12: Life Long Learning	13: PSO - 1	14: PSO - 2	15: PSO – 3
CLO-1 :	*Articulate the main concepts of cloud security*	3	80	70	L	H	L	H	L	M	H	L	L	L	L	H	H	L	M
CLO-2 :	*Explain the architecture design of cloud storage.*	3	85	75	H	H	L	M	L	M	H	L	M	L	H	H	L	H	L
CLO-3 :	*Explain the core issues of cloud management and security*	3	75	70	H	H	H	H	H	M	L	L	M	L	M	H	M	M	M
CLO-4 :	*Be able to install and use current cloud Technologies.*	3	85	80	H	H	H	H	H	L	L	L	M	L	M	H	L	L	H
CLO-5 :	*Apply secure design for cloud Models*	3	85	75	H	H	H	H	L	M	L	L	M	L	M	H	L	M	L

Duration (hour)		9	9	9	9	9
S-1	SLO-1	*Cloud Security Fundamentals-Infrastructure Security*	*Layered Cloud Architecture Design*	*Confidentiality, privacy, integrity, authentication,*	*IBM security virtual server protection*	*Authentication in cloud computing*
	SLO-2	*Network level security*				
S-2	SLO-1	*Host level security*	*NIST cloud computing Reference Architecture*	*non-repudiation, availability,*	*virtualization-based sandboxing*	*Client access in cloud*
	SLO-2	*Application level security*				
S-3	SLO-1	*Data security and Storage*	*Public ,Private and Hybrid Cloud*	*access control, defence in depth, least privilege,*	*Cloud Storage*	*Cloud contracting Model*
	SLO-2		*IaaS,PaaS,SaaS*			
S-4	SLO-1	*Data privacy and security Issues,*	*Architectural design Challenges*	*How these concepts apply in the cloud, what these concepts mean and their importance in PaaS, IaaS and SaaS.*	*Security- HIDPS*	*Commercial and business considerations*
	SLO-2					
S-5	SLO-1	*Jurisdictional issues raised by Data location*	*Cloud Storage*	*Cryptographic Systems- Symmetric cryptography*	*log management*	*Case Study on Open Source & Commercial Clouds*
	SLO-2					
S-6	SLO-1	*Identity & Access Management*	*Storage-as-a-service*	*stream ciphers, block ciphers, modes of operation*	*Data Loss Prevention*	*X.509 certificates, OpenSSL.*
	SLO-2					
S-7	SLO-1	*Access Control*	*Advantages of Cloud storage*	*Public-key cryptography, hashing*	*Security Governance*	*Eucalyptus*
	SLO-2					
S-8	SLO-1	*Trust, Reputation*	*Cloud storage Provider*	*digital signatures, public-key infrastructures*	*Cloud security Challenges*	*Microsoft Azure*
	SLO-2					
S-9	SLO-1	*Risk*	*Storage Provider-S3*	*key management*	*Virtual Machine Security*	*Amazon EC2*
	SLO-2					

Learning Resources	1. *Tim Mather, SubraKumaraswamy, ShahedLatif, "Cloud Security and Privacy:An Enterprise Perspective on Risks and Compliance" O'Reilly Media; 1edition [ISBN: 0596802765], 2009.* 2. *Rittinghouse, John W., and James F. Ransome, —Cloud Computing: Implementation, Management and Security, CRC Press, 2017.* 3. *Kai Hwang, Geoffrey C Fox, Jack G Dongarra, "Distributed and Cloud Computing, From Parallel Processing to the Internet of Things", Morgan Kaufmann Publishers, 2012.*	4. *Ronald L. Krutz, Russell Dean Vines, "Cloud Security" [ISBN: 0470589876],2010.* 5. *Toby Velte, Anthony Velte, Robert Elsenpeter, "Cloud Computing – A Practical Approach, Tata Mcgraw Hill, 2009.* 6. *George Reese, "Cloud Application Architectures: Building Applications and Infrastructure in the Cloud: Transactional Systems for EC2 and Beyond (Theory in Practice), O'Reilly, 2009.*

Learning Assessment											
	Bloom's Level of Thinking	Continuous Learning Assessment (50% weightage)								Final Examination (50% weightage)	
		CLA – 1 (10%)		CLA – 2 (15%)		CLA – 3 (15%)		CLA – 4 (10%)#			
		Theory	Practice	Theory	Practice	Theory	Practice	Theory	Practice	Theory	Practice
Level 1	Remember Understand	40%	-	30%	-	30%	-	30%	-	30%	-
Level 2	Apply Analyze	40%	-	40%	-	40%	-	40%	-	40%	-
Level 3	Evaluate Create	20%	-	30%	-	30%	-	30%	-	30%	-
	Total	100 %		100 %		100 %		100 %		100%	

CLA – 4 can be from any combination of these: Assignments, Seminars, Tech Talks, Mini-Projects, Case-Studies, Self-Study, MOOCs, Certifications, Conf. Paper etc.,

Course Designers		
Experts from Industry	Experts from Higher Technical Institutions	Internal Experts
Mr.T.Madhan, Team Leader, Tata Consultancy Services, siruseri Campus, Chennai.	*Dr. R.Shyamala, Associate Professor [HOD-IT],* *Anna University College of Engineering Tindivanam.*	*1. Dr.R.Naresh*
		2. Dr.MB.Mukesh krishnan

Course Code	18CSE443T	Course Name	BIG DATA ANALYTICS	Course Category	E	Professional Elective	L	T	P	C
							3	0	0	3

Pre-requisite Courses	Nil	Co-requisite Courses	Nil	Progressive Courses	Nil
Course Offering Department	Computer Science and Engineering	Data Book / Codes/Standards	Nil		

Course Learning Rationale (CLR):	*The purpose of learning this course is to:*
CLR-1 :	*Quick and easy approach to learn the fundamental concept of big data analytics*
CLR-2 :	*Understand the concept of Hadoop and installation*
CLR-3 :	*Get to know the concept of key value pair programming*
CLR-4 :	*Learn about Map Reduce and its features*
CLR-5 :	*Understanding and solving of case studies*

		Learning			Program Learning Outcomes (PLO)														
		1	2	3	1	2	3	4	5	6	7	8	9	10	11	12	13	14	15
Course Learning Outcomes (CLO):	*At the end of this course, learners will be able to:*	Level of Thinking (Bloom)	Expected Proficiency (%)	Expected Attainment (%)	Engineering Knowledge	Problem Analysis	Design & Development	Analysis, Design, Research	Modern Tool Usage	Society & Culture	Environment & Sustainability	Ethics	Individual & Team Work	Communication	Project Mgt. & Finance	Life Long Learning	PSO - 1	PSO - 2	PSO – 3
CLO-1 :	*The main objective is to provide the students the knowledge of big data analytics*	*1*	*90*	*85*	*L*	-	-	*M*	-	-	-	-	-	-	-	*H*	*L*	-	-
CLO-2 :	*The students are trained to have knowledge about the architecture, installation and command execution of Hadoop*	*3*	*85*	*80*	*M*	*M*	*H*	*H*	*H*	-	-	-	-	-	-	*H*	*M*	*H*	-
CLO-3 :	*Able to develop a Map Reduce application*	*3*	*85*	*80*	*M*	*H*	*H*	*H*	*H*	-	-	-	-	-	-	*H*	*M*	*H*	-
CLO-4 :	*Identify knowledge of Map Reduce and develop real world map reduce application*	*3*	*80*	*75*	*M*	*H*	*H*	*H*	*H*	-	-	-	-	-	-	*H*	*H*	*H*	-
CLO-5 :	*Apply knowledge and solve various case study problems*	*3*	*80*	*75*	*H*	*H*	*H*	*H*	*H*	*H*	-	*M*	-	-	-	*H*	*M*	*H*	*H*

Duration (hour)		9	9	9	9	9
S-1	SLO-1	*Data, Data storage and Analysis*	*Introduction of Big data programming Hadoop, History of Hadoop*	*Introduction of Map Reduce*	*Map Reduce Types*	*Case studies*
	SLO-2	*Comparison with other systems- Distributed computing vs Big data Framework*	*The eco system and stack*	*Configuration API*	*Default Map Reduce map*	*Healthcare*
S-2	SLO-1	*Basis of Distributed computing, Need for Big data framework*	*The Hadoop Distributed File System (HDFS)*	*Configuring the Development Environment, Writing a Unit Test, Running Locally on Test Data*	*Input Formats*	*Telecom*
	SLO-2					
S-3	SLO-1	*Introduction to Big Data- Big data definition*	*Hadoop file system*	*Running on a Cluster*	*Output formats*	*Privacy preserving Data analytics: Smart Homes*
	SLO-2	*enterprise / structured data, social / unstructured data, unstructured data needs for analytics*	*Java interfaces to HDFS*	*Running on a Cluster*	*Output formats*	*Privacy preserving Data analytics: Smart Homes*
S 4-5	SLO-1	*What is Big Data, Big Deal about Big Data*	*Architecture overview*	*Tuning a Job ,Map Reduce Workflows How Map Reduce Works, The Map Reduce Anatomy of a Map Reduce Job run*	*Map reduce features- counters, built in counters, user defined java and streams counters*	*Data analytics in Intelligent transport system*
	SLO-2					
S-6	SLO-1	*Big Data Sources, Industries using Big Data, Big Data challenges.*	*Hadoop installation*	*Failures, Job Scheduling*	*Sorting*	*Detection and identification of influential spreaders in social media data streams*
	SLO-2					
S-7	SLO-1	*Big Data Technology*	*Hadoop commands execution*	*Shuffle and Sort*	*Joins*	*Predictive analytics in insurance*
	SLO-2	*Old vs. New Approaches*	*Hadoop commands execution*	*The Map Side*	*Programming Real-World Map Reduce*	*Predictive analytics in insurance*
S-8	SLO-1	*Data Discovery*	*Hadoop I/O*	*The Reduce Side, Configuration Tuning*	*Weather dataset*	*Pricing analytics in consumer products*
	SLO-2	*Open-Source Technology for Big Data Analytics*	*Data Integrity*	*Task Execution*	*data with Unix*	*Pricing analytics in consumer products*
S 9	SLO-1	*The Cloud and Big Data*	*Compression*	*Task Execution*	*data with Hadoop*	*Analytics in banking sector*

	SLO-2					

Learning Resources	1. *MichaelMinelli,Michele Chambers,AmbigaDhiraj,"BigData,BigAnalytics-Emerging Business Intelligence and Analytic Trends forToday's Businesses",Wiley.* 2. *TomWhite,"Hadoop–TheDefinitiveGuide",O'Reilly* 3. *FrankOhlhorst,"BigDataAnalytics-TurningBigDataintoBigMoney",Wiley* 4. *AlanAderson,David Semmelroth,"Statistics for BigData for Dummies",JohnWiley&sons*	

Learning Assessment

	Bloom's Level of Thinking	Continuous Learning Assessment (50%								Final Examination (50% weightage)	
		CLA – 1 (10%)		CLA – 2 (15%)		CLA – 3 (15%)		CLA – 4 (10%)#			
		Theory	Practice	Theory	Practice	Theory	Practice	Theory	Practice	Theory	Practice
Level 1	Remember Understand	*40 %*	-	*30 %*	-	*30 %*	-	*30 %*	-	*30%*	-
Level 2	Apply Analyze	*40 %*	-	*40 %*	-	*40 %*	-	*40 %*	-	*40%*	-
Level 3	Evaluate Create	*20 %*	-	*30 %*	-	*30 %*	-	*30 %*	-	*30%*	-
	Total	100 %		100 %		100 %		100 %		100 %	

CLA – 4 can be from any combination of these: Assignments, Seminars, Tech Talks, Mini-Projects, Case-Studies, Self-Study, MOOCs, Certifications, Conf. Paper etc.,

Course Designers		
Experts from Industry	Experts from Higher Technical Institutions	Internal Experts
		Dr. B.Amutha, Professor and Head, Department of CSE, SRM IST
		Dr. G.Vadivu, Professor and Head, Department of IT, SRM IST

Course Code	18CSE444T	Course Name	CLOUD STRATEGY PLANNING AND MANAGEMENT	Course Category	E	Professional Elective	L	T	P	C
							3	0	0	3

Pre-requisite Courses	Nil	Co-requisite Courses	Nil	Progressive Courses	Nil
Course Offering Department	Computer Science and Engineering	Data Book / Codes/Standards	Nil		

Course Learning Rationale (CLR):	*The purpose of learning this course is to:*
CLR-1 :	*To learn the concepts and technological advances fueling the rapid adoption of cloud computing today.*
CLR-2 :	*To provide the students with the skills and knowledge required to plan and manage a Cloud Computing strategy within an organization.*
CLR-3 :	*To enable students to evaluate the strategic value of Cloud Computing using IT Governance and Compliance.*

Course Learning Outcomes (CLO):	*At the end of this course, learners will be able to:*	Learning 1	Learning 2	Learning 3	PLO 1	PLO 2	PLO 3	PLO 4	PLO 5	PLO 6	PLO 7	PLO 8	PLO 9	PLO 10	PLO 11	PLO 12	PLO 13	PLO 14	PLO 15
		Level of Thinking (Bloom)	Expected Proficiency (%)	Expected Attainment (%)	Engineering Knowledge	Problem Analysis	Design & Development	Analysis, Design, Research	Modern Tool Usage	Society & Culture	Environment & Sustainability	Ethics	Individual & Team Work	Communication	Project Mgt. & Finance	Life Long Learning	PSO - 1	PSO - 2	PSO – 3
CLO-1 :	*Strategically assess how cloud computing enables IT Transformation and business value in an organization.*	2	80	85	H	-	-	-	-	-	-	-	-	-	-	-	-	-	-
CLO-2 :	*Analyze the role that cloud computing can play in the business process.*	2	75	80	H	H	-	-	-	-	-	-	-	-	-	-	-	-	-
CLO-3 :	*Evaluate how cloud computing and Service Oriented Architecture (SOA) can deliver business agility.*	2	85	80	H	-	-	-	-	-	-	-	-	-	-	-	-	-	-
CLO-4 :	*Implement IT governance to manage business realization from cloud IT services.*	2	80	75	H	H	-	-	-	-	-	-	-	-	-	-	-	-	-
CLO-5 :	*Critically appraise how the incorporation of cloud computing in an IT strategy can deliver on strategic business objectives.*	2	75	85	H	-	-	H	-	-	-	-	-	-	-	-	-	-	-

Duration (hour)		9	9	9	9	9
S-1	SLO-1	*The four pillars of cloud computing*	*Moving to a cloud architecture and strategy to achieve business value.*	*Develop an IT strategy to deliver on strategic business objectives in the business strategy*	*Shared services delivered by a Service Oriented Architecture (SOA) in a Private or Public Cloud*	*Benefit Realization and it Governance*
	SLO-2	*Cloud applications and Platforms*				
S-2	SLO-1	*Providing the cloud infrastructure*	*BPM, IS, Porter's Value chain model and BPR as a means of delivering business value*	*IT Project planning in the areas of ITaaS is essential in delivering a successful strategic IT Plan*	*Services, Databases and Applications on demand*	*Managing resources (people, process, technology), to realize benefit from Private/Public Cloud IT services*
	SLO-2	*Cloud computing, Spectral efficiency, Sensors and perspiration*				
S-3	SLO-1	*Strategic inflection points in information Technology*	*Developing Business Strategy: Investigate business strategy models to gain competitive advantage for organizations*	*IT Project planning in the areas of SaaSis essential in delivering a successful strategic IT Plan*	*The effect on Enterprise Architecture and its traditional frameworks such as Zachman).*	*Gartner's 5 pillars of benefit realization*
	SLO-2	*Cloud computing and its slogans*	*SWOT/PEST, Economies of scale, Porter's 3 Strategies and 5 Competitive Forces, D'Aveni's hyper competition models*	*IT Project planning in the areas of PaaSis essential in delivering a successful strategic IT Plan*	*The Open Group Architecture Framework (TOGAF).*	*IT governance as a service in measuring the delivery of IT Strategy from Cloud IT Services using Sarbannes Oxley (CobiT) and other commonly-used approaches*
S-4	SLO-1	*User centered solution and cloud computing*	*Emphasize the roles of the strategic IS/IT leaders such as Chief Information Officer (CIO)*	*IT Project planning in the areas of IaaSis essential in delivering a successful strategic IT Plan*	*Customer Relationship Management*	*High Technology for private banking and Asset Management*
	SLO-2	*For cloud vendors inflection point Is risk and opportunity*				
S-5	SLO-1	*Potential customers of cloud technology*	*The Chief Technology Officer (CTO) in planning and managing IT Strategic development in the organization.*	*Searching for an open architecture*	*Enterprise Resource Planning*	*Cloud Software for Private Banking*
	SLO-2					
S-6	SLO-1	*The cloud interests Small and Medium enterprises*	*Budgeting for cloud computing*	*Infrastructure as a Utility*	*Just-in-Time Inventories*	*Leadership Is based on Fundamentals*
	SLO-2					
S-7	SLO-1	*Virtual companies and the cloud*	*Service level agreements*	*Cloud System Architecture and its primitives*	*Machine-to-Machine and RFID Communications*	*Cloud Software For Asset Management*
	SLO-2	*Virtual networked objects*				

S-8	SLO-1 SLO-2	Consumer technologies and the cloud	Outsourcing, Infrastructural inter dependencies, and the cloud	The User Organizations Business Architecture	Challenges Presented by Organization	Cloud Technology can Improve Fund Management
S-9	SLO-1	Social networks and multimedia messaging	Human resources at the CIO level	Financial Services Applications Architecture	Challenges Presented by Commercial vision	Criteria of Success in Asset Management Technology
	SLO-2		*The transition from legacy to competitive system*			

Learning Resources	1. *Dimitris N. Chorafas: Cloud Computing Strategies, CRC Press, 2011.* 2. *Arnold J Cummins, "Easiest Ever Guide to Strategic IT Planning" http://strategicitplanningguide.com/.*	3. *David S. Linthicum, "Cloud Computing and SOA Convergence in Your Enterprise", Addison Wesley [ISBN: 0136009220], 2009.* 4. *Charles Babcock, "Management Strategies for the Cloud Revolution", 1st Ed., Tata McGraw/Hill [ISBN: 0071740759],2010.*

Learning Assessment

	Bloom's Level of Thinking	Continuous Learning Assessment (50% weightage)								Final Examination (50% weightage)	
		CLA – 1 (10%)		CLA – 2 (15%)		CLA – 3 (15%)		CLA – 4 (10%)#			
		Theory	Practice	Theory	Practice	Theory	Practice	Theory	Practice	Theory	Practice
Level 1	Remember Understand	*40 %*	-	*30 %*	-	*30 %*	-	*30 %*	-	*30%*	-
Level 2	Apply Analyze	*40 %*	-	*40 %*	-	*40 %*	-	*40 %*	-	*40%*	-
Level 3	Evaluate Create	*20 %*	-	*30 %*	-	*30 %*	-	*30 %*	-	*30%*	-
	Total	100 %		100 %		100 %		100 %		100 %	

CLA – 4 can be from any combination of these: Assignments, Seminars, Tech Talks, Mini-Projects, Case-Studies, Self-Study, MOOCs, Certifications, Conf. Paper etc.,

Course Designers		
Experts from Industry	Experts from Higher Technical Institutions	Internal Experts
Mr.Saju G Nair, IBM,Bangalore,sajugnair@gmail.com	*Dr.Khanna Nehemiah H,* *Professor, Ramanujan Computing Centre, Anna University*	*Mrs.J D Dorathi Jayaseeli,CSE,SRM IST*

Course Code	18CSE375T	Course Name	DISTRIBUTED COMPUTING	Course Category	E	Professional Elective	L	T	P	C
							3	0	0	3

Pre-requisite Courses	Nil	Co-requisite Courses	Nil	Progressive Courses	Nil
Course Offering	CSE	Data Book /	Nil		

Course Learning Rationale (CLR):	*The purpose of learning this course is to:*	Learning			Program Learning Outcomes (PLO)														
		1	2	3	1	2	3	4	5	6	7	8	9	10	11	12	13	14	15
CLR-1 :	*Layout foundations of Distributed Systems.*																		
CLR-2 :	*Get familiar with the idea of middleware and related issues*																		
CLR-3 :	*Understand in detail the system level and support required for distributed system*																		
CLR-4 :	*Understand the issues involved in studying data and cryptographic algorithms*																		
CLR-5 :	*Expose to the concept of design and implementation of distributed file systems*																		
Course Learning Outcomes (CLO):	*At the end of this course, learners will be able to:*	Level of Thinking (Bloom)	Expected Proficiency (%)	Expected Attainment (%)	Engineering Knowledge	Problem Analysis	Design & Development	Analysis, Design, Research	Modern Tool Usage	Society & Culture	Environment & Sustainability	Ethics	Individual & Team Work	Communication	Project Mgt. & Finance	Life Long Learning	PSO - 1	PSO - 2	PSO – 3
CLO-1 :	*Fundamentals of Distributed System Concepts and access System*	2	80	85	H	-	-	-	-	-	-	-	-	-	-	-	-	-	-
CLO-2 :	*An ability to familiar with various architecture models and Distributed File access techniques*	2	75	80	H	H	-	-	-	-	-	-	-	-	-	-	-	-	-
CLO-3 :	*An ability to understand the security aspects of distributed system*	2	85	80	H	-	-	-	-	-	-	-	-	-	-	-	-	-	-

Duration (hour)		9	9	9	9	9
S-1	SLO-1	*Introduction to Distributed Systems*	*Distributed Computing Model*	*Remote Procedure Call*	*Introduction of Security systems in distributed system*	*Distributed File Systems –Introduction*
	SLO-2				*Potential attacks and threats on computer systems*	
S-2	SLO-1	*Characterization of Distributed Systems*	*Workstation model*	*Remote method invocation*	*Cryptography*	*File Service Architecture*
	SLO-2	*Examples of Distributed Systems*	*Workstation server model*		*Symmetric cryptosystem algorithm –DES*	
S-3	SLO-1	*Architecture of Distributed Systems*	*Process pool model*	*Client server model basics concepts*	*Asymmetric cryptosystems*	*File Models*
	SLO-2	*Shared and Distributed Memory Architechture*	*Comparison of Distributed computing model*	*Client server addressing*		
S-4	SLO-1	*Focus on resource sharing the web*	*Interprocess Communication*	*Client server implementations*	*Secure Channels-Authentication*	*DFS Design*
	SLO-2				*Message Integrity and confidentiality*	
S-5	SLO-1	*Challenges in Distributed Systems*	*External data representation and multicast Communication*	*Client Server Architecture*	*Access control*	*DFS implementation*
	SLO-2					
S-6	SLO-1	*Design issues in Distributed systems*	*API for Internet protocol*	*Group Communication publish and subscribe systems*	*Security Management*	*File catching in DFS*
	SLO-2				*Issues in key distribution*	
S-7	SLO-1	*Networking and Internetworking basic introduction Types of Network*	*Network Virtivalization and overlay networks*	*Shared memory approach*	*Secure group management*	*Implementation in DFS*
	SLO-2			*Distributed objects*	*Authorization management*	
S-8	SLO-1	*Network Principles*	*Case Study : interprocess Communication in UNIX*	*Case study : java RMI*	*Case study - Kerberos*	*Case study – Sun network File systems*
	SLO-2					
S-9	SLO-1	*Internet protocol*	*Case study - MPI*	*Case Study - CORBA*	*Case study - Epayment*	*Case study - Google File systems*
	SLO-2					

Learning Resources	1. GeorgeCoulouris,JeanDollimore,TimKindberg,"DistributedSystemsConceptsandDesign"Fifth edition – 2011- AddisonWesley 2. SunitaMahajan,SeemaShah,"DistributedComputing"SecoundEdition–OxfordPress	3. Liu M.L., "Distributed Computing, Principles and Applications", Pearson and education,2004. 4. Tanenbaum A.S., Van Steen M., " Distributed Systems: Principles and Paradigms" , PearsonEducation,2007.

Learning Assessment

	Bloom's Level of Thinking	Continuous Learning Assessment (50%								Final Examination (50% weightage)	
		CLA – 1 (10%)		CLA – 2 (15%)		CLA – 3 (15%)		CLA – 4 (10%)#			
		Theory	Practice	Theory	Practice	Theory	Practice	Theory	Practice	Theory	Practice
Level 1	Remember Understand	*40 %*	-	*30 %*	-	*30 %*	-	*30 %*	-	*30%*	-
Level 2	Apply Analyze	*40 %*	-	*40 %*	-	*40 %*	-	*40 %*	-	*40%*	-
Level 3	Evaluate Create	*20 %*	-	*30 %*	-	*30 %*	-	*30 %*	-	*30%*	-
	Total	100 %		100 %		100 %		100 %		100 %	

CLA – 4 can be from any combination of these: Assignments, Seminars, Tech Talks, Mini-Projects, Case-Studies, Self-Study, MOOCs, Certifications, Conf. Paper etc.,

Course Designers		
Experts from Industry	Experts from Higher Technical Institutions	Internal Experts
1. Mr. M.Ravichandran,CEO, Terafast	*1.. Dr.K.Vivekanadan, Professor,PEC,k.vivekanandan@pec.edu*	*1. Dr. A.Murugan , SRMIST*
		2. Dr. G.Maragatham,SRMIST *3. Ms. S. Aruna ,SRMIST*

Course Code	18CSE376T	Course Name	OPTICAL NETWORKS	Course Category	E	Professional Elective	L	T	P	C
							3	0	0	3

Pre-requisite Courses	Nil	Co-requisite Courses	Nil	Progressive Courses	Nil
Course Offering Department	CSE	Data Book / Codes/Standards	Nil		

Course Learning Rationale (CLR):	*The purpose of learning this course is to:*
CLR-1 :	*Study the fundamentals of optical networks*
CLR-2 :	*Gather knowledge about different types of components*
CLR-3 :	*Learn single hop and multi hop networks*
CLR-4 :	*Acquire knowledge about different WDM network design*
CLR-5 :	*Understand about OADM architecture*
CLR-6 :	*Gather knowledge about optical TDM and CDMA*

Course Learning Outcomes (CLO):	*At the end of this course, learners will be able to:*	Learning 1 Level of Thinking (Bloom)	2 Expected Proficiency (%)	3 Expected Attainment (%)	PLO 1 Engineering Knowledge	2 Problem Analysis	3 Design & Development	4 Analysis, Design, Research	5 Modern Tool Usage	6 Society & Culture	7 Environment & Sustainability	8 Ethics	9 Individual & Team Work	10 Communication	11 Project Mgt. & Finance	12 Life Long Learning	13 PSO - 1	14 PSO - 2	15 PSO – 3
CLO-1 :	*Acquire knowledge about basic fundamentals of optical networks*	*2*	*80*	*85*	*H*	-	-	-	-	-	-	-	-	-	-	-	-	-	-
CLO-2 :	*Understand various classifications of optical components*	*2*	*75*	*80*	*H*	*H*	-	-	-	-	-	-	-	-	-	-	-	-	-
CLO-3 :	*Develop the ability to apply optical concepts in single and multihop networks*	*2*	*85*	*80*	*H*	-	-	-	-	-	-	-	-	-	-	-	-	-	-
CLO-4 :	*Gather knowledge about various multiplexing techniques*	*2*	*80*	*75*	*H*	*H*	-	-	-	-	-	-	-	-	-	-	-	-	-
CLO-5 :	*Acquire knowledge about OADM concept*	*2*	*75*	*85*	*H*	-	-	*H*	-	-	-	-	-	-	-	-	-	-	-
CLO-6 :	*Apply various techniques to handle spectrum with a different perspective*	*2*	*80*	*85*	*H*	-	-	-	-	-	-	-	-	-	-	-	-	-	-

Duration (hour)		9	9	9	9	9
S-1	SLO-1	*Introduction to optical networks*	*Components :Couplers – Principle of operation*	*Broadcast optical networks – characteristics of single hop networks*	*WDM Network Elements :Optical line terminals*	*Optical TDM Networks*
	SLO-2	*TeleCommunication Network Architecture and services*	*Conservation of energy*	*Experimental WDM Systems*	*optical line amplifiers*	*Basics of TDM*
S-2	SLO-1	*Optical Networks- Multiplexing Techniques*	*Isolators*	*Other Non – Pretransmission Coordination protocols*	*Optical Add/Drop Multiplexers*	*Optical TDM*
	SLO-2	*Second Generation Optical Networks*	*Circulators*	*Pretransmission coordination protocols*	*OADM Architecture*	*Optical Sources*
S-3	SLO-1	*Optical Layer*	*Multiplexers – Gratings, Diffraction Patterns*	*Special Case: Linear Bus with Attempt- and-Defer Nodes*	*Optical crossconnects*	*Modulation*
	SLO-2	*Optical packet switching*	*Bragg and Fiber Gratings*	*AMTRAC and multichannel probabilistic scheduling*	*OXC Configurations*	*multiplexing*
S-4	SLO-1	*Transmission Basics – wavelengths, Frequencies, and channel spacing*	*Filters – fabryperot filters*	*Single- Hop Case study : IBM Rainbow Protocol*	*WDM Network Design: Cost trade-offs*	*Transmission of Ultrafast OTDM signal using soliton*
	SLO-2	*Standards, optical power and loss*	*Mach-Zehnder Interferometers, Arrayed Waveguide gratings*	*Model, Analysis*	*LTD and RWA problems*	*Demultiplexing*
S-5	SLO-1	*WDM Networking Evolutions*	*Optical Amplifiers – Emissions*	*Multihop Networks: characteristics, topological optimization studies*	*Light path topology design*	*Clock Recovery*
	SLO-2	*WDM Network Constructions*	*Erbium -Doped fiber amplifiers, Raman Amplifiers and Semiconductor optical amplifiers*	*Regular structures*	*Routing and wavelength assignment and conversion*	*Optical processing*
S-6	SLO-1	*Optical Fiber- Transmission*	*Transmitters – Lasers, Light emitting diodes,tunable lasers*	*Near- Optimal Node Placement*	*Dimensioning Wavelength*	*Optical TDM network Architectures*
	SLO-2	*Single mode vs Multimode fiber*	*Direct and external modulation, pump sources*	*Shared- channel multihop systems*	*Routing Networks*	*Optical TDM proposals*
S-7	SLO-1	*Attenuation in Fiber*	*Detectors – photo detectors*	*Multihop case study – GEMNET*	*Statistical Dimensioning Models : First passage model*	*Optical CDMA Networks:*
	SLO-2	*Dispersion in Fiber*	*Front end amplifiers*	*GEMNET Architecture and properties*	*Blocking model*	*Basics of CDMA*

S-8	SLO-1	Non Linear Effects – self phase modulation	Switches – large optical switches, optical switch technologies	Channel sharing	Maximum load dimensioning model : offline lightpath requests	Spread spectrum
	SLO-2	Cross phase modulation	Large electronic switches	Multicasting	Online RWA in rings	Code sequences
S-9	SLO-1	Solitons	Wavelength converters – optoelectronic Approach, optical gating	Shared – channel Multihop GEMNET	Access Networks : Network Architecture overview	CDMA Example
	SLO-2	Dispersion- Managed Solitons	Interferometric techniques, wave mixing	Performance Evaluation	Enhanced HFC	Optical CDMA

Learning Resources	1. Rajiv Ramaswami, Kumar N. Sivarajan, Galen H. Sasaki, Optical Networks A Practical Perspective, thirdEdition 2. OpticalSwitchingNetworks:Mayer&Martin,CambridgeUniversityPress,2008.	3. U.Black,"OpticalNetworks:ThirdGenerationTransportSystems"/PearsonEducations 4. R.Ramaswami,&K.N.Sivarajan,"OpticalNetworksaPracticalperspective",MorganKaufmann Publishers, 3rdEd.

Learning Assessment

	Bloom's Level of Thinking	Continuous Learning Assessment (50%								Final Examination (50% weightage)	
		CLA – 1 (10%)		CLA – 2 (15%)		CLA – 3 (15%)		CLA – 4 (10%)#			
		Theory	Practice	Theory	Practice	Theory	Practice	Theory	Practice	Theory	Practice
Level 1	Remember Understand	40 %	-	30 %	-	30 %	-	30 %	-	30%	-
Level 2	Apply Analyze	40 %	-	40 %	-	40 %	-	40 %	-	40%	-
Level 3	Evaluate Create	20 %	-	30 %	-	30 %	-	30 %	-	30%	-
	Total	100 %		100 %		100 %		100 %		100 %	

CLA – 4 can be from any combination of these: Assignments, Seminars, Tech Talks, Mini-Projects, Case-Studies, Self-Study, MOOCs, Certifications, Conf. Paper etc.,

Course Designers

Experts from Industry	Experts from Higher Technical Institutions	Internal Experts
1. Mr. Madhumaran, NOKIA digital and Networking, Technical Lead, p.madhumaran@nokia.com	1. Prof. NilanjanDey, Techno India College of Technology , Kolkata, nilanjan.dey@tict.edu.in	1. Prof. V.Sivakumar, SRMIST
2. Mr. N.Ramkumar, TCS Assistant Consultant, ram.kumarn@tcs.com	2. Prof. E.Rajesh, GalgotiasUniversity,Delhi, rajesh.e@galgotiasuniversity.edu.in	2. Prof. P.Visalakshi, SRMIST

Course Code	18CSE379T	Course Name	INTERNET OF THINGS	Course Category	E	Professional Elective	L	T	P	C
							3	0	0	3

Pre-requisite Courses	Nil	Co-requisite Courses	Nil	Progressive Courses	Nil
Course Offering Department	CSE	Data Book / Codes/Standards	Nil		

Course Learning Rationale (CLR):	*The purpose of learning this course is to:*
CLR-1 :	*Understand the basic concepts of IoT and its possible application areas*
CLR-2 :	*Understand the various IoT architectures along with compute and management stack across layers*
CLR-3 :	*Understand the architecture dissected at physical, Communication and Access levels*
CLR-4 :	*Introduce existing toolkits, available platforms, boards, software and laguages for easy development of IoT products*
CLR-5 :	*Understand the various enabling technologies for IoT including Big data analytics, Machine learning, Cloud and Streaming analytics*
CLR-6 :	*Understand the underlying business model for IoT and also acquire skills for DiY (Do it Yourself)*

Course Learning Outcomes (CLO):	*At the end of this course, learners will be able to:*	Learning			Program Learning Outcomes (PLO)														
		1	2	3	1	2	3	4	5	6	7	8	9	10	11	12	13	14	15
		Level of Thinking (Bloom)	Expected Proficiency (%)	Expected Attainment (%)	Engineering Knowledge	Problem Analysis	Design & Development	Analysis, Design, Research	Modern Tool Usage	Society & Culture	Environment & Sustainability	Ethics	Individual & Team Work	Communication	Project Mgt. & Finance	Life Long Learning	PSO - 1	PSO - 2	PSO – 3
CLO-1 :	*Appreciate the omnipotent presence of IoT in all fields across globe*	*2*	*80*	*85*	*H*	-	-	-	-	-	-	-	-	-	-	-	-	-	-
CLO-2 :	*Compare and contrast various architectures and be able to justify the right choice for adoption*	*2*	*75*	*80*	*H*	*H*	-	-	-	-	-	-	-	-	-	-	-	-	-
CLO-3 :	*Choose appropriate protocols for various levels/layers based on the requirement in hand*	*2*	*85*	*80*	*H*	*M*	-	-	-	-	-	-	-	-	-	-	-	-	-
CLO-4 :	*Implement using the available resources and demonstrate quick to deployment sills wherever applicable*	*2*	*80*	*75*	*H*	*H*	*H*	*M*	-	-	-	-	-	-	-	-	-	-	-
CLO-5 :	*Apply the tools and techniques towards integration in relevant areas of IoT product development*	*2*	*75*	*85*	*H*	*M*	*H*	*M*	*H*	-	-	-	*M*	-	-	*H*	-	-	-
CLO-6 :	*Showcase DiY approach given any implementable idea to product*	*2*	*80*	*85*	*H*	*M*	*H*	*H*	*H*	-	-	-	*H*	-	-	*H*	-	-	-

Duration (hour)		9	9	9	9	9
S-1	SLO-1	*Introduction to IOT*	*Drivers Behind New Network Architectures*	*Smart Objects: The "Things" in IoT*	*Data Analytics for IoT- Overview*	*Business Models for IoT: Introduction*
	SLO-2	*What, Where and How of IoT?*	*Comparing IoT Architectures*	*Sensors, Actuators, and Smart Objects*	*IoT Data Analytics Challenges*	*Business Models*
S-2	SLO-1	*Data Flow of IoT*	*The IoT World Forum (IoTWF) Standardized Architecture*	*Micro-Electro-Mechanical Systems (MEMS)*	*Relevance of ML and IoT- Overview*	*Business Model Innovation*
	SLO-2	*Definition and characteristics of IOT*	*IT and OT Responsibilities in the IoT Reference Model*	*Smart Objects,Smart Objects: A Definition*	*Relevance of Big data and IoT- Overview*	*Value Creation in IoT*
S-3	SLO-1	*Architecture of Internet of Things: Physical-Things*	*A simplified IoT architecture*	*Trends in Smart Objects*	*ML and getting Intelligence from Big Data*	*Laws of Information*
	SLO-2	*Architecture of Internet of Things: Protocols-an Introduction*	*The core IoT functional stack*	*Sensor Networks*	*Big data analytics tools and techniques for IoT: Overview*	*Revenue Generation in the Internet of Things*
S-4	SLO-1	*Architecture of Internet of Things: Logical-Functional Blocks*	*Layer 1: Things: Sensors Layer*	*Wireless Sensor Networks (WSNs)*	*MPP, NoSQL*	*Exemplary Business Model Scenarios for the Internet of Things*
	SLO-2	*Architecture of Internet of Things: Logical-Communication Models*	*Layer 1: Things: Actuators Layer*	*Communication Protocols for WirelessSensor Networks- a Introduction*	*Hadoop and YARN*	*Scenario 1: Product as a Service (PaaS)*
S-5	SLO-1	*Architecture of Internet of Things: Logical-Communication API*	*Layer 2: Communications Network Layer: Access, Gateway*	*Communication Criteria- Introduction*	*Hadoop Eco system*	*Scenario 2: Information Service Providers*
	SLO-2	*IOT enabling technologies*	*Layer 2: Communications Network Layer: Network, Management*	*Communication Criteria- Definitions*	*Apache Kafk, Spark, Storm, Flink,*	*Scenario 3: End-user Involvement*
S-6	SLO-1	*Introduction to IoT Levels and Deployments*	*Layer 3: Applications and Analytics Layer:*	*IoT Access Technologies-Introduction*	*Lamba Architecture*	*Scenario 4: Right-time Business Analysis and Decision making*
	SLO-2	*IoT Deployment Levels: 1 to 6*	*Analytics Versus Control Applications,*	*IoT Access Technologies-Definitions*	*Edge Streaming Analytics for IoT*	*DIY- Smart Experience (DiYSE) Projects- a introduction*

S-7	SLO-1	*IoT Security and Privacy*	*Data Versus Network Analytics*	*IoT Application transport methods- Definitions*	*Edge Analytics core functions*	*Requirements for Enabling DiY in Eco- awareness Applications*
	SLO-2	*IoT Data Analytics, Protocols*	*Data Analytics Versus Business Benefits*	*The Toolkit Approach for End-user Participation in the Internet of Things:*	*Distributed analytics systems*	*Technologies and Standards Relevant for DiY Eco-awareness*
S-8	SLO-1	*IoT Environmental challenges: excess waste disposal*	*Smart Services*	*Existing Toolkits*	*Network Analytics*	*Sensor-actuator Technologies and Middleware as a Basis for a DiY Service Creation Framework*
	SLO-2	*Legal Challenges for a Privacy Framework- an IoT perspective*	*Iot Data Management And Compute Stack: The Hierarchy Of Edge, Fog, And Cloud*	*I/O Boards*	*IoT physical servers and cloud offerings (Cloud computing for IoT)*	*Device Integration, Middleware Technologies*
S-9	SLO-1	*Privacy Enhancing Technologies for IoT*	*Fog Computing*	*HW Based Systems, Introduction to Open source boards (Arduino, Raspberry Pi and other variants)*	*Relevance of Cloud connectivity and IoT- Overview*	*Semantic Interoperabity- a requirement for IoT DiY*
	SLO-2	*Case Studies: Domain specific IOT Applications*	*Edge Computing*	*SW Based Solutions*	*Logical design using Python, Useful IoT libraries*	*DiY Smart Experiences Service Framework-an Introduction*

Learning Resources	1. *ArshdeepBahga, Vijay Madisetti, "Internet of Things, A Hands -on Approach", 1st Edition 2015, University Press, ISBN: 978-81-7371-954-7* 2. *InternetofThings:LegalPerspectivesbyRolfH.Weber,RomanaWeber,Springer,2010* 3. *Uckelmann, D., Harrison, M., & Michahelles, F. (Eds.). Architecting the Internet of Things.doi:10.1007/978-3-642-19157-2 ,2011*	4. *IoT Fundamentals: Networking Technologies, Protocols, and Use Cases for the Internet of Things by Rob Barton, Gonzalo Salgueiro, David Hanes, Publisher: Cisco Press, Release Date: June 2017, ISBN: 9780134307091 (https://www.oreilly.com/library/view/iot-fundamentals-networking/9780134307091/)*

Learning Assessment

	Bloom's Level of Thinking	Continuous Learning Assessment (50%								Final Examination (50% weightage)	
		CLA – 1 (10%)		CLA – 2 (15%)		CLA – 3 (15%)		CLA – 4 (10%)#			
		Theory	Practice	Theory	Practice	Theory	Practice	Theory	Practice	Theory	Practice
Level 1	Remember Understand	40 %	-	30 %	-	30 %	-	30 %	-	30%	-
Level 2	Apply Analyze	40 %	-	40 %	-	40 %	-	40 %	-	40%	-
Level 3	Evaluate Create	20 %	-	30 %	-	30 %	-	30 %	-	30%	-
	Total	100 %		100 %		100 %		100 %		100 %	

CLA – 4 can be from any combination of these: Assignments, Seminars, Tech Talks, Mini-Projects, Case-Studies, Self-Study, MOOCs, Certifications, Conf. Paper etc.,

Course Designers

Experts from Industry	Experts from Higher Technical Institutions	Internal Experts
Dr. Paventhan Arumugum, Director (R&D), ERNET India	*Dr. S. Srinivasan, Professor and Head, Dept. of Computer Science & Engineering, Anna University, Madurai*	*Dr.Kayalvizhi Jayavel, SRMIST*
Mr. Vinay Solanki, Head IoT, Lenovo (APAC & MEA)	*Dr. R. Krishnamoorthy, Professor, Department of CSE and IT, BIT Campus, Anna University, Trichy*	*Dr. Sreekumar, SRMIST*
Mr.Hariharan Ramalingam, Vertical Delivery Head, Wipro ltd	*Dr.S.Chithra Selvaraj, Associate Professor, Department of IT, SSN College of Engineering*	*Mr.V.Haribaabu, SRMIST*

Course Code	18CSE380T	Course Name	PERVASIVE COMPUTING	Course Category	E	Professional Elective	L	T	P	C
							3	0	0	3

Pre-requisite Courses	Nil	Co-requisite Courses	Nil	Progressive Courses	Nil
Course Offering Department	Computer Science and Engineering	Data Book / Codes/Standards	Nil		

Course Learning Rationale (CLR):	*The purpose of learning this course is to:*
CLR-1 :	*Understanding the basics of pervasive computing and its application*
CLR-2 :	*Gain knowledge on the voice enabling*
CLR-3 :	*Understand the fundamental elements of pervasive computing.*
CLR-4 :	*Learn the design process of Pervasive Computing Environments and its solutions*
CLR-5 :	*Familiarize with device connectivity & web applications concepts*
CLR-6 :	*Introduce the concepts of wearale computing and security in pervasive computing*

Course Learning Outcomes (CLO):	*At the end of this course, learners will be able to:*	Learning 1	2	3	Program Learning Outcomes (PLO) 1	2	3	4	5	6	7	8	9	10	11	12	13	14	15
		Level of Thinking (Bloom)	Expected Proficiency (%)	Expected Attainment (%)	Engineering Knowledge	Problem Analysis	Design & Development	Analysis, Design, Research	Modern Tool Usage	Society & Culture	Environment & Sustainability	Ethics	Individual & Team Work	Communication	Project Mgt. & Finance	Life Long Learning	PSO - 1	PSO - 2	PSO – 3
CLO-1 :	*Understand the fundamental elements of pervasive computing.*	*2*	*80*	*85*	*H*	-	-	-	-	-	-	-	-	-	-	-	-	-	-
CLO-2 :	*Learn the design process of Pervasive Computing Environments and its solutions*	*2*	*75*	*80*	*H*	-	-	-	-	-	-	-	-	-	-	-	-	-	-
CLO-3 :	*Familiarize hardware, software and the aspects involved in pervasive computing*	*2*	*80*	*85*	*H*	-	-	-	-	-	-	-	-	-	-	-	-	-	-
CLO-4 :	*Apply the knowledge for implementing security*	*2*	*80*	*75*	*H*	*H*	-	-	-	-	-	-	-	-	-	-	-	-	-
CLO-5 :	*Organize the functionalities and components of PDA in pervasive computing.*	*2*	*75*	*85*	*H*	-	-	*H*	-	-	-	-	-	-	-	-	-	-	-
CLO-6 :	*Describe the user interface issues in pervasive computing.*	*2*	*75*	*80*	*H*	-	-	*M*	-	-	-	-	-	-	-	-	-	-	-

Duration (hour)		9	9	9	9	9
S-1	SLO-1	*- INTRODUCTION*	*Device connectivity*	*WAP & VOICE TECHNOLOGY, WAP and Beyond: Introduction*	*Wearable Computing and Sensor Systems for Healthcare - Introduction*	*Security and Privacy in Pervasive Networks - Introduction*
	SLO-2	*Pervasive Computing: Past, Present and Future Pervasive computing*	*Protocols: wireless*	*Components of the WAP*	*The Health Body Area Network*	*Security Classics - Perimeter Security - Access Control*
S-2	SLO-1	*Pervasive Computing Market,*	*mobile phone technologies*	*architecture*	*Medical and Technological Requirements of Health Sensors*	*Hardening Pervasive Networks - Pervasive Computational Paradigms*
	SLO-2	*m-Business*	*mobile phone technologies*	*WAP infrastructure,*	*Wearable Sensors for Vital Signals Monitoring*	*Pervasive Hardware*
S-3	SLO-1	*Application examples: Retail,*	*mobile internet protocol*	*WAP security issues*	*Wearable Sensors for Activity Recognition*	*Pervasive Networking and Middleware*
	SLO-2	*Application examples: Airline check-in and booking,*	*mobile internet protocol*	*Wireless Markup Language*	*Sensors and Signals for Emotion Recognition*	*Pervasive Applications*
S-4	SLO-1	*Healthcare*	*Synchronization and replication protocol*	*WAP push*	*ntra-BAN Communications in Pervasive Healthcare Systems: Standards and Protocols - IEEE 802.15.4 and ZigBee*	*Pervasive Distributed Application*
	SLO-2	*Tracking, Car information system,*	*Synchronization and replication protocol*	*Products*	*Bluetooth*	*Logic Based Level Security*
S-5	SLO-1	*Sales Force Automation*		*i-Mode*	*Bluetooth Low Energy*	*Deterministic Access Models*
	SLO-2	*Email access via WAP and voice*	*distributed services*	*VoiceTechnology: Basics of Speech recognition,*	*Integrated and Additional Solutions for Health BAN Communications*	*Predictive Statistical Schemes*
S-6	SLO-1	*A Pervasive System for Volcano Monitoring*	*distributed message*	*VoiceTechnology: Basics of Speech recognition,*	*Introduction - Pervasiveness and Mobility in Computing and Communications*	*Privacy in Pervasive Networks - Problem Definition*

	SLO-2	*A Pervasive Computing Platform for Individualized Higher Education*	*transaction protocols*	*Voice Standards*	*Context Awareness*	*Challenges to Privacy Protection*
S-7	SLO-1	*Device Technology*	*Security*	*Voice Standards*	*Heterogeneity*	*Location Dependency*
	SLO-2	*Hardware,*	*Device Management*		*Wireless Technologies and Standards*	*Data Collection*
S-8	SLO-1	*Human machine interface*	*Web Application Concepts: WWW Architecture*	*Speech Applications,*	*Middleware*	*Internet Service Provider (ISP) Role*
	SLO-2	*Bio metrics,*	*Protocols*	*Speech Applications,*	*Future Trends: Beyond the Middleware*	*Data Ownership Private Systems*
S-9	SLO-1	*Operating systems*	*Transcoding*	*Speech and Pervasive Computing*	*Pervasive Computing in Extreme Areas; The Hiker's Personal Digital Assistant*	*Quality of Privacy (QoP)*
	SLO-2	*Java for pervasive devices*	*Client Authentication via Internet*	*Speech and Pervasive Computing*	*Pervasive Computing in Personal Health Systems; The MyHealthService Approach*	*Open Issues in Privacy of Systems 'Sharing' in Personal Networks*

Learning Resources	*1. JochenBurkhardt, Horst Henn, Stefan Hepper, Thomas Schaech & Klaus Rindtorff, "Pervasive Computing, Technology and Architecture of Mobile Internet Applications", Pearson Education,2012.ISBN-13: 978-0201722154* *2. UweHansmann, L. Merk, M. Nicklous, T. Stober, U. Hansmann, "PervasiveComputing (Springer Professional Computing) ", 2003, Springer Verlag,ISBN:3540002189* *3. S. Poslad, "Ubiquitous Computing: Smart Devices, Environments and Interactions," Wiley, 2009*	*4. Frank Adelstein, Sandeep KS Gupta, Golden Richard III, Loren Schwiebert, "Fundamentals of Mobile and Pervasive Computing", McGraw Hill edition, 2006. ISBN-13: 978-0071412377*

Learning Assessment

	Bloom's Level of Thinking	Continuous Learning Assessment (50% weightage)								Final Examination (50% weightage)	
		CLA – 1 (10%)		CLA – 2 (15%)		CLA – 3 (15%)		CLA – 4 (10%)#			
		Theory	Practice	Theory	Practice	Theory	Practice	Theory	Practice	Theory	Practice
Level 1	Remember / Understand	*40 %*	-	*30 %*	-	*30 %*	-	*30 %*	-	*30%*	-
Level 2	Apply / Analyze	*40 %*	-	*40 %*	-	*40 %*	-	*40 %*	-	*40%*	-
Level 3	Evaluate / Create	*20 %*	-	*30 %*	-	*30 %*	-	*30 %*	-	*30%*	-
	Total	100 %		100 %		100 %		100 %		100 %	

CLA – 4 can be from any combination of these: Assignments, Seminars, Tech Talks, Mini-Projects, Case-Studies, Self-Study, MOOCs, Certifications, Conf. Paper etc.,

Course Designers

Experts from Industry	Experts from Higher Technical Institutions	Internal Experts
Suganya Anbumani *Director of Engineering, Wealth Management, Redi2 Technologies* *Greater Boston Area*	*1. Dr. J. Prakash, MIT, Chennai, prakaiit@rediffmail.com*	*1.Dr.V.Kavitha, SRMIST*
Saranya A T *Associate at Cognizant* *Chennai*	*2. 2.Dr. Latha Karthigaa, PhD ,* *Innovation Research Assistant,* *The University of Auckland*	*2. Mr. Haribaabu V, SRMIST*

Course Code	18CSE381T	Course Name	CRYPTOGRAPHY	Course Category	E	Professional Elective	L	T	P	C
							3	0	0	3

Pre-requisite Courses	Nil	Co-requisite Courses	Nil	Progressive Courses	Nil
Course Offering Department	Computer Science and Engineering	Data Book / Codes/Standards	Nil		

Course Learning Rationale (CLR):	*The purpose of learning this course is to:*
CLR-1 :	*Understand OSI security architecture and classical encryption techniques.*
CLR-2 :	*Acquire fundamental knowledge on the concepts of finite fields and number theory*
CLR-3 :	*Understand various block cipher and stream cipher models*
CLR-4 :	*Describe the principles of public key cryptosystems, hash functions and digital signature.*
CLR-5 :	*Gain a first-hand experience on encryption algorithms, encryption modes.*

Course Learning Outcomes (CLO):	*At the end of this course, learners will be able to:*	Learning 1 Level of Thinking (Bloom)	Learning 2 Expected Proficiency (%)	Learning 3 Expected Attainment (%)	PLO 1 Engineering Knowledge	2 Problem Analysis	3 Design & Development	4 Analysis, Design, Research	5 Modern Tool Usage	6 Society & Culture	7 Environment & Sustainability	8 Ethics	9 Individual & Team Work	10 Communication	11 Project Mgt. & Finance	12 Life Long Learning	13 PSO - 1	14 PSO - 2	15 PSO – 3
CLO-1 :	*Implement the Classical Encryption Techniques.*	2	80	85	H									H					
CLO-2 :	*Comprehend fundamental concepts of finite field and number theory.*	2	75	80	H														
CLO-3 :	*Categorize block cipher modes of operation and comprehend digital signature functions*	2	85	80	H														
CLO-4 :	*Implement Public Key Cryptography and hash functions.*	2	80	75	H							H							

Duration (hour)		9	9	9	9	9
S-1	SLO-1	*Introduction to Cryptography and Network Security*	*Groups, Rings, Fields*	*Block cipher principles-Introduction*	*Principles of Public-key Cryptosystems - Structure and key management*	*Message Authentication Codes*
	SLO-2					
S-2	SLO-1	*OSI Security Architecture*	*Modular arithmetic*	*Data Encryption Standard*	*Principles of Public-key Cryptosystems – Applications for Public-key Cryptosystems*	*Requirements for Message Authentication Codes*
	SLO-2					
S-3	SLO-1	*Introduction to Security attacks*	*Euclid's Algorithm*	*DES Example, Strength of DES*	*Requirements for Public-key Cryptosystems and Public – Key Cryptanalysis*	*Applications of Cryptographic Functions - Message Authentication*
	SLO-2					*Two Simple Hash Function*
S-4	SLO-1	*Security mechanisms*	*Polynomial Arithmetic*	*Block cipher Modes of operation – Multiple Encryption*	*RSA algorithm - Key management*	*Security Requirements for Cryptographic hash Functions*
	SLO-2					
S-5	SLO-1	*Symmetric cipher model*	*Finite Fields*	*Block cipher Modes of operation – Triple DES*	*RSA algorithm - Encryption and Decryption*	*Hash Algorithms - MD5*
	SLO-2					
S-6	SLO-1	*Substitution techniques: Caesar cipher*	*Prime Numbers, Testing for Primality*	*Electronic Code Book, Cipher Block Chaining Mode*	*Diffie Hellman key exchange – Algorithm, Key Exchange Protocols*	*Hash Algorithms - SHA*
	SLO-2	*Play fair Cipher*		*Cipher Feedback Mode, Output Feedback Mode and Counter Mode*	*Diffie Hellman key exchange – Man-in-the-Middle Attack*	
S-7	SLO-1	*Mono alphabetic cipher*	*Fermat's and Euler's Theorem*	*Advanced Encryption Standard – Structure and Transformation Functions*	*Elliptic curve: Arithmetic – Abelian Groups, Elliptic Curves over Real Numbers*	*Digital Signature Standard*
	SLO-2	*Poly alphabetic ciphers , Onetime pad*		*AES Key Expansion and AES Example*		
S-8	SLO-1	*Hill Cipher -Encryption*	*The Chinese remainder theorem*	*Blowfish*	*Elliptic Curves over* Z_p*, Elliptic Curves over* $GF(2^m)$	*Applications pertaining to Encryption using different ciphers and modes*
	SLO-2	*Decryption*				
S-9	SLO-1	*Transposition techniques, Steganography*	*Discrete Logarithms*	*RC5 algorithm*	*Elliptic Curve Cryptography*	*One-way hash algorithms.*
	SLO-2					

Learning Resources	1. *WilliamStallings,"CryptographyandNetworkSecurity",6th Edition, 2014,Pearson Education, ISBN:9789332518773.* 2. *AtulKahate,"CryptographyandNetworkSecurity",2nd Edition, 2009, McGraw Hil lEducation India Pvt Ltd,ISBN:100070151458.*	3. *WebTutorial: http://www.cis.syr.edu/~wedu/seed/cryptography.htmlas on 14/04/2016*

Learning Assessment											
	Bloom's Level of Thinking	Continuous Learning Assessment (50% weightage)								Final Examination (50% weightage)	
		CLA – 1 (10%)		CLA – 2 (15%)		CLA – 3 (15%)		CLA – 4 (10%)#			
		Theory	Practice	Theory	Practice	Theory	Practice	Theory	Practice	Theory	Practice
Level 1	Remember Understand	*40 %*	-	*30 %*	-	*30 %*	-	*30 %*	-	*30%*	-
Level 2	Apply Analyze	*40 %*	-	*40 %*	-	*40 %*	-	*40 %*	-	*40%*	-
Level 3	Evaluate Create	*20 %*	-	*30 %*	-	*30 %*	-	*30 %*	-	*30%*	-
	Total	100 %		100 %		100 %		100 %		100 %	

CLA – 4 can be from any combination of these: Assignments, Seminars, Tech Talks, Mini-Projects, Case-Studies, Self-Study, MOOCs, Certifications, Conf. Paper etc.,

Course Designers		
Experts from Industry	Experts from Higher Technical Institutions	Internal Experts
1.Mohanraj N - PayPal	*1. Dr. E.Sivasankar – Assistant Professor – NIT, Trichy*	*1.Dr.E.Sasikala, SRMIST*
		2. Ms. S. Aruna, SRMIST
		3. Ms. G. Sujatha, SRMIST

Course Code	18CSE382T	Course Name	FORENSICS AND INCIDENT RESPONSE	Course Category	E	Professional Elective	L	T	P	C
							3	0	0	3

Pre-requisite Courses	Nil	Co-requisite Courses	Nil	Progressive Courses	Nil
Course Offering Department	Computer Science and Engineering	Data Book / Codes/Standards	Nil		

Course Learning Rationale (CLR):	*The purpose of learning this course is to:*
CLR-1 :	*Gain knowledge on the basics of procedures for identification, preservation of electronic evidence*
CLR-2 :	*Understand the purpose and usage of various forensic tools*
CLR-3 :	*Gain knowledge on how scientific evidence collection/extraction during investigation*
CLR-4 :	*Acquire knowledge on file systems and its innerworking*
CLR-5 :	*Understand the windows and linux investigation procedures*
CLR-6 :	*Introduce the report writingguidelines and principles*

Course Learning Outcomes (CLO):	*At the end of this course, learners will be able to:*	Learning 1: Level of Thinking (Bloom)	Learning 2: Expected Proficiency (%)	Learning 3: Expected Attainment (%)	PLO 1: Engineering Knowledge	PLO 2: Problem Analysis	PLO 3: Design & Development	PLO 4: Analysis, Design, Research	PLO 5: Modern Tool Usage	PLO 6: Society & Culture	PLO 7: Environment & Sustainability	PLO 8: Ethics	PLO 9: Individual & Team Work	PLO 10: Communication	PLO 11: Project Mgt. & Finance	PLO 12: Life Long Learning	PLO 13: PSO - 1	PLO 14: PSO - 2	PLO 15: PSO – 3
CLO-1 :	*Acquire the knowledge on basics of procedures for identification, preservation of electronic evidence*	2	80	85	H	-	-	-	-	-	-	-	-	-	-	-	-	-	-
CLO-2 :	*Acquire the ability to identify the purpose and usage of various forensic tools*	2	75	80	H	H	-	-	H	-	-	-	-	-	-	-	-	-	-
CLO-3 :	*Understand how scientific evidence collection/extraction during investigation*	2	85	80	H	-	-	-	-	-	-	-	-	-	-	-	-	-	-
CLO-4 :	*Appreciate the concepts of file systems and its importance in forensic science.*	2	80	75	H	-	-	-	-	-	-	-	-	-	-	-	-	-	-
CLO-5 :	*Apply the knowledge of windows and Linux investigation procedures*	2	75	85	H	-	-	H	-	-	-	-	-	-	-	-	-	-	-
CLO-6 :	*Acquire the knowledge on forensic report writing guidelines and principles*	2	80	85	H	-	-	-	-	H	-	-	-	-	-	-	-	-	-

Duration (hour)		9	9	9	9	9
S-1	SLO-1	*Introduction to Incident*	*Introduction to ACPO Principles*	*Introduction to File System Analysis*	*Introduction to Investigating Systems*	*Investigating Hacker Tools*
	SLO-2	*Goals of Incident Response*	*ACPO Principles of Computer Based Evidence*	*What is a File System?*	*Investigating Windows Systems*	*What are the goals of tool analysis?*
S-2	SLO-1	*Introduction to Incident Response Methodology (IRM)*	*Introduction to computer Storage Formats*	*Five Data Categories*	*Where Evidence resides on Windows Systems*	*How are files compiled?*
	SLO-2	*Steps in Incident Response Methodology*	*Understanding Storage Formats for Digital Evidence*	*FAT Concepts*	*Conducting a Windows Investigation I*	*Static Analysis of Hacker Tools I*
S-3	SLO-1	*IRM: Pre-incident preparation*	*Forensic Duplication*	*FAT Analysis*	*Conducting a Windows Investigation II*	*Static Analysis of Hacker Tools II*
	SLO-2	*IRM: Detection of incidents*	*Forensic Duplication tools*	*FAT - The Big Picture*	*File Auditing*	*Dynamic Analysis of Hacker Tools I*
S-4	SLO-1	*IRM: Initial Response*	*Forensic Duplicate creation of HDD*	*Introduction to NTFS*	*Theft of Information*	*Dynamic Analysis of Hacker Tools II*
	SLO-2	*IRM: Formulate a Response Strategy*	*Qualified Forensic Duplicate creation*	*Files in NTFS*	*Handling the departing employee*	*Evaluating Computer Forensics Tools*
S-5	SLO-1	*IRM: Investigate the Incident*	*Restored Image*	*MFT Concepts*	*Investigating Unix Systems*	*Types of Forensic Tools*
	SLO-2	*IRM: Reporting*	*Mirror Image*	*MFT Attribute Concepts*	*Overview of steps - Unix Investigation*	*Tasks performed by Forensic Tools*
S-6	SLO-1	*Creating response toolkit - Windows*	*Forensic Duplication Tool Requirements*	*Other MFT Attribute Concepts*	*Reviewing pertinent logs*	*Tool comparisons*
	SLO-2	*Volatile Data Collection - Windows*	*Creating a Forensic Duplicate of a Hard Drive*	*Indexes in NTFS*	*Performing keyword searches*	*Computer Forensics Software Tools*
S-7	SLO-1	*In-depth data collection - Windows*	*Evidence Handling*	*NTFS Analysis - File System Category*	*Reviewing relevant files*	*Computer Forensics Hardware Tools*
	SLO-2	*Storing collected data - Windows*	*Types of Evidence*	*NTFS Analysis - Content Category*	*Identifying unauthorized user accounts/groups*	*Validating and Testing Computer Forensics Software*
S-8	SLO-1	*Creating response toolkit - Unix*	*Challenges in Evidence Handling*	*NTFS Analysis - Metadata Category*	*Identifying rogue processes*	*Introduction to Forensic Report Writing*
	SLO-2	*Volatile Data Collection - Unix*	*Overview of Evidence Handling Procedure.*	*NTFS Analysis - File Name Category*	*Checking for unauthorized access points*	*Understanding the Importance of Reports*
S-9	SLO-1	*In-depth data collection - Unix*	*Evidence Handling Procedure*	*NTFS Analysis - Application Category*	*Analyzing trust relationships*	*Guidelines for Writing Reports*
	SLO-2	*Storing collected data - Unix*	*Evidence Handling reports*	*NTFS - The Big Picture*	*Detecting loadable kernel modules*	*A Template for Computer Forensics Reports*

Learning Resources	1. *KevinMandia,ChrisProsise,"IncidentResponseandcomputerforensics",TataMcGrawHill,2006.* 2. *Bill Nelson,Amelia Philips and Christopher Steuart, "Guide to computer forensics and investigations", coursetechnology,CengageLearning;4thedition,ISBN:1-435-49883-6,2009.*	3. *EoghanCasey,"HandbookComputerCrimeInvestigation'sForensicToolsandTechnology",Academic Press, 1st Edition,2001.* 4. *Brian Carrier, "File System Forensic Analysis", Addison-Wesley Professional; 1st edition 2005, ISBN-13: 978-0321268174*

Learning Assessment											
	Bloom's Level of Thinking	Continuous Learning Assessment (50%								Final Examination (50% weightage)	
		CLA – 1 (10%)		CLA – 2 (15%)		CLA – 3 (15%)		CLA – 4 (10%)#			
		Theory	Practice	Theory	Practice	Theory	Practice	Theory	Practice	Theory	Practice
Level 1	Remember Understand	*40 %*	-	*30 %*	-	*30 %*	-	*30 %*	-	*30%*	-
Level 2	Apply Analyze	*40 %*	-	*40 %*	-	*40 %*	-	*40 %*	-	*40%*	-
Level 3	Evaluate Create	*20 %*	-	*30 %*	-	*30 %*	-	*30 %*	-	*30%*	-
	Total	100 %		100 %		100 %		100 %		100 %	

CLA – 4 can be from any combination of these: Assignments, Seminars, Tech Talks, Mini-Projects, Case-Studies, Self-Study, MOOCs, Certifications, Conf. Paper etc.,

Course Designers		
Experts from Industry	Experts from Higher Technical Institutions	Internal Experts
1. Mr.Balan C, Scientist F, CDAC, cbalan@cdac.in	*1.*	*1. Mr. A.R. Nagoor Meeran, SRMIST*
2.	*2.*	*2. Dr. C.N.S.Vinoth Kumar, SRMIST*

Course Code	18CSE383T	Course Name	INFORMATION ASSURANCE AND SECURITY	Course Category	E	Professional Elective	L	T	P	C
							3	0	0	3

Pre-requisite Courses	Nil	Co-requisite Courses	Nil	Progressive Courses	Nil
Course Offering Department	Computer Science and Engineering	Data Book / Codes/Standards	Nil		

Course Learning Rationale (CLR):	*The purpose of learning this course is to:*
CLR-1 :	*Understand the different ways the information systems may be compromised.*
CLR-2 :	*Learn to model the various types of threats.*
CLR-3 :	*Understand the Information Assurance planning strategies.*
CLR-4 :	*Acquire knowledge by analyzing software systems.*
CLR-5 :	*Understand and apply different countermeasures and protect information.*
CLR-6 :	*Perform vulnerability testing.*

Course Learning Outcomes (CLO):	*At the end of this course, learners will be able to:*	Learning			Program Learning Outcomes (PLO)														
		1	2	3	1	2	3	4	5	6	7	8	9	10	11	12	13	14	15
		Level of Thinking (Bloom)	Expected Proficiency (%)	Expected Attainment (%)	Engineering Knowledge	Problem Analysis	Design & Development	Analysis, Design, Research	Modern Tool Usage	Society & Culture	Environment & Sustainability	Ethics	Individual & Team Work	Communication	Project Mgt. & Finance	Life Long Learning	PSO - 1	PSO - 2	PSO – 3
CLO-1 :	*Acquire the basic knowledge about the Information Assurance.*	2	80	85	H	-	-	-	-	-	-	-	-	-	-	-	-	-	-
CLO-2 :	*Design an appropriate Policies for the organization.*	2	75	80	H	H	-	-	-	-	-	-	-	-	-	-	-	-	-
CLO-3 :	*Deliver professional, ethical, legal, security and social issues and responsibilities in an effective manner.*	2	85	80	H	-	-	-	-	-	-	M	-	-	-	-	-	-	-
CLO-4 :	*.Develop risk management strategies for an enterprise.*	2	80	75	H	H	-	-	-	-	-	-	-	-	-	-	-	-	-
CLO-5 :	*Provide the understanding of different security mechanisms used in various areas of computing*	2	75	85	H	-	-	H	-	-	-	-	-	-	-	-	-	-	-
CLO-6 :	*Apply the current technical concepts and practices in the core information technologies.*	2	80	85	H	-	-	-	-	-	-	-	M	-	-	-	-	-	-

Duration (hour)		9	9	9	9	9
S-1	SLO-1	*Information Assurance Basics*	*Information Security Planning*	*Information Assurance Process : Managing Information Assurance*	*Benefits of Incorporating Security Considerations*	*Information Assurance Detection and Recovery Processes*
	SLO-2	*The Need for Information Assurance*	*Information Security Governance*	*Information Security project management*	*System Development Life Cycle*	*Intrusion Detection and Prevention System(IDPS)*
S-2	SLO-1	*Key Information Security concepts*	*Policy, Standards and Practices*	*Technical aspects of implementing Information Security*	*Information Assurance in System Development Life Cycle*	*IDPS types*
	SLO-2	*Critical characteristics of Information*	*Policy Management, Information Security Blueprint*	*Non-Technical aspects of implementing Information Security*	*Information Assurance in the Service Acquisition Life Cycle*	*IDPS detection methods*
S-3	SLO-1	*MSR Model*	*Continuity Strategies*	*Structure of an Information Assurance*	*Physical and Environmental Security Controls*	*IDPS - Analysis*
	SLO-2	*Security in System lifecycle*	*Crisis Management*	*Organizational Maturity, Asset Management*	*Handling of Media*	*Log Management Tools: SIEM*
S-4	SLO-1	*NIST Approach to Securing SDLC*	*Information Asset Life Cycle, Plan,Do,Check,Act Model*	*APM Maturity model*	*Information Assurance Awareness, Training, and Education (AT and E), Purpose, Benefits*	*Honeypot/Honeynet*
	SLO-2	*Security Professionals and Organizations*	*Current Practices : Due Care and Due Diligence*	*Overview of Risk Management*	*AT and E : Design, Development*	*Scanning and Analysis tools*
S-5	SLO-1	*Communities of Interest*	*Specific Laws and Regulations*	*Risk Identificaion*	*AT and E : Assessment*	*Malware Detection*
	SLO-2	*Information Security: Is it an art or Science?*	*International Laws and Acts*	*Risk Assessment*	*Types of Learning Programs*	*Penetration Test*
S-6	SLO-1	*Information Assurance Concepts : Defense in Depth*	*Standards and Best Practices*	*Risk control*	*Employment Policies and Practices*	*Physical Controls*
	SLO-2	*Information Assurance in Cyber Security*	*Plans for Information Assurance Strategy*	*Quantitative vs Qualitative Risk management practices*	*Securty considerations for temporary employees, consultants and other workers*	*Special considerations for Physical security*

S-7	SLO-1	*CIA Triangle*	*Cryptology*	*Recommended risk control practices*	*Preventive Information Assurance Tools*	*Information Assurance Measurement Process*
	SLO-2	*The Need for Security*	*Cipher methods*	*Process , Secure design through threat modeling*	*Preventive Information Assurance controls*	*Metrics Program*
S-8	SLO-1	*Categories of Threats*	*Cryptographic algorithms*	*Importance of Policy*	*Positioning and staffing the Security function*	*Incident Handling Process*
	SLO-2	*Software Attacks types*	*Cryptographic tools*	*Information Assurance Policy*	*Credentias for Information Security Professionals*	*Continuity Strategies*
S-9	SLO-1	*Other vulnerabilities*	*Protocols for secure Communications*	*Policy Development Steps*	*Access control benefits*	*Computer Forensics*
	SLO-2	*Implications from Lack of Information Assurance*	*Approaches to implement Information Assurance*	*Certification, Accreditation, and Assurance*	*Access control Techniques, Administration*	*Examiner Prerequisites, Team Establishment*

Learning Resources	1. *MichaelE.WhitmanandHerbertJ.Mattord,"PrinciplesofInformationSecurity",5thedition,2015, Thomson Publications, ISBN1111899134.* 2. *Steven Hernandez, Corey Schou, "Information Assurance Handbook: Effective Computer Security and Risk Management Strategies" ,1st Edition, 2014, McGraw Hill Osborne Media ,ISBN:0071821651, ISBN : 9780071821650*	3. *William Stallings, " Cryptography and Network Security- Principles and Practice", 6 th Edition, 2013, Pearson, ISBN:9780136073734.* 4. *CoreySchou, Dan Shoemaker,"InformationAssurancefortheEnterprise",TataMcGraw -HillEdition,2007.*

Learning Assessment											
	Bloom's Level of Thinking	Continuous Learning Assessment (50%								Final Examination (50% weightage)	
		CLA – 1 (10%)		CLA – 2 (15%)		CLA – 3 (15%)		CLA – 4 (10%)#			
		Theory	Practice	Theory	Practice	Theory	Practice	Theory	Practice	Theory	Practice
Level 1	Remember Understand	*40 %*	-	*30 %*	-	*30 %*	-	*30 %*	-	*30%*	-
Level 2	Apply Analyze	*40 %*	-	*40 %*	-	*40 %*	-	*40 %*	-	*40%*	-
Level 3	Evaluate Create	*20 %*	-	*30 %*	-	*30 %*	-	*30 %*	-	*30%*	-
	Total	100 %		100 %		100 %		100 %		100 %	

CLA – 4 can be from any combination of these: Assignments, Seminars, Tech Talks, Mini-Projects, Case-Studies, Self-Study, MOOCs, Certifications, Conf. Paper etc.,

Course Designers		
Experts from Industry	Experts from Higher Technical Institutions	Internal Experts
1. Mr.P.AnandaNatarajan,Senior Associate Consultant, Infosys, Chennai.	*1. Dr.S.Anbuchelian, Assistant Professor(Sl.G), IT Department, Anna University, Chennai*	*1.Ms.C.Fancy ,SRMIST,*
2. Mr.SurenderPalanivel, GM, GGS Information Services Pvt. Ltd., Pune.		*2. Dr.Vinothkumar,SRMIST vinothks1@srmist.edu.in*

Course Code	18CSE384T	Course Name	SECURE SOFTWARE DEVELOPMENT LIFE CYCLE	Course Category	E	Professional Elective	L	T	P	C
							3	0	0	3

Pre-requisite Courses	Nil	Co-requisite Courses	Nil	Progressive Courses	Nil
Course Offering Department	Computer Science and Engineering	Data Book / Codes/Standards	Nil		

Course Learning Rationale (CLR):	*The purpose of learning this course is to:*
CLR-1 :	*Identify project security risks & selecting risk management strategies.*
CLR-2 :	*Analyze software security standards, policies, and guidelines to articulate and elaborate requirements*
CLR-3 :	*Use automated tools and secure coding practices to analyze and test existing code and reduce vulnerabilities*
CLR-4 :	*Select and integrate established security design patterns and address threat assessments to mitigate common vulnerabilities and achieve the target design*
CLR-5 :	*Participate in team-based peer reviews to analyze the security development life cycle and mitigate risks and vulnerabilities*

Course Learning Outcomes (CLO):	*At the end of this course, learners will be able to:*	Learning 1: Level of Thinking (Bloom)	2: Expected Proficiency (%)	3: Expected Attainment (%)	1: Engineering Knowledge	2: Problem Analysis	3: Design & Development	4: Analysis, Design, Research	5: Modern Tool Usage	6: Society & Culture	7: Environment & Sustainability	8: Ethics	9: Individual & Team Work	10: Communication	11: Project Mgt. & Finance	12: Life Long Learning	13: PSO - 1	14: PSO - 2	15: PSO – 3
CLO-1 :	*Explain terms used in secured software development and life cycle process*	*3*	*80*	*70*	*L*	*H*	*-*	*L*	*L*	*-*	*-*	*-*	*L*	*L*	*-*	*H*	*-*	*-*	*-*
CLO-2 :	*Incorporate requirementsinto secured software development process and testsoftware for security vulnerability*	*3*	*85*	*75*	*M*	*H*	*L*	*M*	*L*	*-*	*-*	*-*	*M*	*M*	*-*	*H*	*-*	*-*	*-*
CLO-3 :	*Identify vulnerable code in implemented software and describe attack consequences*	*3*	*75*	*70*	*M*	*H*	*M*	*H*	*L*	*-*	*-*	*-*	*M*	*L*	*-*	*H*	*-*	*-*	*-*
CLO-4 :	*Apply mitigation and implementation practices to construct attack resistant software*	*3*	*85*	*80*	*M*	*H*	*M*	*H*	*L*	*-*	*-*	*M*	*M*	*M*	*-*	*H*	*-*	*-*	*-*
CLO-5 :	*Apply secure design principles for developing attack resistant software*	*3*	*85*	*75*	*H*	*H*	*M*	*H*	*L*	*-*	*-*	*-*	*M*	*M*	*-*	*H*	*-*	*-*	*-*

Program Learning Outcomes (PLO)

Duration (hour)		9	9	9	9	9
S-1	SLO-1	*Software Engineering- Process model*	*A Risk Management Framework*	*Introduction toArchitectural Risk Analysis*	*Code Review with a Tool*	*Software Penetration Testing*
	SLO-2				*Catching Implementation Bugs with a Tool)*	
S-2	SLO-1	*Agile development-Agile Process*	*The Five Stages of Activity*	*Common Themes among Security Risk Analysis Approaches*	*Approaches to Static Analysis*	*Software Penetration Testing—a Better Approach*
	SLO-2	*Extreme Programming*				
S-3	SLO-1	*Need to secure development life cycle*	*Understanding the Business Context*	*Traditional Risk Analysis Terminology*	*Modern Rules*	*Using Penetration Tests to Assess the Application Landscape*
	SLO-2		*Gathering the Artifacts*			
S-4	SLO-1	*Current Software Development Methods Fail to Produce Secure Software .*	*Identifying the Business and Technical Risks*	*Knowledge Requirement*	*Tools from Researchland*	*Risk-Based Security Testing*
	SLO-2	*Incentive to Review Code*				
S-5	SLO-1	*Understanding Security Bugs*	*Synthesizing and Ranking the Risks*	*The Necessity of a Forest-Level View*	*Commercial Tool Vendors*	*Abuse Cases*
	SLO-2	*Critical Mass*		*A Traditional Example of a Risk Calculation*		
S-6	SLO-1	*Proprietary Software Development Methods- CMMI, TSP, and PSP*	*Defining the Risk Mitigation Strategy*	*Modern Risk Analysis*	*Key Characteristics of a Tool*	*Software Security Meets Security Operations*
	SLO-2					
S-7	SLO-1	*SDL for Management*	*Carrying Out Fixes and Validating*	*Touchpoint Process: Architectural Risk Analysis*	*The Fortify Knowledge Base*	*Knowledge for Software Security*
	SLO-2					
S-8	SLO-1	*Managing the SDL*	*The Importance of Measurement*	*Limitations of Traditional Approaches*	*Touchpoint Process: Code Review*	*Establishing a Metrics Program*
	SLO-2					
S-9	SLO-1	*Case study: A Short History of the SDL at Microsoft*	*The Cigital Workbench*	*Getting Started with Risk Analysis*	*Use a Tool to Find Security Bugs*	*Continuous Improvement*
	SLO-2					

Learning Resources	1. *The Security Development Lifecycle: SDL: A Process for Developing Demonstrably More Secure Software (1st Edition) By Michael Howard,2017.* 2. *Software Security: Building Security In by Gary McGraw. Addison-Wesley.2006*	3. *Software Security Engineering: A Guide for Project Managers by Julia H. Allen, Sean Barnum, Robert J. Ellison, Gary McGraw, and Nancy Mead. Addison-Wesley,2012*

Learning Assessment											
	Bloom's Level of Thinking	Continuous Learning Assessment (50% weightage)								Final Examination (50% weightage)	
		CLA – 1 (10%)		CLA – 2 (15%)		CLA – 3 (15%)		CLA – 4 (10%)#			
		Theory	Practice	Theory	Practice	Theory	Practice	Theory	Practice	Theory	Practice
Level 1	Remember Understand	*40%*	-	*30%*	-	*30%*	-	*30%*	-	*30%*	-
Level 2	Apply Analyze	*40%*	-	*40%*	-	*40%*	-	*40%*	-	*40%*	-
Level 3	Evaluate Create	*20%*	-	*30%*	-	*30%*	-	*30%*	-	*30%*	-
	Total	100 %		100 %		100 %		100 %		100%	

CLA – 4 can be from any combination of these: Assignments, Seminars, Tech Talks, Mini-Projects, Case-Studies, Self-Study, MOOCs, Certifications, Conf. Paper etc.,

Course Designers		
Experts from Industry	Experts from Higher Technical Institutions	Internal Experts
Mr.V.SelvaKumar,Assistant General Manager,Hexaware Technologies.	*Dr.N.Prakash,Associate Professor,Department of Information technology,B.S.A Crescent Institute of Science and Technology.*	1. *Mr.Arivazhagan*
		2. *Dr. Naresh*
		3. *Mrs.B.Jothi, SRMIST*

Course Code	18CSE385T	Course Name	SECURITY AUDIT AND RISK ASSESSMENT	Course Category	E	Professional Elective	L	T	P	C
							3	0	0	3

Pre-requisite Courses	Nil	Co-requisite Courses	Nil	Progressive Courses	Nil
Course Offering Department	CSE	Data Book / Codes/Standards	Nil		

Course Learning Rationale (CLR):	The purpose of learning this course is to:
CLR-1 :	*Understand the security audit planning strategies*
CLR-2 :	*Gain knowledge about information risk*
CLR-3 :	*Discover knowledge in collecting data about organization*
CLR-4 :	*Acquire knowledge in various analysis on Information Risk Assessment*
CLR-5 :	*Introduce the System Risk analysis*
CLR-6 :	*Understand the organizational and system specific risk*

Course Learning Outcomes (CLO):	At the end of this course, learners will be able to:	Learning 1 Level of Thinking (Bloom)	2 Expected Proficiency (%)	3 Expected Attainment (%)	PLO 1 Engineering Knowledge	2 Problem Analysis	3 Design & Development	4 Analysis, Design, Research	5 Modern Tool Usage	6 Society & Culture	7 Environment & Sustainability	8 Ethics	9 Individual & Team Work	10 Communication	11 Project Mgt. & Finance	12 Life Long Learning	13 PSO - 1	14 PSO - 2	15 PSO – 3
CLO-1 :	*Acquire the knowledge on various secure auditing techniques*	2	80	85	H	-	-	-	-	-	-	-	-	-	-	-	-	-	-
CLO-2 :	*Acquire the ability to identify knowledge in information risk*	2	75	80	H	H	-	-	-	-	-	-	-	-	-	-	-	-	-
CLO-3 :	*Understand the basic ideas about data collection workload*	2	85	80	H	-	-	-	-	-	-	-	-	-	-	-	-	-	-
CLO-4 :	*Appreciate the concepts of vulnerability catalogs and impact analysis scheme*	2	80	75	H	H	-	-	-	-	-	-	-	-	-	-	-	-	-
CLO-5 :	*Identify the knowledge in risk classification techniques*	2	75	85	H	-	-	H	-	-	-	-	-	-	-	-	-	-	-
CLO-6 :	*Acquire the knowledge on system specific risk*	2	80	85	H	-	-	-	-	-	-	-	-	-	-	-	-	-	-

Duration (hour)		9	9	9	9	9
S-1	SLO-1	*Need for Audit Planning*	*What is Risk?*	*Data Collection-Introduction*	*Compiling Observations from Organizational*	*System Risk Analysis*
	SLO-2	*Steps in Audit Planning*	*Going Deeper with Risk*	*The Sponsor*	*Risk Documents*	*Risk Classification*
S-2	SLO-1	*Audit Risk Assessment*	*Components of Risk*	*The Project Team*	*Preparation of Threat and Vulnerability Catalogs*	*Risk Rankings*
	SLO-2	*Performing Audit*	*Putting it Altogether*	*The size and Breadth of the Risk Assessment*	*Threat Catalog*	*Risk Prioritization and Treatment*
S-3	SLO-1	*Internal Controls*	*Information Security Risk*	*Scheduling and Deadlines*	*Vulnerability Catalogs*	*Review of Audit Findings*
	SLO-2	*Audit Evidence*	*Information Security Risk Assessment Overview*	*Assessor and Organization Experience*	*Threat Vulnerability Pairs*	*Review of Security Incidents*
S-4	SLO-1	*Audit Testing*	*Assess Information Security Risk*	*Work load*	*Overview of the System Risk Computation*	*Review of Security Exceptions*
	SLO-2	*Follow up activities*	*Risk assessment and security Program*	*Data Collection Mechanisms*	*Designing the Impact Analysis Scheme*	*System Specific Risk Treatment*
S-5	SLO-1	*Security Monitoring and Auditing*	*Information Security Management in a Nutshell*	*Collectors*	*Confidentiality, Integrity*	*Information Security Risk Assessment Reporting*
	SLO-2	*Assurance and Trust*	*Drivers, Laws and Regulations*	*Containers*	*Availability*	*Risk Analysis Executive Summary*
S-6	SLO-1	*Need for Assurance*	*Federal Information Security Management*	*Executive Interview*	*Preparing the Impact Score*	*Methodology*
	SLO-2	*Role of Requirements in Assurance*	*Gramm-Leach-Blile(GLBA)*	*Document Requests*	*Designing the Control analysis Scheme*	*Organizational*
S-7	SLO-1	*Audit Assurance in Software Development Phases*	*Health Insurance Portability and Accountability Act(HIPAA)*	*IT Asset Inventories*	*Designing the Likelihood Analysis Scheme*	*System Specific*
	SLO-2	*Building Secure and Trusted Systems*	*State Governments*	*Asset Scoping*	*Exposure*	*Results*
S-8	SLO-1	*Designing an Auditing System*	*ISO 27001*	*Business Impact Analysis and Other Assessments*	*Frequency*	*Organizational Analysis*
	SLO-2	*Auditing to detect Violations of a Security Policy*	*Drivers,Laws and Regulations*	*Critical Success Factor Analysis*	*Controls*	*System Specific*
S-9	SLO-1	*Auditing Mechanisms*	*Risk Assessment Framework*	*Profile & Control Survey*	*Likelihood*	*Risk Register*
	SLO-2	*Audit Browsing*	*Practical Approach*	*Consolidation*	*Final Risk Score*	*Post Mortem*

Learning Resources	1. Mark Talabis, “Information Security Risk Assessment Toolkit: Practical Assessments through DataCollectionandDataAnalysis”,Syngress;1Edition.ISBN:978-1-59749-735-0.Nov2012. 2. David L. Cannon, “CISA Certified Information Systems Auditor Study Guide”, SYBEX Publication. ISBN:978-0-470-23152-4.	3. Thomas R.Peltier, “Information Security Risk Analysis”, CRC Press, 2001

Learning Assessment											
	Bloom’s Level of Thinking	Continuous Learning Assessment (50%								Final Examination (50% weightage)	
		CLA – 1 (10%)		CLA – 2 (15%)		CLA – 3 (15%)		CLA – 4 (10%)#			
		Theory	Practice	Theory	Practice	Theory	Practice	Theory	Practice	Theory	Practice
Level 1	Remember Understand	40 %	-	30 %	-	30 %	-	30 %	-	30%	-
Level 2	Apply Analyze	40 %	-	40 %	-	40 %	-	40 %	-	40%	-
Level 3	Evaluate Create	20 %	-	30 %	-	30 %	-	30 %	-	30%	-
	Total	100 %		100 %		100 %		100 %		100 %	

CLA – 4 can be from any combination of these: Assignments, Seminars, Tech Talks, Mini-Projects, Case-Studies, Self-Study, MOOCs, Certifications, Conf. Paper etc.,

Course Designers		
Experts from Industry	Experts from Higher Technical Institutions	Internal Experts
1.Mr.PrasannaKumar,InfosysPrasanna_kumar11@infosys.com	1.Dr.E.Sivashankar, NIT Trichy,sivasankar@nitt.edu	1.Dr.G.Usha,SRMIST, Dr.M.B.MukeshKrishnan,SRMIST
2.Mr.Mithun, Cognizant,Mithun.SS@cognizant.com	2.Dr.KunvarSingh,NITTrichy,kunwar@nitt.edu	2.Mrs G.K. Sandhia,SRMIST

Course Code	18CSE386T	Course Name	PENETRATION TESTING AND VULNERABILITY ASSESSMENT	Course Category	E	Professional Elective	L	T	P	C
							3	0	0	3

Pre-requisite Courses	Nil	Co-requisite Courses	Nil	Progressive Courses	Nil
Course Offering Department	Computer Science and Engineering	Data Book / Codes/Standards	Nil		

Course Learning Rationale (CLR):	*The purpose of learning this course is to:*
CLR-1 :	*Gain knowledge on various security testing techniques and asses sensitiveness of assets.*
CLR-2 :	*Gain knowledge on weaknesses of various OS, network and applications.*
CLR-3 :	*identify how security controls can be improved to prevent hackers gaining access to operating systems and networked environments.*
CLR-4 :	*Acquire knowledge on methodologies and techniques of Hacking*
CLR-5 :	*To test and exploit systems using various tools.*
CLR-6 :	*Understand the impact of hacking in real time machines*

Course Learning Outcomes (CLO):	*At the end of this course, learners will be able to:*	Learning 1: Level of Thinking (Bloom)	Learning 2: Expected Proficiency (%)	Learning 3: Expected Attainment (%)	PLO 1: Engineering Knowledge	PLO 2: Problem Analysis	PLO 3: Design & Development	PLO 4: Analysis, Design, Research	PLO 5: Modern Tool Usage	PLO 6: Society & Culture	PLO 7: Environment & Sustainability	PLO 8: Ethics	PLO 9: Individual & Team Work	PLO 10: Communication	PLO 11: Project Mgt. & Finance	PLO 12: Life Long Learning	PLO 13: PSO - 1	PLO 14: PSO - 2	PLO 15: PSO – 3
CLO-1 :	Acquire the knowledge on identifying security vulnerabilities	2	80	85	H	-	-	-	-	-	-	-	-	-	-	-	-	-	-
CLO-2 :	Acquire the ability to identify problems in network, OS and applications commonly exploited by hackers	2	75	80	H	H	-	-	-	-	-	-	-	-	-	-	-	-	-
CLO-3 :	Understand management of static and dynamic security controls in firewalls, IPS, IDS	2	85	80	H	-	-	-	-	-	-	-	-	-	-	-	-	-	-
CLO-4 :	Appreciate the concepts of hacking and gaining access to remote and local systems.	2	80	75	H	H	-	-	-	-	-	-	-	-	-	-	-	-	-
CLO-5 :	Apply the knowledge for creating better security controls.	2	75	85	H	-	-	H	-	-	-	-	-	-	-	-	-	-	-
CLO-6 :	Acquire the knowledge to prevent threats in targeted attacks and real time systems.	2	80	85	H	-	-	-	-	-	-	-	-	-	-	-	-	-	-

Duration (hour)		9	9	9	9	9
S-1	SLO-1	*Introduction to penetration testing*	*Types of Scanning*	*Meterpreter Basics*	*Social engineering*	*DOS Attack*
	SLO-2	*Introduction to penetration testing -2*	*Black, White and Grey Scanning*	*Working with Meterpreter session*	*Electronic and Non Electronic Social Engineering*	*DDOS Attack*
S-2	SLO-1	*Understanding basic Ethical Hacking terminologies*	*Foot Printing Stages*	*Exploit Modules*	*SET- Social Engineering Toolkit*	*Web application Vulnerability*
	SLO-2	*Understanding basic Ethical Hacking terminologies -2*	*Foot Printing Stages-2*	*Payload Modules*	*Social Engineering Prevention Techniques*	*Security assessment of public Domains*
S-3	SLO-1	*Batch Programming Basics*	*DNS Information Gathering*	*Privilege Escalation*	*Buffer Over Flow Attack*	*Phishing and its Types*
	SLO-2	*Batch Programming Basics - 2*	*NS Lookup*	*Vertical and horizontal Privilege Escalation*	*Stack Based Buffer overflow*	*Cross Site Request Forgery*
S-4	SLO-1	*Taking control using batch programs*	*Network Information Gathering*	*Token Stealing*	*Heap Based buffer overflow*	*DOM Based XSS*
	SLO-2	*Taking control using batch programs-2*	*NMap*	*Active and Passive stealing*	*Deep packet inspection*	*Brup Suite*
S-5	SLO-1	*Open web Application Security Project(OWASP)*	*Scanning*	*Network Sniffing*	*SQL Injection –Introduction*	*Password Cracking*
	SLO-2		*Port, Network and OS*	*Active and passive sniffing*	*SQL Injection Types*	*John the Ripper*
S-6	SLO-1	*Stages of Ethical Hacking*	*Nmap Scripting*	*Creating Backdoors*	*Error Based SQL,*	*Dictionary Attack, Brute Force Attack*
	SLO-2			*Persistent and Non-Persistent*	*Union Based SQL*	*Rainbow Table Attack,*
S-7	SLO-1	*Vulnerability Research*	*Vulnerability Scanning*	*Key Loggers*	*Blind SQL*	*Shoulder Sniffing, Spidering*
	SLO-2		*Nessus*	*Software and Hardware Key loggers*	*Boolean-based SQL injection, Time-based SQL injection*	*Offline Cracking*
S-8	SLO-1	*Impact of Hacking*	*'Who is' Information Gathering*	*ARP Poisoning*	*SQL Map,DVWA*	*Wifi Hacking*
	SLO-2		*Wireshark*	*Maltigo*	*SQL injection Counter Measures*	*AIrcrack*
S-9	SLO-1	*Introduction to Kali OS*	*Enumeration*	*Man In The Middle Attack*	*Steganography*	*Documentation and Reporting*
	SLO-2	*Installation and configuration*	*Active and Passive Enumeration*	*Port Forwarding*	*Steganography counter measures*	*Dradis Framework*

Learning Resources	1. *David Kennedy, Jim O'Gorman, Devon Kearns, and Mati Aharoni, METASPLOIT The Penetration Tester's Guide, No Starch Press,2011.* 2. *Wil Allsopp, Advanced Penetration Testing: Hacking theworlds most Secure Networks, 1st Edition, John Wiley & Sons,2017*	3. *Sean-Philip Oriyano, Penetration Testing Essentials, JohnWiley & Sons,2017.* 4. *Leebrotherston,AmandaBerlin,DefensiveSecurityhandbook,O'reilly,2017*

Learning Assessment											
	Bloom's Level of Thinking	Continuous Learning Assessment (50% weightage)								Final Examination (50% weightage)	
		CLA – 1 (10%)		CLA – 2 (15%)		CLA – 3 (15%)		CLA – 4 (10%)#			
		Theory	Practice	Theory	Practice	Theory	Practice	Theory	Practice	Theory	Practice
Level 1	Remember Understand	*40 %*	-	*30 %*	-	*30 %*	-	*30 %*	-	*30%*	-
Level 2	Apply Analyze	*40 %*	-	*40 %*	-	*40 %*	-	*40 %*	-	*40%*	-
Level 3	Evaluate Create	*20 %*	-	*30 %*	-	*30 %*	-	*30 %*	-	*30%*	-
	Total	100 %		100 %		100 %		100 %		100 %	

CLA – 4 can be from any combination of these: Assignments, Seminars, Tech Talks, Mini-Projects, Case-Studies, Self-Study, MOOCs, Certifications, Conf. Paper etc.,

Course Designers		
Experts from Industry	Experts from Higher Technical Institutions	Internal Experts
Mr. S Manigandan, prnc Cyber Researcher, Symantec Inc manigandan_s@symantec.com		*1. Geogen George,SRMIST*
		2. Ms. Poornima,SRMIST
		3. Mr.Selvakumaraswamy,SRMIST

Course Code	18CSE472T	Course Name	MALWARE ANALYSIS	Course Category	E	Professional Elective	L	T	P	C
							3	0	0	3

Pre-requisite Courses	Nil	Co-requisite Courses	Nil	Progressive Courses	Nil
Course Offering Department	Computer Science and Engineering	Data Book / Codes/Standards	Nil		

Course Learning Rationale (CLR):	The purpose of learning this course is to:
CLR-1 :	*Understand the fundamentals of static and dynamic analysis.*
CLR-2 :	*Gain knowledge about running malware in virtual environment.*
CLR-3 :	*Study about disassembly constructs and its structures.*
CLR-4 :	*Study about new processors and file types using the IDA SDK*
CLR-5 :	*Explore popular plug-ins that make writing IDA scripts easier, allow collaborative reverse engineering*
CLR-6 :	*Understand how to best approach the subject of Android malware threats and analysis.*

Course Learning Outcomes (CLO):	At the end of this course, learners will be able to:	Learning 1: Level of Thinking (Bloom)	2: Expected Proficiency (%)	3: Expected Attainment (%)	PLO 1: Engineering Knowledge	2: Problem Analysis	3: Design & Development	4: Analysis, Design, Research	5: Modern Tool Usage	6: Society & Culture	7: Environment & Sustainability	8: Ethics	9: Individual & Team Work	10: Communication	11: Project Mgt. & Finance	12: Life Long Learning	13: PSO - 1	14: PSO - 2	15: PSO – 3
CLO-1 :	*Gain knowledge about the different forms of malware.*	2	80	85	H	-	-	-	-	-	-	-	-	-	-	-	-	-	-
CLO-2 :	*Set up a safe virtual environment to analyze malware.*	2	75	80	H	H	-	-	-	-	-	-	-	-	-	-	-	-	-
CLO-3 :	*Navigate, comment, and modify disassembly.*	2	85	80	H	-	-	-	-	-	-	-	-	-	-	-	-	-	-
CLO-4 :	*Use code graphing to quickly make sense of cross references and function calls*	2	80	75	H	H	-	-	-	-	-	-	-	-	-	-	-	-	-
CLO-5 :	*Use IDA's built-in debugger to tackle hostile and obfuscated code.*	2	75	85	H	-	-	H	-	-	-	-	-	-	-	-	-	-	-
CLO-6 :	*Learn procedures for recognizing and analyzing Android malware threats quickly and effectively.*	2	80	85	H	-	-	-	-	-	-	-	-	-	-	-	-	-	-

Duration (hour)		9	9	9	9	9
S-1	SLO-1	*The Goals of Malware Analysis*	*The Structure of a Virtual Machine*	*Disassembly Theory*	*Cross-References*	*Introduction to the Android Operating System and Threats*
	SLO-2	*Malware Analysis Techniques*	*Creating Your Malware Analysis Machine*	*The Why and how of Disassembly*	*Function Calls*	*Malware Threats, Hoaxes, and Taxonomy*
S-2	SLO-1	*Types of Malware*	*Using Your Malware Analysis Machine*	*Reversing and Disassembly Tools.*	*IDA Graphing*	*Open Source Tools*
	SLO-2	*General Rules for Malware Analysis*	*The Risks of Using VMware for Malware Analysis*	*Getting started with IDA.*	*Console Mode IDA*	*Collections*
S-3	SLO-1	*Antivirus Scanning*	*Record/Replay: Running Your Computer in Reverse*	*IDA Data Displays*	*IDA's Batch Mode*	*File Data, Metadata*
	SLO-2	*Hashing- Fingerprint for Malware*	*Sandboxes: The Quick-and-Dirty Approach*	*Disassembly Navigation.*	*Customizing IDA's*	*Creating a JAR File, VisualThreat Modeling*
S-4	SLO-1	*Finding Strings*	*Running Malware*	*Disassembly Manipulation.*	*Library Recognitions*	*Automation*
	SLO-2	*Packing Files*	*Monitoring with Process Monitor*	*Recognizing Data Structure Use*	*Augmenting Function Information*	*Processor Emulation*
S-5	SLO-1	*Detecting Packers with PEiD*	*Viewing Processes with Process Explorer*	*Creating IDA Structures*	*Augmenting Predefined Comments*	*Configuring Emulated Devices within AVD*
	SLO-2	*Portable Executable File Format*	*Comparing Registry Snapshots with Regshot*	*Using Structure Templates*	*The Infamous Patch Program Menu*	*Using the ADB Tool*
S-6	SLO-1	*Static, Runtime, and Dynamic Linking*	*Faking a Network*	*Importing New Structures*	*IDA Output Files and Patch Generation*	*Installing Samples to Devices and Emulators*
	SLO-2	*Exploring Dynamically Linked Functions with Dependency Walker*	*Packet Sniffing with Wireshark*	*Using Standard Structures*	*IDA Scripting*	*Application Storage and Data Locations*
S-7	SLO-1	*Imported and Exported Functions*	*Using INetSim*	*IDA TIL Files*	*IDA Software Development Kit*	*Devices View, LogCat View*
	SLO-2	*PotentialKeylogger.exe: An Unpacked Executable*	*Basic Dynamic Tools in Practice*	*C++ Reversing Primer- The this Pointer*	*The IDA Application Programming Interface*	*Application Tracing*
S-8	SLO-1	*Examining PE Files with PEview*	*Levels of Abstraction*	*Virtual Functions and Vtables*	*Writing a Plug-in, Plug-in User Interface Options*	*Build Your Own Sandbox*

	SLO-2	*Viewing the Resource Section with Resource Hacker*	*Reverse-Engineering*	*The Object Life Cycle*	*IDA Loader Modules*	*USB-cleaver, Torec*
S-9	SLO-1	*Using Other PE File Tools*	*The x86 Architecture*	*Name Mangling, Runtime Type Identification*	*Processor Module Architecture*	*Static and Dynamic Analysis of Uploaded Malware Samples.*
	SLO-2	*PE Header Summary*	*Recognizing C Code Construct in Assembly*	*Inheritance Relationships, C++ Reverse Engineering References*	*Real World Applications- Vulnerability Analysis.*	*Capabilities and Limitations of the Emulators.*

Learning Resources	1. *Michael Sikorski, Practical Malware Analysis – The Hands–On Guide to Dissecting Malicious Software, Kindle Edition, No Starch Press; 1 edition (1 February 2012), ISBN: 1593272901.* 2. *Chris Eagle, The IDA Pro Book, 2nd Edition, No Starch Press, 2011. ISBN-10: 1-59327- 289-8.*	3. *Ken Dunham, Android Malware and Analysis, Kindle Edition, Auerbach Publications.InternationalStandardBookNumber-13:978-1-4822-5220-0.*

Learning Assessment

	Bloom's Level of Thinking	Continuous Learning Assessment (50% weightage)								Final Examination (50% weightage)	
		CLA – 1 (10%)		CLA – 2 (15%)		CLA – 3 (15%)		CLA – 4 (10%)#			
		Theory	Practice	Theory	Practice	Theory	Practice	Theory	Practice	Theory	Practice
Level 1	Remember Understand	*40 %*	-	*30 %*	-	*30 %*	-	*30 %*	-	*30%*	-
Level 2	Apply Analyze	*40 %*	-	*40 %*	-	*40 %*	-	*40 %*	-	*40%*	-
Level 3	Evaluate Create	*20 %*	-	*30 %*	-	*30 %*	-	*30 %*	-	*30%*	-
	Total	100 %		100 %		100 %		100 %		100 %	

CLA – 4 can be from any combination of these: Assignments, Seminars, Tech Talks, Mini-Projects, Case-Studies, Self-Study, MOOCs, Certifications, Conf. Paper etc.,

Course Designers

Experts from Industry	Experts from Higher Technical Institutions	Internal Experts
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		2.Ms. Ida Seraphim, SRMIST

Course Code	18CSE474T	Course Name	CYBER LAW	Course Category	E	Professional Elective	L	T	P	C
							3	0	0	3

Pre-requisite Courses	Nil	Co-requisite Courses	Nil	Progressive Courses	Nil
Course Offering Department	Computer Science and Engineering	Data Book / Codes/Standards	Nil		

Course Learning Rationale (CLR):	The purpose of learning this course is to:	Learning			Program Learning Outcomes (PLO)														
		1	2	3	1	2	3	4	5	6	7	8	9	10	11	12	13	14	15
CLR-1 :	Understand the basics of cyber law and cyber security																		
CLR-2 :	familiarize the issues those are specific to amendment rights																		
CLR-3 :	Become aware on copyright issues in software's																		
CLR-4 :	Understand the Cyber-crimes and Cyber Frauds																		
CLR-5 :	Understand the Legal Framework																		
CLR-6 :	understand ethical laws of computer for different countries																		
Course Learning Outcomes (CLO):	At the end of this course, learners will be able to:	Level of Thinking (Bloom)	Expected Proficiency (%)	Expected Attainment (%)	Engineering Knowledge	Problem Analysis	Design & Development	Analysis, Design, Research	Modern Tool Usage	Society & Culture	Environment & Sustainability	Ethics	Individual & Team Work	Communication	Project Mgt. & Finance	Life Long Learning	PSO - 1	PSO - 2	PSO – 3
CLO-1 :	Gain in-depth knowledge on information on cyber security and issues specific to amendment rights	3	80	70	L	H	H	H	L	H	L	H	H	H	L	H	H	H	H
CLO-2 :	Apply the knowledge on copyright issues within software packages	3	85	75	L	H	H	H	L	H	L	H	H	H	L	H	H	H	H
CLO-3 :	Comprehend ethical laws of computer for various countries	3	75	70	L	H	H	H	L	H	L	H	H	H	L	H	H	H	H
CLO-4 :	Defines the Cyber-crimes and frauds	3	85	80	L	H	H	H	L	H	L	H	H	H	L	H	H	H	H
CLO-5 :	Apply the knowledge of Legal framework	3	85	75	L	H	H	H	L	H	L	H	H	H	L	H	H	H	H
CLO-6 :	Construct the secured environment	3	80	70	L	H	H	H	L	H	L	H	H	H	L	H	H	H	H

Duration (hour)		9	9	9	9	9
S-1	SLO-1	Introduction	Overview Of The Information Technology Act, 2000	Cyber-crimes / Cyber Frauds	Cyber Crimes& Legal Framework	Cyber Security
	SLO-2	History of Internet and World Wide Web	Applicability of the Act	Definition of cyber crime	Cyber Crimes against Individuals, Institution and State	Network and website Security Risks
S-2	SLO-1	Need for cyber law	Scheme of the Act	First Cyber crime	Hacking	Hacking
	SLO-2	Cyber-crime on the rise	Important provisions of the Act		Digital Forgery	E-business Risk management issues
S-3	SLO-1	Important terms related to cyber law	Digital Signature under the IT Act, 2000	Types of cyber frauds	Cyber Stalking/Harassment	Firewall
	SLO-2		E-Governance		Cyber Pornography	Security framework
S-4	SLO-1	Cyber law in India	Attribution, Acknowledgement and Dispatch of Electronic Records	Cyber frauds in India	Identity Theft & Fraud	Cryptocurrency
	SLO-2		Certifying Authorities	Preventive measures	Cyber Terrorism	Blockchain –Technology Stack :Protocol, Currency
S-5	SLO-1	Need for cyber law in India	Controller of Certifying Authorities (CCA)	Cyber crimes	Cyber Defamation	Crowd Funding
	SLO-2		Security Guidelines for Certifying Authorities	Who commits cyber-crimes?	Right to Privacy and Data Protection on Internet	Bitcoin Prediction Markets
S-6	SLO-1	History of cyber law in India	Electronic Signature Certificates	Penalties and offences under the IT Act, 2000	Concept of privacy	Smart Property
	SLO-2		Duties of Subscribers		Self-regulation approach to privacy	Smart Contract
S-7	SLO-1	Information Technology Act, 2000	Penalties and Offences	Offences under other legislations	Ingredients to decide confidentiality of information	Decentralized Governance Services
	SLO-2				Intellectual Property Issues in Cyber Space	E Payments
S-8	SLO-1	Overview of other laws amended by the IT Act, 2000	Intermediaries	Investigation of cyber-crimes in India	Interface with Copyright Law	Digital Token based E payment systems
	SLO-2				Interface with Patent Law	E Wallet
S-9	SLO-1	National Policy on Information Technology 2012	rules issued under the IT Act, 2000	Regulatory Authorities	Trademarks &Domain Names Related issues	Online financial services in India
	SLO-2				Dispute Resolution in Cyberspace	Law to Protect online financial service fraud

Learning Resources	1. Justice Yatindra Singh,Cyber Laws, Universal Law Publishing Co, New Delhi, (2012). 2. Verma S, K, Mittal Raman,Legal Dimensions of Cyber Space, Indian Law Institute, New Delhi, (2004) 3. S. R. Bhansali, Information Technology Act, 2000, University Book House Pvt. Ltd., Jaipur (2003). 4. Blockchain, Blueprint for a new Economy , Melanie Swan, 2017 –O'Reilly	5. SudhirNaib, The Information Technology Act, 2005: A Handbook, OUP, New York, (2011) 6. Upadhyaya and A. Upadhyaya, Material Science and Engineering, Anshan Publications, 2007 7. Vasu Deva, Cyber Crimes and Law Enforcement, Commonwealth Publishers, New Delhi, (2003). 8. Essential CyberSecurity Science, Josiah Dykstra, 2017 –O'Reilly

Learning Assessment

	Bloom's Level of Thinking	Continuous Learning Assessment (50% weightage)								Final Examination (50% weightage)	
		CLA – 1 (10%)		CLA – 2 (15%)		CLA – 3 (15%)		CLA – 4 (10%)#			
		Theory	Practice	Theory	Practice	Theory	Practice	Theory	Practice	Theory	Practice
Level 1	Remember Understand	40 %	-	30 %	-	30 %	-	30 %	-	30%	-
Level 2	Apply Analyze	40 %	-	40 %	-	40 %	-	40 %	-	40%	-
Level 3	Evaluate Create	20 %	-	30 %	-	30 %	-	30 %	-	30%	-
	Total	100 %		100 %		100 %		100 %		100 %	

CLA – 4 can be from any combination of these: Assignments, Seminars, Tech Talks, Mini-Projects, Case-Studies, Self-Study, MOOCs, Certifications, Conf. Paper etc.,

Course Designers

Experts from Industry	Experts from Higher Technical Institutions	Internal Experts
Mr. Kesawan HCL Technologies	*Dr. Surendran Rajendran* *AMA International University Bahrain*	*Dr.M.B Mukesh Krishnan, SRMIST*
Mr.Celeian, Symantec		*Mrs.R.Vidhya, SRMIST*

Course Code	18CSE475T	Course Name	MOBILE AND WIRELESS SECURITY	Course Category	E	Professional Elective	L	T	P	C
							3	0	0	3

Pre-requisite Courses	Nil	Co-requisite Courses	Nil	Progressive Courses	Nil
Course Offering Department	CSE	Data Book / Codes/Standards	Nil		

Course Learning Rationale (CLR):	*The purpose of learning this course is to:*
CLR-1 :	*understand the fundamentals of mobile cellular networks and IEEE wireless networks*
CLR-2 :	*Learn the basic security fundamentals*
CLR-3 :	*understand the security issues in Wi-Fi.and Wi-Max*
CLR-4 :	*explore the security issues in Next generation mobile networks*
CLR-5 :	*understand the security issues and key management in ad-hoc networks.*
CLR-6 :	*study the hacking techniques in IEEE 802.11*

Course Learning Outcomes (CLO):	*At the end of this course, learners will be able to:*	Learning 1 Level of Thinking (Bloom)	Learning 2 Expected Proficiency (%)	Learning 3 Expected Attainment (%)	PLO 1 Engineering Knowledge	PLO 2 Problem Analysis	PLO 3 Design & Development	PLO 4 Analysis, Design, Research	PLO 5 Modern Tool Usage	PLO 6 Society & Culture	PLO 7 Environment & Sustainability	PLO 8 Ethics	PLO 9 Individual & Team Work	PLO 10 Communication	PLO 11 Project Mgt. & Finance	PLO 12 Life Long Learning	PLO 13 PSO - 1	PLO 14 PSO - 2	PLO 15 PSO – 3
CLO-1 :	*understand the fundamentals of mobile cellular networks and IEEE wireless networks*	2	80	85	H	-	-	-	-	-	-	-	-	-	-	-	-	-	-
CLO-2 :	*Identify various possibilities for security threats in wireless networks.*	2	75	80	H	H	-	-	-	-	-	-	-	-	-	-	-	-	-
CLO-3 :	*Handle the security threats in Wi-Fi networks.*	2	85	80	H	-	-	-	-	-	-	-	-	-	-	-	-	-	-
CLO-4 :	*Solve the security attacks in mobile IP networks*	2	80	75	H	H	-	-	-	-	-	-	-	-	-	-	-	-	-
CLO-5 :	*Prevent the attacks in ad-hoc networks.*	2	75	85	H	-	-	H	-	-	-	-	-	-	-	-	-	-	-
CLO-6 :	*Protect the 802.11 Networks from attacks.*	2	80	85	H	-	-	-	-	-	-	-	-	-	-	-	-	-	-

Duration (hour)		9	9	9	9	9
S-1	SLO-1	*Introduction to mobile cellular networks*	*Wi-Fi Security*	*Security in Next Generation Mobile Networks*	*Security in Ad Hoc Networks*	*Overview of Wireless security-Hacking*
	SLO-2	*Cellular network basic concepts*	*Attacks on wireless networks*	*SIP*	*Motivations and application fields*	*Scanning and Enumerating 802.11 Networks*
S-2	SLO-1	*IEEE wireless networks, WLAN: IEEE 802.11*	*IEEE 802.11 security mechanisms*	*VoIP security flaws*	*Routing protocols*	*Windows Sniffing/Injection Tools*
	SLO-2	*WMAN mobile: IEEE 802.20*	*WEP (Wired Equivalent Privacy) and Shortcomings*	*Making VoIP secure*	*Attacks to routing protocols*	*Attacking 802.11 Wireless Networks*
S-3	SLO-1	*Mobile Internet networks*	*Security in 802.1x*	*IP Multimedia Subsystem (IMS)*	*Security mechanisms - Basic protections and existing tools*	*Security Through Obscurity*
	SLO-2	*Security in the digital age*	*Authentication*	*IMS architecture and security*	*Key management architectures*	*Attacking WPA-Protected 802.11 Networks*
S-4	SLO-1	*Threats and risks to TeleCommunication systems*	*The 802.11i security architecture*	*4G security*	*Protections using asymmetric cryptography*	*Breaking Authentication: WPA-PSK*
	SLO-2	*From wireline vulnerabilities to vulnerabilities in wireless Communications*	*Radio security policies*	*Confidentiality*	*Protections using symmetric cryptography*	*Breaking Authentication: WPA Enterprise*
S-5	SLO-1	*Security services*	*Authentication in wireless networks*	*Security of IP-Based Mobile Networks*	*Protection against data modification*	*Attack 802.11 Wireless Clients*
	SLO-2	*Symmetric and asymmetric cryptography*	*Layer 3 security mechanisms*	*Vulnerabilities of Mobile IP networks*	*Protection against tunnel attacks*	*Attacking the Application Layer*
S-6	SLO-1	*Hash functions*	*WiMAX Security*	*Discovery mechanisms and Authenticity of the mobile location*	*Key Management in Ad Hoc Networks*	*Dynamically Generating Rogue APs and Evil Servers with Karmetasploit*
	SLO-2	*Electronic signatures and MAC*	*Security evolution in WiMAX standards*	*Data protection (IP tunnels)*	*The threshold cryptography technique and Self-managed PKI*	*Direct Client Injection Techniques*
S-7	SLO-1	*Public Key Infrastructure (PKI) and electronic certificates*	*WiMAX low layers*	*IPv6 mobility mechanisms*	*Key agreement technique within MANETs and Cryptographic identifiers*	*Overview of Bluetooth Scanning and Reconnaissance*

	SLO-2	*Management of cryptographic keys*	*Security according to the IEEE-802.16e standard*	*Mobile IPv6 bootstrapping*	*The Resurrecting Duckling technique*	*Bluetooth Eavesdropping*
S-8	SLO-1	*Cryptographic protocols*	*Authentication with PKMv2-RSA, PKMv2-EAP*	*Mobility with Mobile IPv4*	*Group key management within ad hoc networks*	*Commercial Bluetooth Sniffing*
	SLO-2	*IPsec protocol suite*	*SA-TEK 3-way handshake*	*Protocol and security*	*Security services and challenges for group Communications within MANETs*	*Open-Source Bluetooth Sniffing*
S-9	SLO-1	*Authentication mechanisms*	*GTEK updating algorithm*	*Mobility with MOBIKE*	*Comparison metrics*	*ZigBee Security*
	SLO-2	*Access control-Firewalls*	*Algorithms associated with the TEKs*	*IP mobility with HIP*	*Approaches for Group key management*	*ZigBee Attacks*

Learning Resources	1. *Hakima Chaouchi, Maryline Laurent-Maknavicius, "Wireless and Mobile Network SecuritySecurity Basics,SecurityinOn-the-shelfandEmergingTechnologies",JohnWiley&SonsInc,2009.* 2. *JohnnyCache,JoshuaWright,VincentLiu,"HackingExposedWireless:WirelessSecuritySecrets& Solutions", Second Edition, McGraw-Hill,2010.*	3. *LeiChen,JiahuangJi,ZihongZhang,"WirelessNetworkSecurity:TheoriesandApplications",Higher Education Press,2013.*

Learning Assessment

	Bloom's Level of Thinking	Continuous Learning Assessment (50% weightage)								Final Examination (50% weightage)	
		CLA – 1 (10%)		CLA – 2 (15%)		CLA – 3 (15%)		CLA – 4 (10%)#			
		Theory	Practice	Theory	Practice	Theory	Practice	Theory	Practice	Theory	Practice
Level 1	Remember Understand	*40 %*	-	*30 %*	-	*30 %*	-	*30 %*	-	*30%*	-
Level 2	Apply Analyze	*40 %*	-	*40 %*	-	*40 %*	-	*40 %*	-	*40%*	-
Level 3	Evaluate Create	*20 %*	-	*30 %*	-	*30 %*	-	*30 %*	-	*30%*	-
	Total	100 %		100 %		100 %		100 %		100 %	

CLA – 4 can be from any combination of these: Assignments, Seminars, Tech Talks, Mini-Projects, Case-Studies, Self-Study, MOOCs, Certifications, Conf. Paper etc.,

Course Designers

Experts from Industry	Experts from Higher Technical Institutions	Internal Experts

Course Code	18CSE476T	Course Name	DATABASE SECURITY	Course Category	E	Professional Elective	L	T	P	C
							3	0	0	3

Pre-requisite Courses	Nil	Co-requisite Courses	Nil	Progressive Courses	Nil
Course Offering Department	Computer Science and Engineering	Data Book / Codes/Standards	Nil		

Course Learning Rationale (CLR):	*The purpose of learning this course is to:*	Learning			Program Learning Outcomes (PLO)														
		1	2	3	1	2	3	4	5	6	7	8	9	10	11	12	13	14	15
CLR-1 :	*Demonstrate understanding of Fundamentals of Security in database technology with its security architecture in modern computer systems in a typical enterprise.*																		
CLR-2 :	*Formulate a working definition of database security and administration and Identify contemporary practices of operating system security.*																		
CLR-3 :	*To identify risks and vulnerabilities in operating systems from a database perspective.*																		
CLR-4 :	*Demonstrate the knowledge and skills for administration of user, profiles, password policies, privileges and roles.*																		
CLR-5 :	*Manage database security Model on application level and Conduct database auditing for security and reliability*																		
CLR-6 :	*Implement typical security projects on enterprise systems.*																		
Course Learning Outcomes (CLO):	*At the end of this course, learners will be able to:*	Level of Thinking (Bloom)	Expected Proficiency (%)	Expected Attainment (%)	Engineering Knowledge	Problem Analysis	Design & Development	Analysis, Design, Research	Modern Tool Usage	Society & Culture	Environment & Sustainability	Ethics	Individual & Team Work	Communication	Project Mgt. & Finance	Life Long Learning	PSO - 1	PSO - 2	PSO – 3
CLO-1 :	*Students are able to identify fundamentals of data , securityof data and security issues*	*3*	*85*	*75*	*M*	*H*	*L*	*H*	*L*	-	-	-	*H*	*H*	*M*	*H*	-	-	-
CLO-2 :	*Students are obtaining knowledge about architecture of data base security and Operating System Security*	*3*	*85*	*75*	*M*	*H*	*L*	*M*	*L*	-	-	-	*M*	*L*	*M*	*H*	-	-	-
CLO-3 :	*Develop and implement a security plan for an enterprise level database (password policies, auditing policies, user privileges, profile, and roles).*	*3*	*75*	*70*	*M*	*H*	*M*	*H*	*H*	*H*	-	-	*M*	*L*	*H*	*H*	-	-	-
CLO-4 :	*Students are able to design and implement access control rules to assign privileges and protect data in databases.*	*3*	*85*	*85*	*M*	*H*	*H*	*H*	*L*	-	*H*	-	*M*	*L*	*H*	*H*	-	-	-
CLO-5 :	*Identify some of the factors driving the need for Database security and classify particular examples of attacks*	*3*	*85*	*75*	*H*	*H*	*M*	*H*	*L*	*M*	-	*M*	*M*	*L*	-	*H*	-	-	-
CLO-6 :	*Students implement database auditing and Virtual Private Database to protect data in databases*	*3*	*80*	*85*	*H*	*H*	*H*	*H*	*H*	-	-	-	*H*	*H*	*M*	*H*	-	-	-

Duration (hour)		9	9	9	9	9
S-1	SLO-1	*Importance of Data,Identity Theft*	*Installing a typical database product*	*Introduction-Authentication-Creating Users*	*Database Application Security Models: Introduction*	*Virtual Private Databases: Introduction-Overview*
	SLO-2			*SQL Server User*	*Types of Users*	*Implementation of VPD using Views*
S-2	SLO-1	*Levels of data security*	*Security architecture: Database Management Systems*	*Removing,Modifying Users-Default, Remote Users*	*Security Models*	*Application Context in Oracle*
	SLO-2	*Authorization in databases*	*Information Security Architecture*			*Implementing Oracle VPD*
S-3	SLO-1	*ACL Application Vulnerabilities*	*Database Security,Basics of Security in distributed databases*	*Database Links-Linked Servers*	*Application Types-Application Security Models*	*Viewing VPD Policies and Application contexts using Data Dictionary*
	SLO-2		*Asset Types and value-Security Methods*			*Policy Manager Implementing Row and Column level Security with SQL Server*
S-4	SLO-1	*Database security issues*	*Operating system security principles*	*Remote Servers-Practices for Administrators and Managers*	*Data Encryption.Excessive privileges, SQL Injections*	*Auditing Database Activities:*
	SLO-2	*Access to key fields,Access to surrogate information*				
S-5	SLO-1	*Problems with data extraction*	*Security Environment*	*Best Practices Profiles*	*Countermeasures of Malware, Countermeasures of Weak Audit Trail*	*Creating DLL Triggers with Oracle*
	SLO-2	*Access control in SQL*		*Password Policies*		
S-6	SLO-1	*Discretionary security in SQL,Schema level*	*Components*	*Introduction-Defining and Using Profiles*	*DB Vulnerabilities and Misconfiguration*	*Auditing Server Activity with SQL Server 2000*
	SLO-2					
S-7	SLO-1	*Authentication, Table level*	*Authentication Methods*	*Designing and Implementing Password Policies*	*Countermeasures of Denial of Service,Stolen Database Backups*	*Using Oracle Database Activities*
	SLO-2		*User Administration*			

S-8	SLO-1	*SQL system tables, Mandatory security in SQL*	*Password Policies*	*Granting and Revoking User Privileges*	*CONTROL METHODS: Access Control,Access control models for XML databases, Inference Policy*	*Security Project Case study-*
	SLO-2		*Vulnerabilities*			
S-9	SLO-1	*Data protection,*	*E-mail Security*	*Creating, Assigning and Revoking User Roles-Best Practices*	*User Identification,Authen tication, Accountability,Pass wordCrptography*	*Security and Auditing Project Case Study Data Protection and the IoT*
	SLO-2					

Learning Resources	*1) Alfred Basta ,Melissa Zgola and Dana Bullaboy "Database Security" 1st Edition Cingage ,2012 (Unit 1 toIII)*	*2) Hassan A. Afyouni, "Database Security and Auditing", Third Edition, Cengage Learning,2009. (UNIT III to V)*
	3) Michael Gertz and SushilJajodia (Editors) ,Handbook of Database Security: Applications and Trends , ISBN-10: 0387485325. Springer, 2007	*4) http://aircconline.com/ijist/V6N2/6216ijist18.pdf (UnitIV)*

Learning Assessment											
	Bloom's Level of Thinking	Continuous Learning Assessment (50%								Final Examination (50% weightage)	
		CLA – 1 (10%)		CLA – 2 (15%)		CLA – 3 (15%)		CLA – 4 (10%)#			
		Theory	Practice	Theory	Practice	Theory	Practice	Theory	Practice	Theory	Practice
Level 1	Remember Understand	*40%*	-	*30%*	-	*30%*	-	*20%*	-	*30%*	-
Level 2	Apply Analyze	*40%*	-	*40%*	-	*40%*	-	*40%*	*10%*	*40%*	-
Level 3	Evaluate Create	*20%*	-	*30%*	-	*30%*	-	*20%*	*10%*	*30%*	-
	Total	100 %		100 %		100 %		100 %		-	

CLA – 4 can be from any combination of these: Assignments, Seminars, Tech Talks, Mini-Projects, Case-Studies, Self-Study, MOOCs, Certifications, Conf. Paper etc.,

Course Designers		
Experts from Industry	Experts from Higher Technical Institutions	Internal Experts
Mr.Prithivi R , Teradata DBA,T.C.S Company	*Dr.N.P.Gopal,Professor,Department of Computer Applications , National Institute of Technology,Triuchy*	*1. Mrs.S.Amudha/SWE, SRMIST*
Mr.JeroTerrence,Project Developer in Datawarehousing and DataMining,T.C.S Company	*Dr.G.R.KanagaChidambaresan,Asso.Prof,VelTechUniveristy,Chennai*	*2. Dr. Madhavan/CSE, SRMIST*
-	*Dr.KannimuthuAsso.Prof,KarpagamCollege of Engineering,Coimbatore*	*3.Dr.MB.MukeshKrishnan/IT,SRMIST*

Course Code	18CSE477T	Course Name	SECURITY GOVERNANCE, RISK AND COMPLIANCE	Course Category	E	Professional Elective	L	T	P	C
							3	0	0	3

Pre-requisite Courses	Nil	Co-requisite Courses	Nil	Progressive Courses	Nil
Course Offering Department	Computer Science and Engineering	Data Book / Codes/Standards	Nil		

Course Learning Rationale (CLR):	*The purpose of learning this course is to:*	Learning			Program Learning Outcomes (PLO)														
		1	2	3	1	2	3	4	5	6	7	8	9	10	11	12	13	14	15
CLR-1 :	*Analyze the expanding role of IT governance and its effect on organizations*																		
CLR-2 :	*Be aware of management issues in IT governance*																		
CLR-3 :	*Analyze the role of risk to an organization and ways to identify key risk factors*																		
CLR-4 :	*Evaluate various risks and appropriate actions*																		
CLR-5 :	*Develop naming conventions for the resources in a system*																		
CLR-6 :	*Create and justify several appropriate policies and procedures to manage resources in a system.*																		
Course Learning Outcomes (CLO):	*At the end of this course, learners will be able to:*	Level of Thinking (Bloom)	Expected Proficiency (%)	Expected Attainment (%)	Engineering Knowledge	Problem Analysis	Design & Development	Analysis, Design, Research	Modern Tool Usage	Society & Culture	Environment & Sustainability	Ethics	Individual & Team Work	Communication	Project Mgt. & Finance	Life Long Learning	PSO - 1	PSO - 2	PSO – 3
CLO-1 :	*Having an overview of IT governance*	*3*	*80*	*70*	*M*	*H*	*H*	*H*	*H*	*M*	*M*	*M*	*H*	*M*	*H*	*H*	*H*	*H*	*H*
CLO-2 :	*Undergo an risk assessment*	*3*	*85*	*75*	*M*	*H*	*H*	*H*	*H*	*M*	*M*	*M*	*H*	*M*	*H*	*H*	*H*	*H*	*H*
CLO-3 :	*Describe legal and ethical considerations related to the handling and management of enterprise information assets.*	*3*	*75*	*70*	*M*	*H*	*H*	*H*	*H*	*M*	*M*	*M*	*H*	*M*	*H*	*H*	*H*	*H*	*H*
CLO-4 :	*Specify what constitutes admissible evidence in a legal proceeding and how to acquire and maintain this information.*	*3*	*85*	*80*	*M*	*H*	*H*	*H*	*H*	*M*	*M*	*M*	*H*	*M*	*H*	*H*	*H*	*H*	*H*
CLO-5 :	*Create a set of policies that implement a specified organizational objective.*	*3*	*85*	*75*	*M*	*H*	*H*	*H*	*H*	*M*	*M*	*M*	*H*	*M*	*H*	*H*	*H*	*H*	*H*
CLO-6 :	*Justify several appropriate policies and procedures to manage resources in a system.*	*3*	*80*	*70*	*M*	*H*	*H*	*H*	*H*	*M*	*M*	*M*	*H*	*M*	*H*	*H*	*H*	*H*	*H*

Duration (hour)		9	9	9	9	9
S-1	SLO-1	*Introduction to IT Governance*	*overview of Industry Best Practice Standards*	*Security mindset*	*Trends*	*Creation of policies*
	SLO-2					
S-2	SLO-1	*IT Risk Management Life Cycle*	*Model and Guidelines covering some aspect of IT governance*	*Design principles*	*Auditing*	*Maintenance of policies*
	SLO-2					
S-3	SLO-1	*IT Risk framework*	*principles of Business/IT Alignment Excellence,*	*System/security life-cycle*	*Cost / benefit analysis*	*Prevention*
	SLO-2					
S-4	SLO-1	*IT Risk identification*	*principles of Program/Project Management Excellence*	*Security implementation mechanisms*	*Asset management*	*Avoidance*
	SLO-2					
S-5	SLO-1	*IT Risk Security Governance*	*principles of IT Service Management and Delivery Excellence*	*Information assurance analysis model*	*Standards*	*Incident response*
	SLO-2					
S-6	SLO-1	*IT Risk assessment*	*principles of Vendor Management*	*Disaster recovery*	*Enforcement*	*Domain integration*
	SLO-2					
S-7	SLO-1	*IT Risk evaluation*	*Outsourcing Excellence*	*Forensics*	*Legal issues*	*Social engineering*
	SLO-2					
S-8	SLO-1	*IT Risk response,*	*critical success factors*	*threats*	*Disaster recovery*	*Protocol attacks*
	SLO-2			*vulnerabilities*		
S-9	SLO-1	*IT Risk monitoring and reporting*	*Case Study*	*attacks*	*security related issues and incidents*	*Security awareness*
	SLO-2			*countermeasures*		

Learning Resources	1. *Iannarelli, J. G., & O'Shaughnessy, M. O. (2015). Information governance and security: Protecting and managing your company's proprietary information. Waltham, MA: Butterworth Heinemann, Elsevier.* 2. *van Wyk, K. R., Graff, M. G., Peters, D. S., & Burley, D. L. (2015). Enterprise software security: A confluence of disciplines. Upper Saddle River, NJ: Pearson Education.*	3. *Legal Issues in Information Security, Joanna Lyn Grama, 2015. Jones & Bartlett Learning, Second Edition, ISBN: 978-1-284-05474-3.* 4. *Ethics of Big Data, Kord Davis, 2012. O'Reilly Media, ISBN: 978-1449311797*

Learning Assessment

	Bloom's Level of Thinking	Continuous Learning Assessment (50% weightage)								Final Examination (50% weightage)	
		CLA – 1 (10%)		CLA – 2 (15%)		CLA – 3 (15%)		CLA – 4 (10%)#			
		Theory	Practice	Theory	Practice	Theory	Practice	Theory	Practice	Theory	Practice
Level 1	Remember Understand	*40 %*	-	*30 %*	-	*30 %*	-	*30 %*	-	*30%*	-
Level 2	Apply Analyze	*40 %*	-	*40 %*	-	*40 %*	-	*40 %*	-	*40%*	-
Level 3	Evaluate Create	*20 %*	-	*30 %*	-	*30 %*	-	*30 %*	-	*30%*	-
	Total	100 %		100 %		100 %		100 %		100 %	

CLA – 4 can be from any combination of these: Assignments, Seminars, Tech Talks, Mini-Projects, Case-Studies, Self-Study, MOOCs, Certifications, Conf. Paper etc.,

Course Designers

Experts from Industry	Experts from Higher Technical Institutions	Internal Experts
Mr. Kesawan HCL Technologies	*Dr. Surendran Rajendran* *AMA International University Bahrain*	1. *Dr.M.B Mukesh Krishnan, SRMIST*
Mr.Celeian, Symantec		2. *Ms. Ramaprabha.J,SRMIST*
		3. *Dr. G. Usha,SRMIST*

Course Code	18CSE478T	Course Name	OPERATION SYSTEM SECURITY	Course Category	E	Professional Elective	L	T	P	C
							3	0	0	3

Pre-requisite Courses	Nil	Co-requisite Courses	Nil	Progressive Courses	Nil
Course Offering Department	Computer Science and Engineering	Data Book / Codes/Standards	Nil		

Course Learning Rationale (CLR):	*The purpose of learning this course is to:*
CLR-1 :	*To introduce students to a broad range of operating system security topics*
CLR-2 :	*To introduce students network and system security plans*
CLR-3 :	*To introduce students security design*
CLR-4 :	*To introduce students security threats and risks*
CLR-5 :	*To introduce students system and application security tools*
CLR-6 :	*To introduce students Network monitoring and audit logs and resolution of any security breach*

Course Learning Outcomes (CLO):	*At the end of this course, learners will be able to:*	Learning			Program Learning Outcomes (PLO)														
		1	2	3	1	2	3	4	5	6	7	8	9	10	11	12	13	14	15
		Level of Thinking (Bloom)	Expected Proficiency (%)	Expected Attainment (%)	Engineering Knowledge	Problem Analysis	Design & Development	Analysis, Design, Research	Modern Tool Usage	Society & Culture	Environment & Sustainability	Ethics	Individual & Team Work	Communication	Project Mgt. & Finance	Life Long Learning	PSO - 1	PSO - 2	PSO – 3
CLO-1 :	*Identify and assess current and anticipated security risks and vulnerabilities*	*3*	*80*	*70*	*H*	*H*	*M*	*M*	*M*	*L*	*L*	*L*	*H*	*M*	*L*	*H*	*H*	*H*	*H*
CLO-2 :	*Monitor, evaluate and test security conditions and environment*	*3*	*85*	*75*	*H*	*H*	*M*	*M*	*M*	*L*	*L*	*L*	*H*	*M*	*L*	*H*	*H*	*H*	*H*
CLO-3 :	*Develop an organizational security plan that provides for periodic reviews of security policies and procedures*	*3*	*75*	*70*	*H*	*H*	*M*	*M*	*M*	*L*	*L*	*L*	*H*	*M*	*L*	*H*	*H*	*H*	*H*
CLO-4 :	*Evaluate tools and technologies for use in protecting the network and individual network systems*	*3*	*85*	*80*	*H*	*H*	*M*	*M*	*M*	*L*	*L*	*L*	*H*	*M*	*L*	*H*	*H*	*H*	*H*
CLO-5 :	*Implement security plan and monitor solutions*	*3*	*85*	*75*	*H*	*H*	*M*	*M*	*M*	*L*	*L*	*L*	*H*	*M*	*L*	*H*	*H*	*H*	*H*
CLO-6 :	*Monitor and evaluate audit logs and set administrator alerts*	*3*	*80*	*70*	*H*	*H*	*M*	*M*	*M*	*L*	*L*	*L*	*H*	*M*	*L*	*H*	*H*	*H*	*H*

Duration (hour)		9	9	9	9	9
S-1	SLO-1	*Secure operating systems*	*What is a secure OS?*	*Information Protection And Security*	*Kali Linux*	*Implementation of strong password*
	SLO-2	*Security goals*				
S-2	SLO-1	*Trust model*	*Nature of threats/attacks*	*Requirements*	*Installation and Configuration*	*Implementation of buffer overflow attack*
	SLO-2			*Computer System Assets*		
S-3	SLO-1	*Threat model*	*Parts of an OS*	*Design Principles*	*Information Gathering Tools*	*Creation of child process using fork() function*
	SLO-2					
S-4	SLO-1	*Access Control fundamentals: Lampson's access matrix*	*Processes & Threads*	*Protection of Memory*	*Vulnerability Analyses Tools*	*Executing programs with exec() functions*
	SLO-2					
S-5	SLO-1	*Mandatory protection systems*	*Secure handling of Processes & Threads, Concurrency*	*User-Oriented Access Control*	*Wireless Attacks*	*Communication among multiple processes*
	SLO-2					
S-6	SLO-1	*Reference monitor*	*Memory management*	*Data-Oriented Access Control*	*Website Penetration Testing*	*Automating simple jobs simple scripts*
	SLO-2					
S-7	SLO-1	*Secure operating system definition*	*Secure memory management*	*File Sharing*	*Exploitation Tools*	*Executing programs at periodic intervals using at and crontab*
	SLO-2			*Access Rights*		
S-8	SLO-1	*Assessment criteria*	*Secure Communication and messaging*	*Simultaneous Access*	*Forensics Tools*	*Building own shell interpreter with limited features (mini project)*
	SLO-2			*Trusted Systems*		
S-9	SLO-1	*OS Security Assessment*	*Security perspective: end-user*	*Trojan Horse Defense*	*Social Engineering*	*Retrofitting security into operating systems*
	SLO-2		*Hardware/Architecture support for OS security*			

Learning Resources	1. *Abraham Silberschatz, Peter Baer Galvin and Greg Gagne, "Operating System Concepts", John Wiley & Sons ,Inc., 9th Edition, 2012* 2. *William Stallings, "Operating System: Internals and Design Principles", Prentice Hall, 7th Edition,2012* 3. *Tom Adelstein and Bill Lubanovic, "Linux System Administration", O'Reilly Media, Inc., 1st Edition, 2007*	4. *Trent Jaeger, "Operating Systems Security", Morgan & Claypool Publishers, 2008* 5. *Michael J.Palmer, "Guide to Operating Systems Security", Thomson/Course Technology, 2004*

Learning Assessment

	Bloom's Level of Thinking	Continuous Learning Assessment (50% weightage)								Final Examination (50% weightage)	
		CLA – 1 (10%)		CLA – 2 (15%)		CLA – 3 (15%)		CLA – 4 (10%)#			
		Theory	Practice	Theory	Practice	Theory	Practice	Theory	Practice	Theory	Practice
Level 1	Remember Understand	*40 %*	-	*30 %*	-	*30 %*	-	*30 %*	-	*30%*	-
Level 2	Apply Analyze	*40 %*	-	*40 %*	-	*40 %*	-	*40 %*	-	*40%*	-
Level 3	Evaluate Create	*20 %*	-	*30 %*	-	*30 %*	-	*30 %*	-	*30%*	-
	Total	100 %		100 %		100 %		100 %		100 %	

CLA – 4 can be from any combination of these: Assignments, Seminars, Tech Talks, Mini-Projects, Case-Studies, Self-Study, MOOCs, Certifications, Conf. Paper etc.,

Course Designers		
Experts from Industry	Experts from Higher Technical Institutions	Internal Experts
Mr. Kesawan HCL Technologies	*Dr. Surendran Rajendran* *AMA International University Bahrain*	1. *Dr.M.B Mukesh Krishnan, SRMIST*
Mr.Celeian, Symantec		2. *Mr. M.V. Ranjith Kumar,SRMIST*
		3. *Mrs. S. Aruna Sankaralingam, SRMIST*

Course Code	18CSE361T	Course Name	WEB PROGRAMMING	Course Category	E	Professional Elective	L	T	P	C
							3	0	0	3

Pre-requisite Courses	Nil	Co-requisite Courses	Nil	Progressive Courses	Nil
Course Offering Department	Computer Science and Engineering	Data Book / Codes/Standards	Nil		

Course Learning Rationale (CLR):	*The purpose of learning this course is to:*
CLR-1 :	*Web has become ubiquitous in nature*
CLR-2 :	*Organizations have integrated the Internet "seamlessly" into their information systems and the Web offers endless opportunity to do so.*
CLR-3 :	*This course provides the basic concepts and techniques used to design, develop, and deploy web applications satisfying the requirements in terms of flexibility, availability and scalability.*

Course Learning Outcomes (CLO):	*At the end of this course, learners will be able to:*	Learning			Program Learning Outcomes (PLO)														
		1	2	3	1	2	3	4	5	6	7	8	9	10	11	12	13	14	15
		Level of Thinking (Bloom)	Expected Proficiency (%)	Expected Attainment (%)	Engineering Knowledge	Problem Analysis	Design & Development	Analysis, Design, Research	Modern Tool Usage	Society & Culture	Environment & Sustainability	Ethics	Individual & Team Work	Communication	Project Mgt. & Finance	Life Long Learning	PSO - 1	PSO - 2	PSO – 3
CLO-1 :	*Understand different internet Technologies, web 2.0 and create a basic website using HTML and Cascading Style Sheets*	*1*	*80*	*70*	*H*	*H*	*H*	*H*	*H*	*M*	*L*	*M*	*H*	*M*	*M*	*H*	*H*	*H*	*M*
CLO-2 :	*Design a dynamic web page with validation using JavaScript objects and by applying different event handling mechanisms*	*1*	*85*	*75*	*H*	*H*	*H*	*H*	*H*	*M*	*L*	*M*	*H*	*M*	*M*	*H*	*H*	*H*	*M*
CLO-3 :	*Design a server side program using Servlets and JSP*	*1*	*75*	*70*	*H*	*H*	*H*	*H*	*H*	*M*	*L*	*M*	*H*	*M*	*M*	*H*	*H*	*H*	*M*
CLO-4 :	*Design a simple web page in PHP, and to present data in XML format.*	*2*	*85*	*80*	*H*	*H*	*H*	*H*	*H*	*M*	*L*	*M*	*H*	*M*	*M*	*H*	*H*	*H*	*M*
CLO-5 :	*Get overviews of java specific web services architecture and to enable rich client presentation using AJAX.*	*2*	*85*	*75*	*H*	*H*	*H*	*H*	*H*	*M*	*L*	*M*	*H*	*M*	*M*	*H*	*H*	*H*	*M*

Duration (hour)		9	9	9	9	9
S-1	SLO-1	*Understanding Internet , Difference between websites and web server*	*An introduction to JavaScript*	*Java Servlet Architecture*	*An introduction to PHP*	*Introduction to Ajax*
	SLO-2	*Internet technologies Overview*	*Java Script Terminologies*	*Servlet Life Cycle*	*Using PHP, Variables, Program control*	*Ajax Client Server Architecture*
S-2	SLO-1	*Understanding websites and web servers:*	*Introduction to DOM Model*	*Form GET and POST actions*	*Built-in functions*	*Introduction to XMLhttpRequest Object*
	SLO-2	*Understanding the difference between internet and*	*DOM Model*	*Session Handling ,*	*Connecting to Database*	*XMLhttpRequest Object*
S-3	SLO-1	*Web 2.0: Basics, RIA Rich Internet Applications*	*Introduction to Objects*	*Understanding Cookies,*	*Using Cookies*	*Introduction to Call Back Methods*
	SLO-2	*collaborations tools*	*Built-in objects: Math Object*	*Installing and Configuring Apache Tomcat Web Server*	*Regular Expressions*	*Call Back Methods*
S-4	SLO-1	*HTML5.0 Introduction*	*Built-in objects: String Object*	*Introduction to JSP*	*Introduction to XML*	*Introduction to Web Services*
	SLO-2	*HTML5.0 Elements Headers ,Linking,Images,List*	*Date Object*	*Understanding Java Server Pages*	*Basic XML Concepts*	*Java web services Basics*
S-5	SLO-1	*HTML5.0 Elements Tables, Formatting,Frames*	*Boolean Object*	*Applications on JSP*	*Introduction to DTD*	*Introduction to SOAP*
	SLO-2	*CSS Introduction*	*Object Collections*	*Introduction to JSTL*	*Document Type Definition*	*Elements of SOAP*
S-6	SLO-1	*CSS Types*	*Regular Expressions*	*Understanding of JSTL*	*Introduction to XML*	*Introduction to WSDL*
	SLO-2	*CSS : Positioning,Text Flow and Box Model*	*Examples of Regular Expressions*	*JSP Standard Tag Library(JSTL)*	*XML Schema*	*Creating, Publishing a WSDL*
S-7	SLO-1	*XHTML Introduction*	*Exception Handling*	*Creating HTML forms by embedding JSP code*	*DOM and Presenting XML*	*Testing and Describing a Web services(WSDL)*
	SLO-2	*XHTML Elements:Headers ,Linking,Images,List*	*Validation*	*Creating HTML forms by embedding JSP code*	*XML Parsers*	*Consuming a web service*
S-8	SLO-1	*XHTML Elements:Tables, Formatting,Frames*	*Event Handling Concept*	*Creating HTML forms by embedding JSP code*	*XML Validation*	*Introduction to Database Driven web*

						service from an application
	SLO-2	*CSS 3 Introduction*	*Introduction to DHTML*	*Creating HTML forms by embedding JSP code*	*XSLTransformation*	*Database Driven web service from an application*
S-9	SLO-1	*CSS 3 Types*	*DHTML with JavaScript*	*Lab 6:Creating HTML forms by embedding JSP code*	*XSLT Transformation*	*Applications on Database Driven web service*
	SLO-2	*CSS 3: Positioning,Text Flow and Box Model*		*Creating HTML forms by embedding JSP code*	*News Feed (RSS and ATOM)*	*Applications on Database Driven web service*

Learning Resources	*1. Deitel, Deitel and Nieto, Internet and World Wide Web : How to Program, 5 thEdition, 2012, Prentice Hall,. ISBN-13:978-0-13-215100-9* *2. Stephen Wynkoop, Running a perfect website, QUE, 2ndEdition,2001. ISBN 13: 9780789709448 3.Chris Bates, Web Programming : Building Intranet applications, 3rdEdition,2009, Wiley Publications,. ISBN 13:9780470017753.*	*3.Jeffrey C. Jackson, "Web Technologies A computer Science Perspective", 2011, Pearson, ISBN 9780133001976* *4. https://www.W3Schools.com*

Learning Assessment

	Bloom's Level of Thinking	Continuous Learning Assessment (50% weightage)								Final Examination (50% weightage)	
		CLA – 1 (10%)		CLA – 2 (15%)		CLA – 3 (15%)		CLA – 4 (10%)#			
		Theory	Practice	Theory	Practice	Theory	Practice	Theory	Practice	Theory	Practice
Level 1	Remember Understand	*40%*	-	*30%*	-	*30%*	-	*30%*	-	*30%*	-
Level 2	Apply Analyze	*40%*	-	*40%*	-	*40%*	-	*40%*	-	*40%*	-
Level 3	Evaluate Create	*20%*	-	*30%*	-	*30%*	-	*30%*	-	*30%*	-
	Total	100 %		100 %		100 %		100 %		100%	

CLA – 4 can be from any combination of these: Assignments, Seminars, Tech Talks, Mini-Projects, Case-Studies, Self-Study, MOOCs, Certifications, Conf. Paper etc.,

Course Designers		
Experts from Industry	Experts from Higher Technical Institutions	Internal Experts
		Dr.R.Jebakumar

Course Code	18CSE362T	Course Name	INTEGRATIVE PROGRAMMING AND TECHNOLOGY	Course Category	E	Professional Elective	L	T	P	C
							3	0	0	3

Pre-requisite Courses	Nil	Co-requisite Courses	Nil	Progressive Courses	Nil
Course Offering Department	Computer Science and Engineering	Data Book / Codes/Standards	Nil		

Course Learning Rationale (CLR):	*The purpose of learning this course is to:*	Learning			Program Learning Outcomes (PLO)														
		1	2	3	1	2	3	4	5	6	7	8	9	10	11	12	13	14	15
CLR-1 :	*Understand the concepts and features of Integrative programming*																		
CLR-2 :	*Gain knowledge on Java network programming and JDBC for integrating applications*																		
CLR-3 :	*Gain knowledge on Java component based technology for integrating reusable components across applications*																		
CLR-4 :	*Acquire knowledge on XML and JSON technology for data representation and exchange in integrating applications*																		
CLR-5 :	*Acquire knowledge in Java Messaging Service*																		
CLR-6 :	*Understand interoperability between programming languages*																		
Course Learning Outcomes (CLO):	*At the end of this course, learners will be able to:*	Level of Thinking (Bloom)	Expected Proficiency (%)	Expected Attainment (%)	Engineering Knowledge	Problem Analysis	Design & Development	Analysis, Design, Research	Modern Tool Usage	Society & Culture	Environment & Sustainability	Ethics	Individual & Team Work	Communication	Project Mgt. & Finance	Life Long Learning	PSO - 1	PSO - 2	PSO – 3
CLO-1 :	*Understand the basic ideas in Integrative coding*	*2*	*80*	*85*	*H*	-	-	-	-	-	-	-	-	-	-	-	-	-	-
CLO-2 :	*Acquire the ability to code java socket programming and java application to integrate databases*	*2*	*75*	*80*	*H*	*H*	-	-	-	-	-	-	-	-	-	-	-	-	-
CLO-3 :	*Acquire the ability to develop Enterprise Java bean components and Java based Web services*	*2*	*85*	*80*	*H*	-	-	-	-	-	-	-	-	-	-	-	-	-	-
CLO-4 :	*Appreciate the concepts of ML and JSON techniques in data representation and exchange for integrating applications*	*2*	*80*	*75*	*H*	*H*	-	-	-	-	-	-	-	-	-	-	-	-	-
CLO-5 :	*Acquire the knowledge for developing JMS based enterprise application integration*	*2*	*75*	*85*	*H*	-	-	*H*	-	-	-	-	-	-	-	-	-	-	-

Duration (hour)		9	9	9	9	9
S-1	SLO-1	*Programming paradigms an overview*	*Java network programming and RMI overview*	*Component Based technology overview*	*Data representation and exchange techniques in integrating applications overview*	*Interoperability between programming languages an overview*
	SLO-2	*Integrative programming an overview,*	*Java networking basics*	*Java beans concept and feature for reusability*	*Understanding XML and JSON for data representation and exchange*	*Understanding Java platform runtime environment and JVM*
S-2	SLO-1	*Integrative coding and its supporting Object Oriented concepts like inheritance, interface polymorphism .*	*Socket programming for TCP*	*Visual Java Beans components features and steps for creation*	*Understanding XML validation, Schema,*	*Understanding Java Native Interface(JNI) concepts in integrating native application code in java applications*
	SLO-2	*Object oriented design pattern for integrative coding overview..*	*Options and features for socket programming*	*Integrating visual beans to different applications*	*Understanding XML parsers DOM and SAX variant parsers.*	*Java tools for JNI programming*
S-3	SLO-1	*Creational design pattern, structural design pattern, Behavioral design pattern*	*UDP programming using Datagram*	*Enterprise Java platform overview*	*Understanding Integration of Enterprise applications with XML*	*Java libraries for JNI support*
	SLO-2	*Concept of Inversion of Control*	*options and features for UDP programming*	*Enterprise java bean components features and types*	*JSON encoding and decoding implementation*	*Understanding Usage of IDE for JNI programming*
S-4	SLO-1	*Application Architecture overview*	*Secure socket Communication*	*Session bean concepts and its types*	*Concept of Messaging Queue in integrating software systems to exchange information Asynchronously*	*Understanding concepts in JNI programming .Name mangling and function signatures DLL ,The JNIEnv argument*
	SLO-2	*Multi-tier architecture for integrating application packages like client side, middleware and databases*	*IP multicast and Multicast socket programming*	*Entity bean concepts and types*	*JMS and its role in integrating application in java enterprise platform*	*Understanding Accessing of Java Strings, Passing and using Java objects in native code*
S-5	SLO-1	*Enterprise application architecture, overview*	*RMI and distributed applications*	*Implementing Enterprise application through integrating session and Entity beans*	*JMS features and benefits*	*Exception handling in JNI*
	SLO-2	*JEE platform and its features*	*Understanding stub and skeleton concept in RMI*	*Java web services an overview*	*JMS service providers*	*Threading concept in JNI*

S-6	SLO-1	*Understanding Design principles in Enterprise applications*	*RMI programming application steps*	*SOAP based web services .WSDL,SOAP message*	*Concept of Message queues*	*Python integration in java platform overview*
	SLO-2	*Enterprise application integration overview*	*RMI programming implementation*	*JAX-WS implementation for SOAP based webservices*	*Point to point messaging domain features*	*Jython programming concepts and features*
S-7	SLO-1	*Role of Design Patterns in Enterprise application integration,*	*Concepts in Java Database connectivity in integrating java applications with various databases*	*RESTful web services features*	*Application scenario for integrating applications through p2p messaging*	*Installation of Jython for developing applications to run in java platform.*
	SLO-2	*Designing distributed object interfaces*	*Understanding Types of data base connectivity Different drivers*	*JAX-RS implementation for Restful web services*	*Concept of publish/subscribe method of messaging*	*Jython programming basics*
S-8	SLO-1	*Front controller patterns*	*JDBC application program concepts and implementation*	*Integrating web services component to client application*	*Application scenario for integrating applications through publish/subscribe method based messaging*	*Accessing Java features and libraries of java in Jython code*
	SLO-2	*Facade patterns,*	*Java persistence API overview*	*Service discovery, UDDI*	*Message driven beans in Enterprise JavaBeans*	*Java swing based GUI development in Jython*
S-9	SLO-1	*Adapter patterns*	*Java Data Objects(JDO) concepts*	*Policy and security for web services*	*Features and environmental setup for implementing Message driven beans*	*Understanding Jython JDBC connectivity*
	SLO-2	*Concepts of DAO*	*Java persistence API frameworks overview*	*Comparison between SOAP and RESTful web services*	*Understanding and using JMS in Message driven beans*	*Integrating Jython code in Java application*

Learning Resources	1. *KogentLearningSolutionsInc,JAVAServerProgrammingJavaEE7BlackBook , 5th ed., Weily India, 2016.* 2. *ElliotteRustyHarold,JavaNetworkprogramming,O'Reilly,2013*	3. *Cay S. Horstmann , D. R., Core Java Volume II - Advanced Features 10nd ed., John Wiley & Sons, 2013.*

Learning Assessment

	Bloom's Level of Thinking	Continuous Learning Assessment (50% weightage)								Final Examination (50% weightage)	
		CLA – 1 (10%)		CLA – 2 (15%)		CLA – 3 (15%)		CLA – 4 (10%)#			
		Theory	Practice	Theory	Practice	Theory	Practice	Theory	Practice	Theory	Practice
Level 1	Remember Understand	*40 %*	-	*30 %*	-	*30 %*	-	*30 %*	-	*30%*	-
Level 2	Apply Analyze	*40 %*	-	*40 %*	-	*40 %*	-	*40 %*	-	*40%*	-
Level 3	Evaluate Create	*20 %*	-	*30 %*	-	*30 %*	-	*30 %*	-	*30%*	-
	Total	100 %		100 %		100 %		100 %		100 %	

CLA – 4 can be from any combination of these: Assignments, Seminars, Tech Talks, Mini-Projects, Case-Studies, Self-Study, MOOCs, Certifications, Conf. Paper etc.,

Course Designers		
Experts from Industry	Experts from Higher Technical Institutions	Internal Experts
1. Mr. Venketasan Palavesam Delivery Head L &T		*1.Mr. K. Navin, SRMIST*
2. K.S.Kumar COO MindZen,India private Ltd		*Mr S.Ramaraj and Dr. Parthiban*

Course Code	18CSE364T	Course Name	SYSTEM ADMINISTRATION AND MAINTENANCE	Course Category	E	Professional Elective	L	T	P	C
							3	0	0	3

Pre-requisite Courses	Nil	Co-requisite Courses	Nil	Progressive Courses	
Course Offering Department	Computer Science and Engineering	Data Book / Codes/Standards	Nil		

Course Learning Rationale (CLR):	*The purpose of learning this course is to:*
CLR-1 :	*Understand the factors that make Authentication/Authorization and stores of system Administration*
CLR-2 :	*Acquire a knowledge and understanding of the specific problems in the Enterprise Security, and be able to apply some of the techniques*
CLR-3 :	*Identify the specific challenges that inherent in the Budget and Desktop Deployment of system Administration that are able to apply some of the techniques that can be of use in comprehending and changing them*
CLR-4 :	*Evaluate and understand the specific problems inherent in the system maintenance and evolution of package- based operating system, and be able to apply techniques for designing change-resistant systems from pre- packaged code.*
CLR-5 :	*Analyze and apply system maintenance technical concepts that relate to UPS software administration*

Course Learning Outcomes (CLO):	*At the end of this course, learners will be able to:*	Learning 1: Level of Thinking (Bloom)	Learning 2: Expected Proficiency (%)	Learning 3: Expected Attainment (%)	PLO 1: Engineering Knowledge	PLO 2: Problem Analysis	PLO 3: Design & Development	PLO 4: Analysis, Design, Research	PLO 5: Modern Tool Usage	PLO 6: Society & Culture	PLO 7: Environment & Sustainability	PLO 8: Ethics	PLO 9: Individual & Team Work	PLO 10: Communication	PLO 11: Project Mgt. & Finance	PLO 12: Life Long Learning	PLO 13: PSO - 1	PLO 14: PSO - 2	PLO 15: PSO – 3
CLO-1 :	*Explain terms used in make Authentication/Authorization and stores of system Administration*	3	80	70	H	H	H	H	H	-	-	-	H	H	-	H	-	-	-
CLO-2 :	*Incorporate a knowledge and understanding of the specific problems Enterprise Security, and be able to apply some of the*	3	85	75	M	H	H	M	H	-	-	-	M	H	-	H	-	-	-
CLO-3 :	*Identify challenges that inherent in maintenance and evolution of package-based operating system, and be able to apply techniques*	3	75	70	M	H	M	H	H	-	-	-	M	H	-	H	-	-	-
CLO-4 :	*Apply techniques for designing change-resistant systems from pre-packaged code.*	3	85	80	M	H	M	H	H	-	-	-	M	H	-	H	-	-	-
CLO-5 :	*Apply system maintenance technical concepts that relate to UPS software administration*	3	85	75	H	H	M	H	H	-	-	-	M	H	-	H	-	-	-

Duration (hour)		9	9	9	9	9
S-1	SLO-1 SLO-2	*Authentication/Authorization*	*Thin client support:*	*Issues relating to proposal construction and endorsement: New project development issues,*	*Customization of Operating System and maintenance of system:3 types of media to use when backing up your data and when each method is appropriate,*	*UPS: Identify the specifications of UPS,*
S-2	SLO-1 SLO-2	*Storage: Storage Area Networks*	*LTSP, Citrix*	*RFC construction, RFP Process,*	*How to create automated backups to ensure you always have a recent backup,*	*Switch-on and Switch-off procedure of UPS,*
S-3	SLO-1 SLO-2	*Network Attached Storage*	*Windows Terminal services,*	*Budgeting,*	*Learn how to manually backup data, How to make an exact copy of a hard drive*	*Measurement of Input/output voltage/current levels, battery charge level,*
S-4	SLO-1 SLO-2	*Storage Virtualization, Enterprise Backup and Restoration Issues*	*Sun Ray Services*	*Budgeting for new projects*	*Hardware Troubleshooting: The danger in not diagnosing problems first,*	*Identifying status of UPS from front panelindicators,*
S-5	SLO-1 SLO-2	*Enterprise Service Deployment: Clustering and fault tolerance,*	*Enterprise Security:*	*Desktop Deployment and Management, Alternative Desktops: SUS*	*Learn how to test your RAM ,*	*carryout routine maintenance of battery, battery terminals, loose contacts etc.,*
S-6	SLO-1 SLO-2	*Virtualization of services, Grids/On Demand/N1*	*Disaster Recovery*	*RIS,*	*check your hard drive for errors*	*Test UPS as per specification. Verification of back-up time.*
S-7	SLO-1 SLO-2	*Enterprise Applications: Enterprise Resource Planning,*	*Policies*	*Sun Java Desktop,*	*PC Cleaning: The best cleaning supplies to use,*	*Circuit tracing and fault finding practice*
S-8	SLO-1 SLO-2	*Customer Relationship Management,*	*Planning*	*Xandros*	*How to increase airflow and increase your computers lifespan*	*Servicing of UPS by simulating more likely faults and systematic approach to identify and rectify them*
S-9	SLO-1 SLO-2	*Office Automation*	*Procedures*	*Lindows*	*How to clean your computer*	*backup times its dependence on battery's load and its calculations*

Learning Resources	1. *Tittel, et al, A Guide to Microsoft Exchange Server 5.5, Course Technology*	2. *2.Hughes and Thomas, Novell's Guide to NetWare 5 Networks, IDG* 3. *3.Harvel et al, Unix and Windows 2000 Handbook, Prentice Hall*

Learning Assessment											
	Bloom's Level of Thinking	Continuous Learning Assessment (50%								Final Examination (50% weightage)	
		CLA – 1 (10%)		CLA – 2 (15%)		CLA – 3 (15%)		CLA – 4 (10%)#			
		Theory	Practice	Theory	Practice	Theory	Practice	Theory	Practice	Theory	Practice
Level 1	Remember Understand	*40%*	-	*30%*	-	*30%*	-	*30%*	-	*30%*	-
Level 2	Apply Analyze	*40%*	-	*40%*	-	*40%*	-	*40%*	-	*40%*	-
Level 3	Evaluate Create	*20%*	-	*30%*	-	*30%*	-	*30%*	-	*30%*	-
	Total	100 %		100 %		100 %		100 %		100%	

CLA – 4 can be from any combination of these: Assignments, Seminars, Tech Talks, Mini-Projects, Case-Studies, Self-Study, MOOCs, Certifications, Conf. Paper etc.,

Course Designers		
Experts from Industry	Experts from Higher Technical Institutions	Internal Experts
		1. MrS.Selvakumara Samy., SRMIST

Course Code	18CSE365T	Course Name	FUNDAMENTALS OF VIRTUALIZATION	Course Category	E	Elective	L	T	P	C
							3	0	0	3

Pre-requisite Courses	Nil	Co-requisite Courses	Nil	Progressive Courses	Nil
Course Offering Department	Computer Science and Engineering	Data Book / Codes/Standards	Nil		

Course Learning Rationale (CLR):	*The purpose of learning this course is to:*	Learning			Program Learning Outcomes (PLO)														
CLR-1 :	*Understand about Computing Virtualization tools, applications and techniques*	1	2	3	1	2	3	4	5	6	7	8	9	10	11	12	13	14	15
CLR-2 :	*Understand CPU virtualization, memory virtualization*																		
CLR-3 :	*How to configure VM CPU and memory options*																		
CLR-4 :	*Understand storage and network virtualization*																		
CLR-5 :	*Acquire knowledge about virtualization security*																		
CLR-6 :	*Learn about many case studies*																		
Course Learning Outcomes (CLO):	*At the end of this course, learners will be able to:*	Level of Thinking (Bloom)	Expected Proficiency (%)	Expected Attainment (%)	Engineering Knowledge	Problem Analysis	Design & Development	Analysis, Design, Research	Modern Tool Usage	Society & Culture	Environment & Sustainability	Ethics	Individual & Team Work	Communication	Project Mgt. & Finance	Life Long Learning	PSO - 1	PSO - 2	PSO – 3
CLO-1 :	*Able to define, distinguish Computing Virtualization tools, applications and techniques*	*3*	*80*	*70*	*L*	*H*	-	*H*	*L*	-	-	-	*L*	*L*	-	*H*	-	-	-
CLO-2 :	*Create a virtual environment and install VM with several guest operating systems*	*3*	*85*	*75*	*M*	*H*	*L*	*M*	*L*	-	-	-	*M*	*L*	-	*H*	-	-	-
CLO-3 :	*Able to configure virtual machine CPU and memory options*	*3*	*75*	*70*	*M*	*H*	*M*	*H*	*L*	-	-	-	*M*	*L*	-	*H*	-	-	-
CLO-4 :	*Able to configure VM storage and network options*	*3*	*85*	*80*	*M*	*H*	*M*	*H*	*L*	-	-	-	*M*	*L*	-	*H*	-	-	-
CLO-5 :	*Identify threats and able to security to virtualized environment*	*3*	*85*	*75*	*H*	*H*	*M*	*H*	*L*	-	-	-	*M*	*L*	-	*H*	-	-	-
CLO-6 :	*Investigate and discuss about case studies*	*3*	*80*	*70*	*L*	*H*	-	*H*	*L*	-	-	-	*L*	*L*	-	*H*	-	-	-

Duration (hour)		9	9	9	9	9
S-1	SLO-1	*Overview Of Virtualization -Basics of Virtualization -*	*Creating a Virtual machine- Performing P2V Conversions*	*Managing Storage for a virtual machine-Understanding storage virtualization*	*Theory Network Device Virtualization - VLANs*	*Case study: Load balancing*
	SLO-2	*Virtualization Types – Desktop Virtualization*	*Loading your Environment*	*Configuring VM Storage options*	*VRF Instances- VFIs -Virtual Firewall Contexts Network Device Virtualization*	*Autonomic computing*
S-2	SLO-1	*Storage Virtualization – System-level Operating Virtualization – Application Virtualization-*	*Building a new Virtual machine*	*Tuning practices for VM storage*	*Fundamentals of Virtualization security-Virtualization architecture*	*Xen para virtualization*
S-3	SLO-1	*Virtualization Advantages*	*Managing CPUs for a virtual machine-Understanding CPU Virtualization*	*SCSI- Speaking SCSI- Using SCSI buses – Fiber Channel – Fiber Channel Cables – Fiber Channel Hardware Devices – iSCSI Architecture – Securing iSCSI*	*Threats to a virtualized environment*	*Any Simulation tool*
S-4	SLO-2		*Configuring VM CPU options*	*Server virtualization concepts*	*How security must adapt to virtualization*	*Webhosting*
S-5	SLO-1	*Understanding Hypervisors*	*Tuning practices for VM CPUs*	*Introduction to server virtualization, Types of server virtualization technologies*	*Securing hypervisors-Hypervisor configuration and security*	*KVM virtualization*
S-6	SLO-2			*Limitations of server virtualization*		
S-7	SLO-1	*Understanding Virtual Machines*	*Managing Memory for a virtual Machine-Understanding memory virtualization, Configuring VM memory options*	*Managing Networking for a virtual machine-understanding network virtualization*	*Designing virtual networks for security-comparing virtual and physical networks*	*Microsoft Virtual Server*
S-8	SLO-2	Assignment-Installing windows, Linux on a virtual machine	*Tuning practices for VM memory*	*Configuring VM network options*	*Virtual network security considerations*	*Live migration*
S-9				*Tuning practices for Virtual networks*	*Configuring virtual switches for security*	

Learning Resources	1. *William von Hagen, Professional Xen Virtualization, Wrox Publications, January, 2008* 2. *Virtualization Essentials by Matthew Portnoy ISBN: 978-1118176719*	3. *Virtualization Security: Protecting Virtualized Environments, Dave shackleford, sybex publications,2013* 4. *Kumar Reddy, Victor Moreno, Network virtualization, Cisco Press, July, 2006.* 5. *David Marshall, Wade A. Reynolds, Advanced Server Virtualization: VMware and Microsoft Platform in the Virtual Data Center, Auerbach Publications, 2006.*

Learning Assessment

	Bloom's Level of Thinking	Continuous Learning Assessment (50% weightage)								Final Examination (50% weightage)	
		CLA – 1 (10%)		CLA – 2 (15%)		CLA – 3 (15%)		CLA – 4 (10%)#			
		Theory	Practice	Theory	Practice	Theory	Practice	Theory	Practice	Theory	Practice
Level 1	Remember Understand	*40 %*	-	*30 %*	-	*30 %*	-	*30 %*	-	*30%*	-
Level 2	Apply Analyze	*40 %*	-	*40 %*	-	*40 %*	-	*40 %*	-	*40%*	-
Level 3	Evaluate Create	*20 %*	-	*30 %*	-	*30 %*	-	*30 %*	-	*30%*	-
	Total	100 %		100 %		100 %		100 %		100 %	

CLA – 4 can be from any combination of these: Assignments, Seminars, Tech Talks, Mini-Projects, Case-Studies, Self-Study, MOOCs, Certifications, Conf. Paper etc.,

Course Designers

Experts from Industry	Experts from Higher Technical Institutions	Internal Experts
	Ms.SS.Subashka, SRMIST, Ramapuram	*1. Mrs. TYJ Naga Malleswari SRMIST*
	Mr. B.S. Vidhyasagar, SRMIST, Vadapalani	*2. Mrs Sasirekha Sankar, SRMIST*
		3. Dr.MB.Mukesh krishnan SRMIST

Course Code	18CSE366T	Course Name	HUMAN COMPUTER INTERACTION	Course Category	E	Professional Elective	L	T	P	C
							3	0	0	3

Pre-requisite Courses	NA	Co-requisite Courses	NA	Progressive Courses	//Course code
Course Offering Department	Computer Science and Engineering	Data Book / Codes/Standards	NA		

Course Learning Rationale (CLR):	*The purpose of learning this course is to:*
CLR-1 :	*Understandthe basic concepts of HCI*
CLR-2 :	*Learn the various design and software processes*
CLR-3 :	*Become familiar with different models of HCI and evaluation techniques*
CLR-4 :	*Learn web interface design*
CLR-5 :	*Learn mobile interface design*

Course Learning Outcomes (CLO):	*At the end of this course, learners will be able to:*	Learning 1 Level of Thinking (Bloom)	Learning 2 Expected Proficiency (%)	Learning 3 Expected Attainment (%)	PLO 1 Engineering Knowledge	PLO 2 Problem Analysis	PLO 3 Design & Development	PLO 4 Analysis, Design, Research	PLO 5 Modern Tool Usage	PLO 6 Society & Culture	PLO 7 Environment & Sustainability	PLO 8 Ethics	PLO 9 Individual & Team Work	PLO 10 Communication	PLO 11 Project Mgt. & Finance	PLO 12 Life Long Learning	PLO 13 PSO - 1	PLO 14 PSO - 2	PLO 15 PSO – 3
CLO-1 :	*Explain why it is important to design interactive products that are usable*	3	75	70				M											
CLO-2 :	*Explain key terms used in interactive design*	3	75	70				M											
CLO-3 :	*Explain the need for different models and the importance of evaluation*	3	65	60														M	
CLO-4 :	*Gain knowledge on web interface design*	3	55	50				M	H				M					M	
CLO-5 :	*Attain knowledge on mobile interface design*	3	55	50				M	H				M					M	

Duration (hour)	9	9	9	9	9
S-1	*Human: I/O Channels, Memory*	*Interactive design basics: Design process, Navigation design*	*Cognitive models: Introduction and GOMS*	*Designing web interfaces:*	*Mobile Interface design:*
S-2	*Thinking: Reasoning and Problem Solving, Emotion*	*Screen design and layout, Iteration and prototyping*	*Linguistic model*	*Introduction and Brainstorming session*	*Introduction and Brainstorming session*
S-3	*Individual differences, Psychology design of interactive systems*	*Software process: Software lifecycle, Usability engineering*	*Physical and device models*	*Drag and Drop,*	*Mobile Ecosystem: Platforms*
S-4	*Computer: Devices, Physical controls, sensors and special devices*	*Iterative design and prototyping, Design rationale*	*Organizational issues, Capturing requirements*	*Direct Selection*	*Application frameworks*
S-5	*Readability of text, Memory, Processing and networks*	*Design rules: Principles, Standards*	*Communication and collaboration models:*	*Contextual tools*	*Types of mobile applications: Widgets,*
S-6	*Interaction: Basics and Models*	*Guidelines, Golden rules*	*face-to-face and conversation*	*Overlays*	*Application, Games*
S-7	*Frameworks, Ergonomics, Interaction styles*	*Evaluation techniques: Goals, evaluation through expert analysis*	*Text based Communication and Group working*	*Inlays and Virtual pages*	*Mobile Information Architecture*
S-8	*WIMP interface elements, Interactivity*	*Evaluation through user participation*	*Task analysis: Introduction and Task decomposition comparison*	*Process flow*	*Mobile design: Elements and Tools*
S-9	*Paradigms: Interactive paradigms*	*Universal design: Principles, Multi-modal interaction User support: Requirements and Approaches*	*Knowledge based analysis*	*Case Study discussion*	*Case Study discussion*

Learning Resources	1. *Human Computer Interaction by Alan Dix, Janet Finlay, Gregory D.Abowd and Russell Beale – Third Edition - Pearson Education – 2004* 2. *Human Computer Interaction by K.Meena and R.Sivakumar – 2015 – Prentice Hall India* 3. *Designing the User Interface: Strategies for Effective Human Computer Interaction by Ben Shneiderman and Catherine Plaisant – Fifth Edition - 2009 – Pearson Addison Wesley* 4. *Designing Web Interfaces by Bill Scott and Theresa Neil – First Edition – O'Reilly Media Inc. – 2009* 5. *Mobile Design and Development by Brian Fling - First Edition – O'Reilly Media Inc. – 2009*

Learning Assessment

	Bloom's Level of Thinking	Continuous Learning Assessment (50% weightage)								Final Examination (50% weightage)	
		CLA – 1 (10%)		CLA – 2 (15%)		CLA – 3 (15%)		CLA – 4 (10%)#			
		Theory	Practice	Theory	Practice	Theory	Practice	Theory	Practice	Theory	Practice
Level 1	Remember Understand	*40 %*	-	*30 %*	-	*30 %*	-	*30 %*	-	*30%*	-
Level 2	Apply Analyze	*40 %*	-	*40 %*	-	*40 %*	-	*40 %*	-	*40%*	-
Level 3	Evaluate Create	*20 %*	-	*30 %*	-	*30 %*	-	*30 %*	-	*30%*	-
	Total	100 %		100 %		100 %		100 %		100 %	

CA – 3 can be from any combination of these: Assignments, Seminars, Tech Talks, Mini-Projects, Case-Studies, Self-Study, MOOCs, Certifications, Conf. Paper etc.,
SLO – Session Learning Outcome

Course Designers		
Experts from Industry	Experts from Higher Technical Institutions	Internal Experts
	Dr.T.Nagarajan, Professor and Head,Dept. of IT, SSN college of Engineering.	*1. Dr. M. Thenmozhi, SRMIST*
		2. Dr.S Prabakaran, SRMIST
		3. Dr. Alice Nithya , SRMIST

Course Code	18CSE397T	Course Name	COMPUTATIONAL DATA ANALYSIS	Course Category	E	Professional Elective	L	T	P	C
							3	0	0	3

Pre-requisite Courses	Nil	Co-requisite Courses	Nil	Progressive Courses	Nil
Course Offering Department	Computer Science and Engineering	Data Book / Codes/Standards	Nil		

Course Learning Rationale (CLR):	The purpose of learning this course is to:
CLR-1 :	*Understand the underlying assumptions, verify them, and propose appropriate actions if some assumptions do not hold*
CLR-2 :	*Identify appropriate statistical learning methods for the given problem involving real data.*
CLR-3 :	*Evaluate performance of the chosen regression and classification techniques and compare them*
CLR-4 :	*Show, analytically or empirically, the optimal balance between precision within training data and prediction power.*
CLR-5 :	*Use training and testing data to evaluate performance of the chosen regression and classification techniques and compare them.*
CLR-6 :	*Illustrate results with appropriate plots and diagrams.*

Course Learning Outcomes (CLO):	At the end of this course, learners will be able to:	Learning 1: Level of Thinking (Bloom)	2: Expected Proficiency (%)	3: Expected Attainment (%)	PLO 1: Engineering Knowledge	2: Problem Analysis	3: Design & Development	4: Analysis, Design, Research	5: Modern Tool Usage	6: Society & Culture	7: Environment & Sustainability	8: Ethics	9: Individual & Team Work	10: Communication	11: Project Mgt. & Finance	12: Life Long Learning	13: PSO - 1	14: PSO - 2	15: PSO – 3
CLO-1 :	*Acquire the knowledge on methods, theory, mathematics and algorithms in data analysis*	2	80	85	H	-	-	-	-	-	-	-	-	-	-	-	-	-	-
CLO-2 :	*Acquire the ability to To formulate and model mathematical and computational tasks*	2	75	80	H	H	-	-	-	-	-	-	-	-	-	-	-	-	-
CLO-3 :	*Understand the basic ideas about high-level data analysis, concepts and techniques*	2	85	80	H	-	-	-	-	-	-	-	-	-	-	-	-	-	-
CLO-4 :	*Acquire the ability identify other possible problems with messy data, such as multi-collinearity, understand their consequences, and propose solutions.*	2	80	75	H	H	-	-	-	-	-	-	-	-	-	-	-	-	-
CLO-5 :	*Apply the knowledge To build from scratch the basic components of a data analysis pipeline*	2	75	85	H	-	-	H	-	-	-	-	-	-	-	-	-	-	-
CLO-6 :	*To Show, analytically or empirically, the optimal balance between precision within training data and prediction power.*	2	80	85	H	-	-	-	-	-	-	-	-	-	-	-	-	-	-

Duration (hour)		9	9	9	9	9
S-1	SLO-1	*General Introduction*	*Generative Algorithms: Multivariate Normal*	*Unsupervised Learning:*	*Regularization and Model Selection:*	*Decision Tree and Random Forest:*
	SLO-2	*Supervised Learning*	*Linear Discriminant Analysis*	*PCA*	*Cross Validation,*	*Entropy*
S-2	SLO-1	*Least Squares and Nearest Neighbors*	*Naive Bayes*	*Mixture Models*	*Hill Climbing*	*Building Tree Bagging features*
	SLO-2	*Statistical Models*	*Laplacian Smoothing*	*Bayesian Graphical Models*	*Bayesian Optimization*	*Bagging Samples*
S-3	SLO-1	*Discriminative Algorithms*	*Multiclass Classification*	*Power Method*	*Bayesian Regression*	*Random Forest Adaboost*
	SLO-2	*Supervised Learning Concept*	*K-NN*	*Oja's algorithm*	*Bayesian Logistic*	*Gradient Tree Boosting*
S-4	SLO-1	*Linear Regression*	*Multi-class Fisher Discriminant Analysis*	*EM Algorithm*	*Regression Forward and*	*Boosting and Regularization Paths*
	SLO-2	*The Gauss–Markov Theorem*	*Multinomial Regression*	*Variational Inference*	*Backward Regression*	*Learning Ensembles*
S-5	SLO-1	*Multiple Regression*	*Support Vector Machines and Kernel Methods*	*Matrix Factorization/Completion*	*Lasso*	*Proximity Plots*
	SLO-2	*Maximum Likelihood*	*Intuition, Geometric Margins,*	*Independent Component Analysis*	*elastic-net*	*Random Forests and Overfitting*
S-6	SLO-1	*Normal Equation*	*Optimal Margin Classifier*	*The Google PageRank Algorithm*	*Proximal Gradient*	*Neural Network: Concept*
	SLO-2	*Gradient Descent*	*Lagrangian Duality, Soft-margin,*	*Principal Components, Curves and Surfaces*	*Prox-SVRG*	*Deep Neural Network*
S-7	SLO-1	*Stochastic Gradient*	*Loss function, Stochastic Subgradient Method*	*Cluster Analysis*	*Coordinate Proximal Gradient*	*Backpropagation*
	SLO-2	*SVRG*	*Kernel, SMO algorithm*	*Proximity Matrices*	*Pathwise Coordinate Descent*	*Convolutional Neural Network;*
S-8	SLO-1	*Linear Classification*	*Coordinate Gradient Descent*	*Dissimilarities Based on Attributes*	*Principal Components Regression*	*Bayesian Neural Nets*
	SLO-2	*Linear Discriminant Analysis*	*Kernel PCA, Kernel Logistic Regression*	*Object Dissimilarity*	*Incremental Forward Stage wise Regression*	*Bayes, Boosting and Bagging*
S-9	SLO-1	*Logistic Regression*	*Kernel Ridge Regression*	*Clustering Algorithms*	*The Dantzig Selector*	*Fitting Neural Networks*
	SLO-2	*Newton Method*	*Multiclass SVM*	*Combinatorial Algorithms*	*The Grouped Lasso*	*Issues in Training Neural Networks*

Learning Resources	1. *Hastie,Tibshirani and friedman,The Elements of Statistical Learning, Data Mining, Inference and Prediction, 2nd ed., Springer,2008.* 2. *Mohri, Rostamizadeh and Talwalker , Foundations of Machine Learning, The MIT Press Cambridge,Massachusetts London,England,2012*	3. *AndrewNg.CS229Lecturenotes:http://cs229.stanford.edu/notes/cs229-notes1.pdf*

Learning Assessment											
	Bloom's Level of Thinking	Continuous Learning Assessment (50% weightage)								Final Examination (50% weightage)	
		CLA – 1 (10%)		CLA – 2 (15%)		CLA – 3 (15%)		CLA – 4 (10%)#			
		Theory	Practice	Theory	Practice	Theory	Practice	Theory	Practice	Theory	Practice
Level 1	Remember Understand	*40 %*	-	*30 %*	-	*30 %*	-	*30 %*	-	*30%*	-
Level 2	Apply Analyze	*40 %*	-	*40 %*	-	*40 %*	-	*40 %*	-	*40%*	-
Level 3	Evaluate Create	*20 %*	-	*30 %*	-	*30 %*	-	*30 %*	-	*30%*	-
	Total	100 %		100 %		100 %		100 %		100 %	

CLA – 4 can be from any combination of these: Assignments, Seminars, Tech Talks, Mini-Projects, Case-Studies, Self-Study, MOOCs, Certifications, Conf. Paper etc.,

Course Designers		
Experts from Industry	Experts from Higher Technical Institutions	Internal Experts
Mr.Jayaraj Chandrasekaran, UST Global,Chennai, jayaraj.chandrasekaran@ust-global.com	*Dr.Devaki,Rajalakshmi Engineering College,Professor, Department of Computer Science and Engineering,*	*Mrs.S.Nagadevi*
		Dr.G.Vadivu

Course Code	18CSE461T	Course Name	INTERNET SECURITY AND CYBER FORENSICS	Course Category	E	Professional Elective	L	T	P	C
							3	0	0	3

Pre-requisite Courses	18CSC302J	Co-requisite Courses	Nil	Progressive Courses	Nil
Course Offering Department	Computer Science and Engineering	Data Book / Codes/Standards	Nil		

Course Learning Rationale (CLR):	*The purpose of learning this course is to:*
CLR-1 :	*Study about various threats associated with security and information warfare*
CLR-2 :	*Study about email security and the Importance of Firewalls and their types*
CLR-3 :	*Impart an introduction to the need of computer forensics*
CLR-4 :	*Study the tools and tactics associated with cyber forensics*
CLR-5 :	*Analyze and validate computer forensics data*

Course Learning Outcomes (CLO):	*At the end of this course, learners will be able to:*	Learning 1: Level of Thinking (Bloom)	Learning 2: Expected Proficiency (%)	Learning 3: Expected Attainment (%)	PLO 1: Engineering Knowledge	PLO 2: Problem Analysis	PLO 3: Design & Development	PLO 4: Analysis, Design, Research	PLO 5: Modern Tool Usage	PLO 6: Society & Culture	PLO 7: Environment & Sustainability	PLO 8: Ethics	PLO 9: Individual & Team Work	PLO 10: Communication	PLO 11: Project Mgt. & Finance	PLO 12: Life Long Learning	PLO 13: PSO - 1	PLO 14: PSO - 2	PLO 15: PSO – 3
CLO-1 :	*Have thorough knowledge about various threats associated with security and information warfare*	2	85	80	L	H	-	L	L	-	-	-	L	L	-	H	-	-	-
CLO-2 :	*Have in-depth knowledge about email security and understand the Importance of Firewalls and their types*	2	85	75	M	H	-	M	L	-	-	-	M	L	-	H	-	-	-
CLO-3 :	*Understand the need of computer forensics*	2	80	75	M	H	M	H	L	-	-	H	M	M	-	H	-	-	-
CLO-4 :	*Utilize the tools and tactics associated with cyber forensics*	3	75	70	M	H	M	H	H	-	-	H	M	M	-	H	-	-	-
CLO-5 :	*Analyze and validate computer forensics data and apply them for solving computer forensics issues*	3	75	70	H	H	M	H	M	-	-	H	M	M	-	H	-	-	-

Duration (hour)		9	9	9	9	9
S-1	SLO-1	*IPSec Protocol – Basics*	*PGP – Confidentiality and Authentication*	*Computer Forensics Fundamentals: Introduction to Computer Forensics, Use of Computer Forensics in Law Enforcement, Computer Forensics Assistance to Human Resources/Employment Proceedings*	*Processing Crime and Incident Scenes: Identifying Digital Evidence*	*Computer Forensics Analysis and Validation, Determining what data to collect and analyze*
	SLO-2	*IPSec Protocol - Documents*	*PGP – Compression and E-mail compatibility via Radix-64 conversion*	*Computer Forensics Services, Benefits of Professional Forensics Methodology, Steps Taken by Computer Forensics Specialists, Who Can Use Computer Forensic Evidence?*	*Collecting Evidence in Private-Sector Incident Scenes, Processing Law Enforcement Crime Scenes*	*Validating Forensics Data, Validating with Hexadecimal Editors, Validating with Computer Forensics Programs*
S-2	SLO-1	*IPSec Protocol – Security Associations*	*MIME*	*Types of Computer Forensics Technology: Types of Military Computer Forensic Technology*	*Preparing for a Search*	*Data Hiding Techniques - Hiding Partitions, Marking Bad Clusters, Bit-Shifting*
	SLO-2	*Hashed Message Authentication Code (HMAC)*	*S/MIME*	*Types of Law Enforcement: Computer Forensic Technology*	*Securing a Computer Incident or Crime Scene , Seizing Digital Evidence at the Scene*	*Using Steganography to Hide Data,*
S-3	SLO-1	*IP Authentication Header*	*Internet Firewalls for Trusted System: Roles of Firewalls*	*Types of Business Computer Forensic Technology*	*Storing Digital Evidence, Obtaining a Digital Hash*	*Examining Encrypted Files, Recovering Passwords*
	SLO-2	*IP ESP*	*Firewall related terminology*	*Specialized Forensics Techniques*	*Reviewing a Case*	*Performing Remote Acquisition, Remote Acquisitions with Runtime Software*
S-4	SLO-1	*Key Management Protocol for IPSec – OAKELY Key Determination Protocol*	*Types of Firewalls*	*Types of Computer Forensics Systems: Internet Security Systems, Intrusion Detection Systems, Firewall Security Systems*	*Working with Windows and DOS Systems*	*Network Forensics*
	SLO-2	*Key Management Protocol for IPSec – ISAKMP*	*Packet filters*	*Storage Area Network Security Systems, Network Disaster Recovery Systems, Public Key Infrastructure Systems*	*Understanding File Systems, Exploring Microsoft File Structures*	*Securing a Network*
S-5	SLO-1	*Transport layer Security : SSL and TLS*	*Circuit level gateways*	*Wireless Network Security Systems, Satellite Encryption Security Systems, Instant Messaging (IM) Security Systems , Net Privacy Systems*	*Examining NTFS Disks*	*Email Investigations – Exploring the Role of E-mail in Investigations, Exploring the Roles of the Client and Server in E-mail*
	SLO-2	*SSL Protocol*	*Application level gateways*	*Identity Management Security Systems, Identity Theft,*	*Understanding Whole Disk Encryption*	*Investigating E-mail Crimes and Violations:*

				Biometric Security Systems, Homeland Security Systems		*Examining E-mail Messages, Viewing E-mail Headers, Examining E-mail Headers, Examining Additional E-mail Files*
S-6	SLO-1	*SSL Record Protocol*	*Firewall designs*	*Understanding Computer Investigation: Preparing a Computer Investigation, Taking a Systematic Approach*	*Understanding the Windows Registry*	*Tracing an E-mail Message,Using Network E-mail Logs*
	SLO-2	*SSL Change Cipher Spec Protocol*	*Screened Host Firewall (Single – Homed Bastion Host)*	*Procedures for Corporate High-Tech Investigations*	*Understanding Microsoft Startup Tasks, Understanding MS-DOS Startup Tasks, Understanding Virtual Machines*	*Understanding E-mail Servers - Examining UNIX E-mail Server Logs, Examining Microsoft E-mail Server Logs, Examining Novell GroupWise E-mail Logs, Using Specialized E-mail Forensics Tools*
S-7	SLO-1	*SSL Alert Protocol*	*Screened Host Firewall (Dual – Homed Bastion Host)*	*Understanding Data Recovery Workstations and Software*	*Current Computer Forensics Tools: Software/ Hardware Tool*	*Cell Phone and Mobile Devices Forensics*
	SLO-2	*SSL Handshake Protocol*	*Screened Subnet Firewall*	*Conducting an Investigation, Completing the Case*	*Evaluating Computer Forensics Tool Needs*	*Understanding Mobile Device Forensics*
S-8	SLO-1	*Cryptographic Computations – Computing the Master Secret*	*SET for E-Commerce Transactions: Business requirements for SET*	*Data Acquisition: Understanding Storage Formats for Digital Evidence, Determining the Best Acquisition Method, Contingency Planning for Image Acquisitions, Using Acquisition Tools*	*Types of Computer Forensics Tools, Tasks Performed by Computer Forensics Tools*	*Mobile Phone Basics, Inside Mobile Devices*
	SLO-2	*Cryptographic Computations – Converting the Master Secret into Cryptographic Parameters*	*SET System Participants*	*Validating Data Acquisitions, Performing RAID Data Acquisitions*	*Computer Forensics Software Tools, Command-Line Forensics Tools, UNIX/Linux Forensics Tools, Other GUI Forensics Tools*	*Inside PDAs*
S-9	SLO-1	*TLS Protocol*	*SET Cryptographic Operation Principles, Dual Signature, Authentication and Message Integrity*	*Using Remote Network Acquisition Tools*	*Computer Forensics Hardware Tools, Forensic Workstations, Using a Write-Blocker, Recommendations for a Forensic Workstation*	*Understanding Acquisition Procedures for Cell Phones and Mobile Devices*
	SLO-2	*Cryptographic Computations for TLS*	*SET Payment Processing*	*Using Other Forensics Acquisition Tools*	*Validating and Testing Forensics Software, Using National Institute of Standards and Technology (NIST) Tools, Using Validation Protocols*	*Mobile Forensics Equipment*

Learning Resources	*1. Man Young Rhee, "Internet Security: Cryptographic Principles, Algorithms and Protocols", Wiley Publications, 2003* *2. Christopher Steuart, Bill Nelson, Amelia Phillips, "Guide Computer Forensics and Investigations", Cengage Learning, India, Fourth Edition, 2013.*	*2. John R.Vacca, "Computer Forensics: Computer Crime Scene Investigation", Charles RiverMedia, 2002.* *3. Richard E.Smith, "Internet Cryptography", Pearson Education, 3rd Edition, 2008.* *4. Marjie T.Britz, "Computer Forensics and Cyber Crime: An Introduction", Pearson Education, 3rd Edition, 2013.*

Learning Assessment

	Bloom's Level of Thinking	Continuous Learning Assessment (50% weightage)								Final Examination (50% weightage)	
		CLA – 1 (10%)		CLA – 2 (15%)		CLA – 3 (15%)		CLA – 4 (10%)#			
		Theory	Practice	Theory	Practice	Theory	Practice	Theory	Practice	Theory	Practice
Level 1	Remember Understand	40 %	-	30 %	-	30 %	-	30 %	-	30%	-
Level 2	Apply Analyze	40 %	-	40 %	-	40 %	-	40 %	-	40%	-
Level 3	Evaluate Create	20 %	-	30 %	-	30 %	-	30 %	-	30%	-
	Total	100 %		100 %		100 %		100 %		100 %	

CLA – 4 can be from any combination of these: Assignments, Seminars, Tech Talks, Mini-Projects, Case-Studies, Self-Study, MOOCs, Certifications, Conf. Paper etc.,

Course Designers		
Experts from Industry	Experts from Higher Technical Institutions	Internal Experts
	1. Dr.L.Kavisankar, Associate Professor, Department of Computer Science and Engineering, Hindustan Institute of Technology and Science, Chennai, India	*1. Mr. S.Saminathan, SRMIST*
		2. Dr.M.B.Mukesh Krishnan, SRMIST

Course Code	18CSE462T	Course Name	DATA CENTRE ADMINISTRATION AND MANAGEMENT	Course Category	E	Professional Elective	L	T	P	C
							3	0	0	3

Pre-requisite Courses	Nil	Co-requisite Courses	Nil	Progressive Courses	Nil
Course Offering Department	Computer Science and Engineering	Data Book / Codes/Standards	Nil		

Course Learning Rationale (CLR):	*The purpose of learning this course is to:*
CLR-1 :	*Critically discuss data center networking technologies*
CLR-2 :	*Evaluate key concepts in data center design*
CLR-3 :	*Concepts related to data center maintenance*
CLR-4 :	*Design, build and configure a data centers*
CLR-5 :	*Expose to implementing the various system management practices*

Course Learning Outcomes (CLO):	*At the end of this course, learners will be able to:*	Learning 1: Level of Thinking (Bloom)	Learning 2: Expected Proficiency (%)	Learning 3: Expected Attainment (%)	PLO 1: Engineering Knowledge	PLO 2: Problem Analysis	PLO 3: Design & Development	PLO 4: Analysis, Design, Research	PLO 5: Modern Tool Usage	PLO 6: Society & Culture	PLO 7: Environment & Sustainability	PLO 8: Ethics	PLO 9: Individual & Team Work	PLO 10: Communication	PLO 11: Project Mgt. & Finance	PLO 12: Life Long Learning	PLO 13: PSO - 1	PLO 14: PSO - 2	PLO 15: PSO – 3
CLO-1 :	*Manage Server Systems and Data Centres Infrastructure Management*	*1*	*90*	*85*	*L*	-	-	*M*	-	-	-	-	-	-	-	*H*	*L*	-	-
CLO-2 :	*Utilize the Storage, Bandwidth, Efficiency of systems and other resources for Data centre.*	*3*	*85*	*80*	*M*	*M*	*H*	*H*	*H*	-	-	-	-	-	-	*H*	*M*	*H*	-
CLO-3 :	*Monitoring the Networks and Resources. .*	*3*	*85*	*80*	*M*	*H*	*H*	*H*	*H*	-	-	-	-	-	-	*H*	*M*	*H*	-
CLO-4 :	*Planning for Flexible resource allocation*	*3*	*80*	*75*	*M*	*H*	*H*	*H*	*H*	-	-	-	-	-	-	*H*	*H*	*H*	-
CLO-5 :	*Administer the data centers*	*3*	*80*	*75*	*H*	*H*	*H*	*H*	*H*	*H*	-	*M*	-	-	-	*H*	*M*	*H*	*H*

Duration (hour)		9	9	9	9	9
S-1	SLO-1 SLO-2	*Data center Architecture*	*Data Center design*	*Data Center Maintenance*	*Data Center HVAC*	*System Management Best Practices*
S-2	SLO-1 SLO-2	*Data center Requirements*	*Characteristics of an Outstanding Design*	*Network Operations Center, Network Monitoring*	*Reasons for Strict Environmental Requirements*	*Server Cluster Best Practices*
S-3	SLO-1 SLO-2	*Data center prerequisites*	*Characteristics of an Outstanding Design*	*Datacenter physical security*	*Need for Energy-Efficient HVAC Systems*	*Data Storage Best Practices*
S-4-5	SLO-1 SLO-2	*Physical Area for Equipment and Unoccupied Space*	*Guidelines for Planning a Data Center*	*Data center Logical security*	*Air-Conditioning Systems*	*Network Management Best Practices*
S-6	SLO-1 SLO-2	*Required power to run all the devices*	*Data Center structures*	*Data center Cleaning*	*Air Circulation in a Data Center*	*Security Guidelines Internet security*
S-7	SLO-1	*Required cooling and HVAC Required weight*	*Raised Floor Design and Deployment*	*Floor Surface Cleaning*	*Placement of Hardware Racks*	*Best Practices for System Administration*
	SLO-2				*Bottom-to-Top Cooled Racks*	
S-8	SLO-1	*Budget Constraints*	*Design and Plan against Vandalism*	*Subfloor and Above-Ceiling Plenum Cleaning*	*Top-to-Bottom Cooled Racks*	*Device Naming, Naming Practices*
	SLO-2				*Front-to-Front Cooled Racks*	
S-9	SLO-1 SLO-2	*Selecting a Geographic Location Safety from Natural hazards*	*Data center design case study*	*Equipment Cleaning*	*Front-to-Back Cooled Racks*	*Load balancing, Terminology, Advantages &Types of load balancing*

Learning Resources	1. *Mouricio Arregoces, "Data Centre Fundamentals", Cisco Press ,2003* 2. *Administering Data Centers: Servers, Storage and Voice over IP, Kailash Jayaswal.* 3. *Kevin Corbin, Ron Fuller, David Jansen, "NX-OS and Cisco Nexus Switching: Next-Generation Data Center Architectures" Cisco Press; 1 edition [ISBN: 9781587058929], 2010.* 4. *SilvanoGai, TommiSalli, Roger Andersson, "Cisco Unified Computing System" Cisco Press; 1 edition, [ISBN: 9781587141935], 2010.* 5. *Nash Darukhanawalla, Patrice Bellagamba, "Interconnecting Data Centers Using VPLS" Cisco Press; 1 edition, [ISBN: 9781587059926], 2009.* 6. *Robert W. Kembel, Roger Cummings (Introduction), "The Fibre Channel Consultant" Northwest Learning Assoc; 3rd edition, [ISBN: 0931836840], 1998.* 7. *Robert W Kembal"Fiber Channel Switched Fabric" Northwest Learning Associates, inc. [ISBN: 0931836719], 2009.* 8. *John L. Hufferd, "ISCSI", Addison-Wesley Boston [ISBN: 978- 0201784190], 2003.*

Learning Assessment

	Bloom's Level of Thinking	Continuous Learning Assessment (50% weightage)								Final Examination (50% weightage)	
		CLA – 1 (10%)		CLA – 2 (15%)		CLA – 3 (15%)		CLA – 4 (10%)#			
		Theory	Practice	Theory	Practice	Theory	Practice	Theory	Practice	Theory	Practice
Level 1	Remember Understand	*40 %*	-	*30 %*	-	*30 %*	-	*30 %*	-	*30%*	-
Level 2	Apply Analyze	*40 %*	-	*40 %*	-	*40 %*	-	*40 %*	-	*40%*	-
Level 3	Evaluate Create	*20 %*	-	*30 %*	-	*30 %*	-	*30 %*	-	*30%*	-
	Total	100 %		100 %		100 %		100 %		100 %	

CLA – 4 can be from any combination of these: Assignments, Seminars, Tech Talks, Mini-Projects, Case-Studies, Self-Study, MOOCs, Certifications, Conf. Paper etc.,

Course Designers

Experts from Industry	Experts from Higher Technical Institutions	Internal Experts
Dr.M.S.Sricharan/Wipro Technologies		*Dr. B.Amutha, Professor and Head, Department of CSE, SRM IST*
		Dr. G.Vadivu, Professor and Head, Department of IT, SRM IST

Course Code	18CSE463T	Course Name	IT SERVICE MANAGEMENT AND OPERATIONS	Course Category	E	Professional Elective	L	T	P	C
							3	0	0	3

Pre-requisite Courses	Nil	Co-requisite Courses	Nil	Progressive Courses	Nil
Course Offering Department	Computer Science and Engineering	Data Book / Codes/Standards	Nil		

Course Learning Rationale (CLR):	*The purpose of learning this course is to:*
CLR-1 :	*To develop an awareness of the opportunities that information technology can have for enhancing service firms' competitiveness.*
CLR-2 :	*To appreciate the organizational significance of managing the IT service encounter to achieve internal and external customer satisfaction.*
CLR-3 :	*To understand new service development from both a product and process perspective.*
CLR-4 :	*To gain an appreciation of the complexities associated with implementing change during IT services.*
CLR-5 :	*to understand how an integrated ITSM framework*
CLR-6 :	*To Understand practical implementation of Information Technology Service Management*

		Learning			Program Learning Outcomes (PLO)														
		1	2	3	1	2	3	4	5	6	7	8	9	10	11	12	13	14	15
Course Learning Outcomes (CLO):	*At the end of this course, learners will be able to:*	Level of Thinking (Bloom)	Expected Proficiency (%)	Expected Attainment (%)	Engineering Knowledge	Problem Analysis	Design & Development	Analysis, Design, Research	Modern Tool Usage	Society & Culture	Environment & Sustainability	Ethics	Individual & Team Work	Communication	Project Mgt. & Finance	Life Long Learning	PSO - 1	PSO - 2	PSO – 3
CLO-1 :	*Illustrate the basic concepts of Service Science, Management, and Engineering*	*3*	*80*	*70*	*L*	*H*	*L*	*H*	*L*	*L*	*M*	*L*	*L*	*L*	*M*	*L*	*L*	*L*	*L*
CLO-2 :	*Examine the principle of IT service processes*	*3*	*85*	*75*	*L*	*H*	*L*	*H*	*L*	*L*	*M*	*L*	*L*	*L*	*M*	*L*	*L*	*L*	*L*
CLO-3 :	*Skills for planning, estimating, and resourcing for IT services*	*3*	*75*	*70*	*L*	*H*	*L*	*H*	*L*	*L*	*M*	*L*	*L*	*L*	*M*	*L*	*L*	*L*	*L*
CLO-4 :	*Manage the scope changes and the organizational changes in IT services*	*3*	*85*	*80*	*L*	*H*	*L*	*H*	*L*	*L*	*M*	*L*	*L*	*L*	*M*	*L*	*L*	*L*	*L*
CLO-5 :	*Ability to identify IT services as a means to provide functionality and value to customers in the context of specific case studies*	*3*	*85*	*75*	*L*	*H*	*L*	*H*	*L*	*L*	*M*	*L*	*L*	*L*	*M*	*L*	*L*	*L*	*L*
CLO-6 :	*Ability to understand the needs and targets of the different stakeholders (service providers, customers, suppliers/partners) in the services value chain.*	*3*	*80*	*70*	*L*	*H*	*L*	*H*	*L*	*L*	*M*	*L*	*L*	*L*	*M*	*L*	*L*	*L*	*L*

Duration (hour)		9	9	9	9	9
S-1	SLO-1	*Introduction*	*IT Project/Service Management*	*Communication Management*	*Service management concepts and frameworks*	*Planning and delivery processes*
	SLO-2	*Overview of Service Science, Management, Engineering*				
S-2	SLO-1	*IT Infrastructure*	*Planning*	*Team Building in IT Services*	*Services and service management*	*Service reporting*
	SLO-2					
S-3	SLO-1	*RFID Applications*	*Estimating*	*IT service project in a start-up company*	*Customer-facing services*	*Service availability and continuity management*
	SLO-2					
S-4	SLO-1	*Data Storage Management*	*Resourcing*	*Smaller IT service organization*	*Resource-facing services*	*Capacity management*
	SLO-2					
S-5	SLO-1	*IT Service Strategy*	*IT Project/Service Change*	*Soft Skills in IT Service Management*	*The service lifecycle. Processes. Functions. Roles*	*Information security management*
	SLO-2					
S-6	SLO-1	*Approach, and Practice*	*Quality*	*Presentation skills*	*Service strategy*	*Customer relationship management*
	SLO-2					
S-7	SLO-1	*IT Infrastructure Library*	*Issue*	*Negotiation skills*	*Service portfolio*	*Supplier relationship management.*
	SLO-2					
S-8	SLO-1	*e-Business Case Study*	*Risk Management*	*Job interview skills*	*Service catalog management*	*Service management tools*
	SLO-2					

S-9	SLO-1	*IT service report of IBM e-business at Ford Motor*	*Evaluate issue, and mitigate risk in IT service management*	*IBM perspectives of IT Service Management*	*Service level agreements.*	*Tool assessment framework*
	SLO-2				*Operational level agreements*	*Analysis of specific ITSM tools*

Learning Resources	1. Service Management, Fourth Edition, J.A. Fitzsimmons and M.J. Fitzsimmons, McGraw Hill. 2. Services Marketing, Valerie Zeithaml, Mary Jo Bitner, and Dwayne Gremler, McGraw-Hill. 3. Introduction to Operations Research, Hillier and Lieberman	4. Service modeling, Principles and Applications. Vilho Råisånen, Wiley 5. Understanding Service Business, S.E. Sampson, Wiley.

Learning Assessment

	Bloom's Level of Thinking	Continuous Learning Assessment (50% weightage)								Final Examination (50% weightage)	
		CLA – 1 (10%)		CLA – 2 (15%)		CLA – 3 (15%)		CLA – 4 (10%)#			
		Theory	Practice	Theory	Practice	Theory	Practice	Theory	Practice	Theory	Practice
Level 1	Remember Understand	*40 %*	-	*30 %*	-	*30 %*	-	*30 %*	-	*30%*	-
Level 2	Apply Analyze	*40 %*	-	*40 %*	-	*40 %*	-	*40 %*	-	*40%*	-
Level 3	Evaluate Create	*20 %*	-	*30 %*	-	*30 %*	-	*30 %*	-	*30%*	-
	Total	100 %		100 %		100 %		100 %		100 %	

CLA – 4 can be from any combination of these: Assignments, Seminars, Tech Talks, Mini-Projects, Case-Studies, Self-Study, MOOCs, Certifications, Conf. Paper etc.,

Course Designers

Experts from Industry	Experts from Higher Technical Institutions	Internal Experts
Mr. Kesawan HCL Technologies	*Dr. Surendran Rajendran* *AMA International University Bahrain*	*1. Dr.M.B Mukesh Krishnan, SRMIST*
Mr.Celeian, Symantec		*2. Mr.C.Santhanakrishnan, SRMIST*
		3. Mr. G. Senthil Kumar , SRMIST

Course Code	18CSE464T	Course Name	COMPUTER GRAPHICS AND GAME PROGRAMMING	Course Category	E	Professional Elective	L	T	P	C
							3	0	0	3

Pre-requisite Courses	Nil	Co-requisite Courses	Nil	Progressive Courses	Nil
Course Offering Department	Computer Science and Engineering	Data Book / Codes/Standards	Nil		

Course Learning Rationale (CLR):	*The purpose of learning this course is to:*
CLR-1 :	*Understand the fundamental concepts of generating basic output primitives*
CLR-2 :	*Know the basics of transformations and curves and surface representations*
CLR-3 :	*Know the various visible surface detection methods and various color models*
CLR-4 :	*Learn the interfaces of Unity and its installation procedure*
CLR-5 :	*Know the various objects in Unity to develop games*

Course Learning Outcomes (CLO):	*At the end of this course, learners will be able to:*	Learning 1: Level of Thinking (Bloom)	Learning 2: Expected Proficiency (%)	Learning 3: Expected Attainment (%)	PLO 1: Engineering Knowledge	PLO 2: Problem Analysis	PLO 3: Design & Development	PLO 4: Analysis, Design, Research	PLO 5: Modern Tool Usage	PLO 6: Society & Culture	PLO 7: Environment & Sustainability	PLO 8: Ethics	PLO 9: Individual & Team Work	PLO 10: Communication	PLO 11: Project Mgt. & Finance	PLO 12: Life Long Learning	PLO 13: PSO - 1	PLO 14: PSO - 2	PLO 15: PSO – 3
CLO-1 :	*Have a very good understanding of generating various output primitives*	2	80	85	-	-	H	-	-	-	-	-	-	-	-	-	-	M	-
CLO-2 :	*Posses the ability to represent various curves and surfaces*	2	75	80	-	-	-	-	-	-	-	-	-	-	-	-	-	M	-
CLO-3 :	*Have a clear understanding of various visible surface detection algorithms and color models*	2	85	80	-	-	-	-	-	-	-	-	-	-	-	-	-	M	-
CLO-4 :	*Apply the knowledge to install and explore the interfaces of Unity*	2	80	75	-	-	H	-	H	-	-	-	H	-	-	-	-	-	-
CLO-5 :	*Possess the ability to design and implement games using Unity*	2	75	85	-	-	H	-	H	-	-	-	H	-	-	-	-	-	-

Duration (hour)		9	9	9	9	9
S-1	SLO-1	*Graphics systems Overview and IO devices*	*Basic Three-Dimensional Concepts*	*Classification of visible surface detection Algorithms*	*Introduction to Unity Installation and its interface*	*Concept of collisions*
	SLO-2					
S-2	SLO-1	*Applications of Computer Graphics*	*Clipping operations-Point, Line and Polygon*	*Back-face detection, Depth buffer method and A-buffer method*	*Game objects, 2D&3D and its transformation*	*Introduction to Prefabs*
	SLO-2					
S-3	SLO-1	*Line drawing algorithms*	*Curve, Text and Exterior Clipping*	*Scan line method, Depth sorting method, BSP and Area sub division method*	*Fundamentals of models, materials and shaders*	*Handling sprites and adding UI to the game*
	SLO-2					
S-4	SLO-1	*Circle drawing algorithms*	*Polygon Clipping algorithms*	*Octree, Ray casting method and curved surfaces*	*How to sculpt terrain*	*Basics of particle systems*
	SLO-2					
S-5	SLO-1	*Ellipse drawing algorithms*	*Plane equations and meshes*	*Basic models of illumination*	*Adding environments*	*Basics of animation*
	SLO-2					
S-6	SLO-1	*Filled area primitives*	*Curved line& surfaces*	*Halftone and ditheringtechniques*	*Using lights*	*Designing a complex game*
	SLO-2					
S-7	SLO-1	*Basics of Geometric transformations*	*Quadratic surfaces and Blobby objects*	*Properties of Light, RGB Color Model*	*Using cameras*	*Basics of audio in Unity*
	SLO-2					
S-8	SLO-1	*Reflection and shearing -2D*	*Fractals*	*YIQ, and CMY color model*	*Designing a basic game*	*Basics of audio in Unity*
	SLO-2					
S-9	SLO-1	*2D viewing and window to viewport*	*Bezier and B-Spline curves and surfaces*	*HSV and HLScolor model, Color selection*	*Introduction to scripting*	*Requirements for mobile game development*
	SLO-2					

Learning Resources	1. *Donald Hearn & M.PaulineBaker,"Computer Graphics C Version", 2nd Edition, Pearson Education, 2010, ISBN 978-93-325-3587-9* 2. *John F.Hughes, Andries VanDam, Morgan McGuire, David F.Sklar, James D.Foley, Steven K.Feiner, KurtAkeley, "Computer Graphics: Principles and Practice",3rd Edition, Addison-Wesley Professional, 2013, ISBN-13: 0785342399523* 3. *Mike Geig, "Unity 2018 Game Development in 24 Hours, Sams Teach Yourself " 3rd Edition, Pearson Education, 2018, ISBN-13:978-0134998138, ISBN-10:0134998138*	4. *Joseph Hocking, "Unity in Action: Multiplatform game development in C#", 2nd Edition, Manning Publications Company, ISBN: 9781617294969* 5. *Dr. Edward Lavieri, "Getting Started with Unity 2018 - Third Edition: A Beginner's Guide to 2D and 3D game development with Unity ", Packt Publishing Ltd., 2018, ISBN-10: 1788830105, ISBN-13: 978-1788830102.*

Learning Assessment

	Bloom's Level of Thinking	Continuous Learning Assessment (50% weightage)								Final Examination (50% weightage)	
		CLA – 1 (10%)		CLA – 2 (15%)		CLA – 3 (15%)		CLA – 4 (10%)#			
		Theory	Practice	Theory	Practice	Theory	Practice	Theory	Practice	Theory	Practice
Level 1	Remember Understand	*40 %*	-	*30 %*	-	*30 %*	-	*30 %*	-	*30%*	-
Level 2	Apply Analyze	*40 %*	-	*40 %*	-	*40 %*	-	*40 %*	-	*40%*	-
Level 3	Evaluate Create	*20 %*	-	*30 %*	-	*30 %*	-	*30 %*	-	*30%*	-
	Total	100 %		100 %		100 %		100 %		100 %	

CLA – 4 can be from any combination of these: Assignments, Seminars, Tech Talks, Mini-Projects, Case-Studies, Self-Study, MOOCs, Certifications, Conf. Paper etc.,

Course Designers		
Experts from Industry	Experts from Higher Technical Institutions	Internal Experts
Valiyullasha, Bugtreat Technologies, UK, coe@bugtreat.com	*C.M.T.Karthigeyan, Assistant Professor, Government College of Engineering, Bargur, email: c.m.t.karthikeyan@gcebargur.ac.in*	*P.Rajasekar, Assistant Professor, Department of Information Technology, Faculty of E&T,&SRMIST, email: rajasekp@srmist.edu.in*

Course Code	18CSE465T	Course Name	COMPUTATIONAL MEDIA	Course Category	E	Professional Elective	L	T	P	C
							3	0	0	3

Pre-requisite Courses	Nil	Co-requisite Courses	Nil	Progressive Courses	Nil
Course Offering Department	Computer Science and Engineering	Data Book / Codes/Standards	Nil		

Course Learning Rationale (CLR):	*The purpose of learning this course is to:*
CLR-1 :	*Understand the fundamental concepts of analog and digital data*
CLR-2 :	*Know the basics of bitmap, DCT and color models*
CLR-3 :	*Learn the various tools for digital image processing*
CLR-4 :	*Know the basics of digital audio representation*
CLR-5 :	*Understand the concepts of video and its compression methods*

Course Learning Outcomes (CLO):	*At the end of this course, learners will be able to:*	Learning 1: Level of Thinking (Bloom)	Learning 2: Expected Proficiency (%)	Learning 3: Expected Attainment (%)	PLO 1: Engineering Knowledge	PLO 2: Problem Analysis	PLO 3: Design & Development	PLO 4: Analysis, Design, Research	PLO 5: Modern Tool Usage	PLO 6: Society & Culture	PLO 7: Environment & Sustainability	PLO 8: Ethics	PLO 9: Individual & Team Work	PLO 10: Communication	PLO 11: Project Mgt. & Finance	PLO 12: Life Long Learning	PLO 13: PSO - 1	PLO 14: PSO - 2	PLO 15: PSO – 3
CLO-1 :	*Have a very good understanding of analog and digital data*	*2*	*80*	*85*	-	-	*H*	-	-	-	-	-	-	-	-	-	-	-	-
CLO-2 :	*Have a clear understanding of bitmap, DCT and color models*	*2*	*75*	*80*	-	-	*H*	-	-	-	-	-	-	-	-	-	-	*M*	-
CLO-3 :	*Possess the ability to handle various tools for digital image processing*	*2*	*85*	*80*	-	-	*H*	-	-	-	-	-	-	-	-	-	-	*M*	-
CLO-4 :	*Apply the knowledge to represent digital audio*	*2*	*80*	*75*	-	-	*H*	-	*H*	-	-	-	*H*	-	-	-	-	*M*	-
CLO-5 :	*Possess the ability to compress the video*	*2*	*75*	*85*	-	-	*H*	-	*H*	-	-	-	*H*	-	-	-	-	-	-

Duration (hour)		9	9	9	9	9
S-1	SLO-1	*Introduction*	*Bitmaps- Frequency in digital images*	*Tools for digital image processing*	*Introduction of digital audio representation*	*Tools for digital audio processing*
	SLO-2					
S-2	SLO-1	*Analog to digital conversion*	*Discrete Cosine Transform*	*Digital image file types*	*Audio waveforms*	*Dynamics processing- Audio restoration*
	SLO-2					
S-3	SLO-1	*Data storage*	*Aliasing*	*Indexed colors - Dithering*	*Pulse code modulation & audio digitization*	*Digital audio filters and related processing*
	SLO-2					
S-4	SLO-1	*Data Communication*	*Color models*	*Channels, layers and masks*	*Sampling rate and aliasing*	*Pulse code modulation & audio digitization*
	SLO-2					
S-5	SLO-1	*Data Communication*	*Color models*	*Blending modes*	*quantization and quantization error*	*Designing and implementing your own file*
	SLO-2					
S-6	SLO-1	*Compression methods*	*Color models*	*Pixel point processing*	*Frequency analysis*	*Digital audio compression*
	SLO-2					
S-7	SLO-1	*Compression methods*	*Vector graphics*	*Spatial filtering*	*Frequency analysis*	*Fundamental concepts in video*
	SLO-2					
S-8	SLO-1	*Standards and standardization organizations*	*Vector graphics*	*Resampling and interpolation*	*Statistical analysis of an audio file*	*Basic video compression*
	SLO-2					
S-9	SLO-1	*Mathematical modeling tools for the study of digital media*	*Algorithmic art and procedural modeling*	*Digital image compression*	*MIDI*	*MPEG 1 and 2*
	SLO-2					

Learning Resources		
	1. Jennifer Burg, "The Science of Digital Media", Pearson Education, ISBN: 978-01324335802 *2. Ze-Nian Li and Mark.s.Drew, "Fundamentals of Multimedia", Pearson Education International, ISBN 0-13-127256-X*	*3. Fred Halsall, "Multimedia Communications: Applications, Networks, Protocols and Standards", Pearson Education India, 2002, ISBN-10: 8131709949 and ISBN-13: 978-8131709948*

Learning Assessment											
	Bloom's Level of Thinking	Continuous Learning Assessment (50% weightage)								Final Examination (50% weightage)	
		CLA – 1 (10%)		CLA – 2 (15%)		CLA – 3 (15%)		CLA – 4 (10%)#			
		Theory	Practice	Theory	Practice	Theory	Practice	Theory	Practice	Theory	Practice
Level 1	Remember Understand	*40 %*	-	*30 %*	-	*30 %*	-	*30 %*	-	*30%*	-
Level 2	Apply Analyze	*40 %*	-	*40 %*	-	*40 %*	-	*40 %*	-	*40%*	-
Level 3	Evaluate Create	*20 %*	-	*30 %*	-	*30 %*	-	*30 %*	-	*30%*	-
	Total	100 %		100 %		100 %		100 %		100 %	

CLA – 4 can be from any combination of these: Assignments, Seminars, Tech Talks, Mini-Projects, Case-Studies, Self-Study, MOOCs, Certifications, Conf. Paper etc.,

Course Designers		
Experts from Industry	Experts from Higher Technical Institutions	Internal Experts
Valiyullasha, Bugtreat Technologies, UK, coe@bugtreat.com	C.M.T.Karthigeyan, Assistant Professor, Government College of Engineering, Bargur, email: c.m.t.karthikeyan@gcebargur.ac.in	P.Rajasekar, Assistant Professor, Department of Information Technology, Faculty of E&T,&SRMIST, email: rajasekp@srmist.edu.in

Course Code	18CSE345T	Course Name	IOT ARCHITECTURE AND PROTOCOLS	Course Category	E	Professional Elective	L	T	P	C
							3	0	0	3

Pre-requisite Courses	Nil	Co-requisite Courses	Nil	Progressive Courses	Nil
Course Offering Department	CSE	Data Book / Codes/Standards	Nil		

Course Learning Rationale (CLR):	*The purpose of learning this course is to:*
CLR-1 :	*Understand Data and Knowledge Management and use of Devices in IoT Technology.*
CLR-2 :	*Understand State of the Art – IoT Architecture.*
CLR-3 :	*To Understand the Architectural Overview of IoT*
CLR-4 :	*Understand the IoT Reference Architecture and RealWorld Design Constraints*
CLR-5 :	*To Understand the various IoT Protocols (Datalink, Network, Transport, Session, Service)*
CLR-6 :	*Understand and apply IoT protocols appropriately*

Course Learning Outcomes (CLO):	*At the end of this course, learners will be able to:*	Learning 1: Level of Thinking (Bloom)	2: Expected Proficiency (%)	3: Expected Attainment (%)	PLO 1: Engineering Knowledge	2: Problem Analysis	3: Design & Development	4: Analysis, Design, Research	5: Modern Tool Usage	6: Society & Culture	7: Environment & Sustainability	8: Ethics	9: Individual & Team Work	10: Communication	11: Project Mgt. & Finance	12: Life Long Learning	13: PSO - 1	14: PSO - 2	15: PSO – 3
CLO-1 :	*Interpret the vision of IoT architecture from a global context.*	2	80	85	H	-	-	-	-	-	-	-	-	-	-	-	-	-	-
CLO-2 :	*Implement state of the art architecture in IoT.*	2	75	80	H	H	-	-	-	-	-	-	-	-	-	-	-	-	-
CLO-3 :	*Compare and Contrast the use of Devices, Gateways and Data Management in IoT.*	2	85	80	H	M	-	-	-	-	-	-	-	-	-	-	-	-	-
CLO-4 :	*Implement using the available resources and demonstrate quick to deployment protocols wherever applicable*	2	80	75	H	H	H	M	-	-	-	-	-	-	-	-	-	-	-
CLO-5 :	*Apply the protocols and Techniques towards integration in relevant areas of IoT Product development*	2	75	85	H	M	H	M	H	-	-	-	M	-	-	H	-	-	-
CLO-6 :	*Choose appropriate protocols for various layers (Datalink, Network, Transport, Session, Service)*	2	80	85	H	M	H	H	H	-	-	-	H	-	-	H	-	-	-

Duration (hour)		9	9	9	9	9
S-1	SLO-1	*M2M and IoT- Relevance and Transition*	*Data Management- Introduction*	*Introduction to RFID*	*Transport Layer Protocols -Introduction*	*Service Layer Protocols- Introduction*
	SLO-2	*Building an architecture*	*Managing M2M data: Data generation,*	*Introduction to NFC*	*TCP*	*oneM2M*
S-2	SLO-1	*Main design principles and needed capabilities*	*Data acquisition, Data validation*	*WSN(Large topic),*	*MPTCP*	*ETSI M2M*
	SLO-2	*IoT architecture outline*	*Data storage, Data processing*	*Narrow band IoT (NbIOT)*	*UDP*	*OMA*
S-3	SLO-1	*M2M and IoT Technology Fundamentals*	*Data remanence, Data analysis*	*WiFi*	*DCCP*	*BBF*
	SLO-2	*Devi ces and Gateways-Introduction*	*Data management,*	*PLC Communication Protocols: A comparison*	*SCT*	*Understanding Security and Interoperability*
S-4	SLO-1	*Basic Devices*	*Business processes in IoT*	*Popular radio protocols and its security drawbacks*	*TLS*	*Modes of attack: DoS, Getting Access, Guess, Man in Middle, Sniff, Post Scan*
	SLO-2	*Gateways*	*Everything as a Service (XaaS)*	*802.15.4 in depth*	*DTLS*	*Modes of attack: Web Crawl, Search Features and Wild Cards, Breaking Cipher*
S-5	SLO-1	*Advanced devices*	*M2M and IoT Analytics*	*Network Layer Protocols- Introduction*	*Session Layer-HTTP*	*Tools for achieving Security: VPN, X.509, Authentication,*
	SLO-2	*Need for networking*	*Knowledge Management*	*IPv4*	*CoAP*	*Tools for achieving Security: User names and Passwords, Message Brokers,*
S-6	SLO-1	*State of the art-ETSI M2M*	*Data Link Layer Protocols: PHY/MAC Layer:3GPP MTC*	*IPv6*	*Implementation demo of CoAP*	*Tools for achieving Security: Provisioning servers, Centralization versus decentralization,*
	SLO-2	*IoT Reference model-IoT Domain model*	*IEEE 802.11*	*6LoWPAN in depth*	*MQTT*	*The need for interoperability:*
S-7	SLO-1	*Information model*	*IEEE 802.15*	*6TiSCH*	*Implementation demo of MQTT*	*Combining Security and Interoperability*
	SLO-2	*Functional model*	*Wireless HART*	*ND*	*MQTT-SN*	*Need for Security in IoT Protocols – Introduction*

S-8	SLO-1	*Communication model*	*Z-Wave*	*DHCP*	*Implementation demo of MQTT-SN*	*Security in IoT Protocols :MAC 802.15.4*
	SLO-2	*Safety, privacy, trust, security model*	*Bluetooth, Bluetooth Low Energy*	*ICMP*	*XMPP*	*Security in IoT Protocols :6LoWPAN,*
S-9	SLO-1	*Introduction to Protocols- Physical, Data Link*	*Zigbee, Zigbee Smart Energy*	*RPL*	*AMQP*	*Security in IoT Protocols :RPL*
	SLO-2	*Introduction to Protocols- Network, Transport, Application*	*DASH7*	*CORPL, CARP*	*Introduction to Contiki- Practical demo*	*Security in IoT Protocols: Application Layer*

Learning Resources	1. *Uckelmann, D., Harrison, M., & Michahelles, F. (Eds.). Architecting the Internet of Things.doi:10.1007/978-3-642-19157-2 , 2011* 2. *IoT Fundamentals: Networking Technologies, Protocols, and Use Cases for the Internet of Things by Rob Barton, Gonzalo Salgueiro, David Hanes, Publisher: Cisco Press, Release Date: June 2017, ISBN: 9780134307091 (https://www.oreilly.com/library/view/iot-fundamentals-networking/9780134307091/)* 3. *Jan Holler, VlasiosTsiatsis, Catherine Mulligan, Stefan Avesand, StamatisKarnouskos, David Boyle, "From Machine-to-Machine to the Internet of Things: Introduction to a New Age of Intelligence", 1st Edition, Academic Press, 2014*	5. *Peter Waher, "Learning Internet of Things", PACKT publishing, BIRMINGHAM – MUMBAI* 6. *Daniel Minoli, "Building the Internet of Things with IPv6 and MIPv6: The Evolving World of M2M Communications", ISBN: 978-1-118-47347-4, Willy Publications*

Learning Assessment											
	Bloom's Level of Thinking	Continuous Learning Assessment (50% weightage)								Final Examination (50% weightage)	
		CLA – 1 (10%)		CLA – 2 (15%)		CLA – 3 (15%)		CLA – 4 (10%)#			
		Theory	Practice	Theory	Practice	Theory	Practice	Theory	Practice	Theory	Practice
Level 1	Remember Understand	*40 %*	-	*30 %*	-	*30 %*	-	*30 %*	-	*30%*	-
Level 2	Apply Analyze	*40 %*	-	*40 %*	-	*40 %*	-	*40 %*	-	*40%*	-
Level 3	Evaluate Create	*20 %*	-	*30 %*	-	*30 %*	-	*30 %*	-	*30%*	-
	Total	100 %		100 %		100 %		100 %		100 %	

CLA – 4 can be from any combination of these: Assignments, Seminars, Tech Talks, Mini-Projects, Case-Studies, Self-Study, MOOCs, Certifications, Conf. Paper etc.,

Course Designers		
Experts from Industry	Experts from Higher Technical Institutions	Internal Experts
Mr. Vinay Solanki, Head IoT, Lenovo (APAC & MEA)	*Dr.Zayaraj, Professor / CSE, PEC, Pondicherry*	*Dr. S.Babu, SRMIST*
Dr. Paventhan Arumugum, Director (R&D), ERNET India	*Dr.Vijalakshmi Associate Professor / CSE, PEC, Pondicherry*	*Dr.Kayalvizhi Jayavel, SRMIST*
Shiv Kumar Ganesh, Full Stack Developer, Altimetrik	*Dr.P.Yogesh, Professor/IT, Anna University, Chennai.*	*Mr.V.Haribaabu, SRMIST*

Course Code	18CSE346T	Course Name	NETWORK PROGRAMMING	Course Category	E	Professional Elective	L	T	P	C
							3	0	0	3

Pre-requisite Courses	18CSC302J	Co-requisite Courses	Nil	Progressive Courses	Nil
Course Offering Department	Computer Science and Engineering	Data Book / Codes/Standards	Nil		

Course Learning Rationale (CLR):	The purpose of learning this course is to:
CLR-1 :	*To learn different socket function and implement client server applications using sockets*
CLR-2 :	*To conduct experiments to know how different internet protocols like TCPIP works*
CLR-3 :	*To analyze various application program like TELNET, DNS, DHCP*
CLR-4 :	*Build different application like Routing, Load balancing & Security*
CLR-5 :	*To apply protocols get adapted to emerging technologies*

Course Learning Outcomes (CLO):	At the end of this course, learners will be able to:	Learning 1 Level of Thinking (Bloom)	2 Expected Proficiency (%)	3 Expected Attainment (%)	PLO 1 Engineering Knowledge	2 Problem Analysis	3 Design & Development	4 Analysis, Design, Research	5 Modern Tool Usage	6 Society & Culture	7 Environment & Sustainability	8 Ethics	9 Individual & Team Work	10 Communication	11 Project Mgt. & Finance	12 Life Long Learning	13 PSO - 1	14 PSO - 2	15 PSO – 3
CLO-1 :	*Become familiar with elementary socket functions*	3	80	70	L	H	-	H	L	-	-	-	L	L	-	H	-	-	-
CLO-2 :	*Design and implement client –server applications using Sockets*	3	85	75	M	H	L	M	L	-	-	-	M	L	-	H	-	-	-
CLO-3 :	*Learn about functions that convert between names and numeric values and protocols*	3	75	70	M	H	M	H	L	-	-	-	M	L	-	H	-	-	-
CLO-4 :	*Analyze network programs*	3	85	80	M	H	M	H	L	-	-	-	M	L	-	H	-	-	-
CLO-5 :	*Build network applications*	3	85	75	H	H	M	H	L	-	-	-	M	L	-	H	-	-	-

Program Learning Outcomes (PLO)

Duration (hour)		9	9	9	9	9
S-1	SLO-1	*Introduction*	*Socket function*	*Get sock opt function*	*DNS*	*Internet Protocol*
	SLO-2	*simple daytime client*	*connect function*	*set sock opt function*	*resolvers and name servers*	
S-2	SLO-1	*protocol independence*	*bind function*	*IPV4*	*gethostbyname function*	*IPV4*
	SLO-2	*Error handling*	*listen function*	*ICMP*	*gethostbyaddr function*	
S-3	SLO-1	*simple daytime server*	*accept function*	*TCP socket options*	*getservbyname*	*IPV6 interoperability*
	SLO-2	*Roadmap to client/server.*	*Fork function*		*getservbyport function*	
S 4-5	SLO-1	*Overview of TCP/IP protocol- TCP connection establishment and termination*	*exec function*	*UDP Echo server and client*	*tcp_connect function-*	*Daemon processes*
	SLO-2					
S-6	SLO-1	*TCP state transition diagram – Time-wait state*	*concurrent servers*	*recvfrom function*	*tcp_listen function*	*Daemon processes and the inetdsuperserver*
	SLO-2	*SCTP association establishment and termination*	*close function-getsockname and getpeername*	*send to function*	*udp_client*	
S-7	SLO-1	*TCP port numbers and concurrent servers*	*TCP Echo server, TCP Echo client*	*Connect function with UDP*	*udp_connect*	*Advanced I/O functions*
	SLO-2	*Buffer size and limitations*	*normal startup and termination*		*udp_server function*	

S 8-9	SLO-1	*standard internet services*	*POSIX signal handling, Wait and Waitpid functions*	*dg_cli function*	*BOOTP*	*Advanced I/O functions*
	SLO-2	*protocol usage by common, Internet applications*	*Termination of server process, Crashing and rebooting of server host*	*lack of flow control with UDP*	*DHCP*	

Learning Resources	1. *W.Richard Stevens, Bill Fenner, Andrew M. Rudoff " Unix Network programming " 3rd edition, Volume – 1, Pearson Education , 2015 R.F.Gilberg, B.A.Forouzan, Data Structures, 2nd ed., Thomson India, 2005* 2. *Douglas.E.Comer " Internetworking with TCP/IP " principles, protocols and architecture, 6th Edition , Volume 1, Pearson Education,2013*	3. *Behrouz A.Forouzan , " TCP/IP protocol suite", 4th edition, Mc Graw Hill education private limited,2010* 4. *Wendell Odom , " IP networking ", 1st edition, Pearson Education 2012*

Learning Assessment

	Bloom's Level of Thinking	Continuous Learning Assessment (50% weightage)								Final Examination (50% weightage)	
		CLA – 1 (10%)		CLA – 2 (15%)		CLA – 3 (15%)		CLA – 4 (10%)#			
		Theory	Practice	Theory	Practice	Theory	Practice	Theory	Practice	Theory	Practice
Level 1	Remember Understand	40 %	-	30 %	-	30 %	-	30 %	-	30%	-
Level 2	Apply Analyze	40 %	-	40 %	-	40 %	-	40 %	-	40%	-
Level 3	Evaluate Create	20 %	-	30 %	-	30 %	-	30 %	-	30%	-
	Total	100 %		100 %		100 %		100 %		100 %	

CLA – 4 can be from any combination of these: Assignments, Seminars, Tech Talks, Mini-Projects, Case-Studies, Self-Study, MOOCs, Certifications, Conf. Paper etc.,

Course Designers

Experts from Industry	Experts from Higher Technical Institutions	Internal Experts
Dr.Viswanadham, Teken BIM Technologies Pvt. Ltd, 9962514477, Viswanathan_alladi@yahoo.com	*Dr. Latha, Prof & Head, CSE dept, SAIRAM engg college,latha.cse@sairam.edu.in, 8754502224*	*1. MrsT.Manoranjitham, SRMIST*
		2. Mr. Godwin , SRMIST
		3. Ms. Vinoth, SRMIST

Course Code	18CSE445T	Course Name	IOT SECURITY	Course Category	E	Professional Elective	L	T	P	C
							3	0	0	3

Pre-requisite Courses	Nil	Co-requisite Courses	Nil	Progressive Courses	
Course Offering Department	Computer Science and Engineering	Data Book / Codes/Standards		Nil	

Course Learning Rationale (CLR):	*The purpose of learning this course is to:*
CLR-1 :	*Understand the fundamentals, various attacks and importance of Security aspects in IoT*
CLR-2 :	*Understand the techniques, protocols and some idea on security towards Gaming models*
CLR-3 :	*Understand the relevance of Blockchain, its techniques towards IoT*
CLR-4 :	*Understand the operations of Bitcoin blockchain, crypto-currency as application of blockchain technology*
CLR-5 :	*Understand the essential components of IoT*
CLR-6 :	*Understand security and privacy challenges of IoT*

Course Learning Outcomes (CLO):	*At the end of this course, learners will be able to:*	Learning 1: Level of Thinking (Bloom)	2: Expected Proficiency (%)	3: Expected Attainment (%)	PLO 1: Engineering Knowledge	2: Problem Analysis	3: Design & Development	4: Analysis, Design, Research	5: Modern Tool Usage	6: Society & Culture	7: Environment & Sustainability	8: Ethics	9: Individual & Team Work	10: Communication	11: Project Mgt. & Finance	12: Life Long Learning	13: PSO - 1	14: PSO - 2	15: PSO – 3
CLO-1 :	*Incorporate the best practices learnt to identify the attacks and mitigate the same*	*3*	*80*	*70*	*L*	*H*	*M*	*H*	*M*	-	-	-	*M*	*L*	-	*H*	-	-	-
CLO-2 :	*Adopt the right security techniques and protocols during the design of IoT products*	*3*	*85*	*75*	*L*	*H*	*M*	*H*	*M*	-	-	-	*M*	*L*	-	*H*	-	-	-
CLO-3 :	*Apply the skills learnt towards gaming designs*	*3*	*75*	*70*	*L*	*H*	*M*	*H*	*M*	-	-	-	*M*	*L*	-	*H*	-	-	-
CLO-4 :	*Assimilate and apply the skills learnt on cipers and blockchains when appropriate*	*3*	*85*	*80*	*L*	*H*	*M*	*H*	*M*	-	-	-	*M*	*L*	-	*H*	-	-	-
CLO-5 :	*Describe the essential components of IoT*	*3*	*85*	*75*	*L*	*H*	*M*	*H*	*M*	-	-	-	*M*	*L*	-	*H*	-	-	-
CLO-6 :	*Find appropriate security / privacy solutions for IoT*	*3*	*80*	*70*	*L*	*H*	*M*	*H*	*M*	-	-	-	*M*	*L*	-	*H*	-	-	-

Duration (hour)		9	9	9	9	9
S-1	SLO-1	*Fundamentals of IoT and Security and its need*	*Prevent Unauthorized Access to Sensor Data*	*Block ciphers*	*Introduction to Blockchain*	*Introduction of IoT devices*
	SLO-2	*IoT Security Requirements*	*,M2M Security,*	*Message integrity*	*Modeling faults and adversaries*	*Difference among IoT devices, computers, and embedded devices.*
S-2	SLO-1	*IoT and cyber-physical systems*	*RFIDSecurity,*	*Authenticated encryption*	*Byzantine Generals problem*	*sensors and actuators in IoT*
	SLO-2	*IoT security (vulnerabilities, attacks, and countermeasures),*	*Cyber Physical Object Security, ,*	*Hash functions*	*Consensus algorithms and their scalability problems*	*Accelerometer, photoresistor, buttons*
S-3	SLO-1	*Security engineering for IoT development*	*Hardware Security,*	*Merkle trees and Elliptic curves*	*digital signatures, verifiable random functions, Zero-knowledge systems*	*motor, LED, vibrator,*
	SLO-2	*IoT security lifecycle*	*Front-end System Privacy Protection, Management,Secure IoT Databases*	*Public-key crypto (PKI),*	*blockchain, the challenges, and solutions,*	*analog signal vs. digital signal*
S-4	SLO-1	*Data Privacy*	*Networking Function Security*	*Trees signature algorithms*	*proof of work, Proof of stake,*	*Networking in IoT*
	SLO-2	*Device/User Authentication in IoT*	*IoT Networking Protocols,*	*Crypto-currencies,*	*alternatives to Bitcoin consensus, Bitcoin scripting language and their use*	*Real-time communication*
S-5	SLO-1	*Introduction to Authentication Techniques*	*SecureIoT Lower Layers,*	*Bitcoin P2P network,*	*Ethereum and Smart Contracts,*	*Bandwidth efficiency*
	SLO-2	*Data Trustworthiness in IoT*	*SecureIoT Higher Layers,*	*Distributed consensus, , ,*	*Smart Contract Languages and verification challenges*	*data analytics in IoT - simple data analyzing methods*
S-6	SLO-1	*Human IoT Trust Relationship*	*Secure Communication*	*Incentives and proof-of-work*	*comparing Bitcoin scripting vs. Ethereum Smart Contracts*	*IoT architecture, component and technology*
	SLO-2	*Trust and Reputation Systems*	*Links in IoTs,Back-end Security -Secure Resource*	*Mining, scripts and smart contracts*	*Hyperledger fabric*	*Case study: discussion on specific IoT applications and their design considerations*
S-7	SLO-1	*Trust Negotiation*	*Game Theory Foundation*	*Wallets: hot and cold storage ,anonymity, altcoins*	*Mechanisms in permissioned blockchain*	*cybersecurity overview in IoT*

	SLO-2	*IoT Privacy Preservation Issues*	*Mixed-strategy, ,*	*Credential management for connected devices: Security credential management system (SCMS),*	*Pseudo-anonymity vs. anonymity*	*General cybersecurity concepts in IoT*
S-8	SLO-1	*Attack Models - Attacks to Sensors in IoTs,*	*Nash equilibrium*	*VehicleBased Security System (VBSS),*	*Zcash and Zk-SNARKS for anonymity preservation*	*security threats in IoT*
	SLO-2	*Attacks to RFIDs in IoTs,*	*Repeated games*	*PKI design, Certification provisioning*	*Attacks on Blockchains*	*data privacy in IoT*
S-9	SLO-1	*Attacks to Network Functions in IoTs,*	*Bayesian games*	*Pseudonyms (privacy-by design),*	*Sybil attacks, selfish mining*	*device/User authentication in IoT*
	SLO-2	*Attacks to Back-end Systems and security in Front end Systems*	*Coalitional games.*	*Misbehavior detection and Revocation,*	*51% attacks*	*data trustworthiness problem in IoT*

Learning Resources	1. *B.RusellandD.VanDuren,"PracticalInternetofThingsSecurity,"PacktPublishing,2016.* 2. *FeiHU,"SecurityandPrivacyinInternetofThings(IoTs):Models,Algorithms,and Implementations", CRCPress,2016* 3. *Narayanan et al., "Bitcoin and Cryptocurrency Technologies: A Comprehensive Introduction," Princeton University Press,2016.* 4. *A.Antonopoulos,"MasteringBitcoin:UnlockingDigitalCryptocurrencies,"O'Reilly,2014*	5. *T. Alpcan and T. Basar, "Network Security: A Decision and Game-theoretic Approach," Cambridge University Press,2011.* 6. *SecurityandtheIoTecosystem,KPMGInternational,2015* 7. *InternetofThings:IoTGovernance,PrivacyandSecurityIssues"byEuropeanResearchCluster* 8. *Ollie Whitehouse, "Security of Things: An Implementers' Guide to Cyber-Security forInternet of Things Devices and Beyond", NCC Group,2014* 9. *JoshThompson,'Blockchain:TheBlockchainforBeginnings,GuildtoBlockchainTechnologyand BlockchainProgramming',CreateSpaceIndependentPublishingPlatform,2017.*

Learning Assessment											
	Bloom's Level of Thinking	Continuous Learning Assessment (50% weightage)								Final Examination (50% weightage)	
		CLA – 1 (10%)		CLA – 2 (15%)		CLA – 3 (15%)		CLA – 4 (10%)#			
		Theory	Practice	Theory	Practice	Theory	Practice	Theory	Practice	Theory	Practice
Level 1	Remember Understand	40 %	-	30 %	-	30 %	-	30 %	-	30%	-
Level 2	Apply Analyze	40 %	-	40 %	-	40 %	-	40 %	-	40%	-
Level 3	Evaluate Create	20 %	-	30 %	-	30 %	-	30 %	-	30%	-
	Total	100 %		100 %		100 %		100 %		100 %	

CLA – 4 can be from any combination of these: Assignments, Seminars, Tech Talks, Mini-Projects, Case-Studies, Self-Study, MOOCs, Certifications, Conf. Paper etc.,

Course Designers		
Experts from Industry	Experts from Higher Technical Institutions	Internal Experts
	Dr.A.Amuthan, Associate Dean, Dept. of CSE, Pondicherry Engg. College, Pondicherry	*Dr.M.Murali* *Dr.Kayalvizhi Jayavel* *Mr. H.Karthikeyan*

Course Code	18CSE446T	Course Name	ADVANCED DATABASE SYSTEMS	Course Category	E	Professional Elective	L	T	P	C
							3	0	0	3

Pre-requisite Courses	Nil	Co-requisite Courses	Nil	Progressive Courses	Nil
Course Offering Department	Computer Science and Engineering	Data Book / Codes/Standards	Nil		

Course Learning Rationale (CLR):	*The purpose of learning this course is to:*
CLR-1 :	*Familiarize with the various query processing, join and optimization techniques*
CLR-2 :	*Improve their ability to choose the appropriate techniques for any parallel and distributed database systems*
CLR-3 :	*Familiarize with the various object based databases techniques*
CLR-4 :	*Familiarize with the various Motivation, Structure, Storage, Application and Evaluation of XML Queries*
CLR-5 :	*Expose to the concepts of Performance Tuning, Temporal, Spatial, Multimedia and Mobile data bases*
CLR-6 :	*Expose to the latest Spatial and Geographic data, R Trees and Multimedia databases*

Course Learning Outcomes (CLO):	*At the end of this course, learners will be able to:*	Learning 1: Level of Thinking (Bloom)	Learning 2: Expected Proficiency (%)	Learning 3: Expected Attainment (%)	PLO 1: Engineering Knowledge	2: Problem Analysis	3: Design & Development	4: Analysis, Design, Research	5: Modern Tool Usage	6: Society & Culture	7: Environment & Sustainability	8: Ethics	9: Individual & Team Work	10: Communication	11: Project Mgt. & Finance	12: Life Long Learning	13: PSO - 1	14: PSO - 2	15: PSO – 3
CLO-1 :	*Acquire the knowledge on query processing, join and optimization on a database*	2	80	85	H	H	L	M	L	-	-	-	M	M	M	-	-	-	-
CLO-2 :	*Acquire the ability to identify & design a parralel and distributed database*	2	75	80	H	H	L	M	L	-	-	-	M	M	M	-	-	-	-
CLO-3 :	*Understand the basic ideas about various object based databases*	2	85	80	H	M	L	M	L	-	-	-	M	M	M	-	-	-	-
CLO-4 :	*Apply the knowledge of XML on various applications*	2	80	75	H	H	L	M	L	-	-	-	M	M	M	-	-	-	-
CLO-5 :	*Appreciate the concepts of Performance Tuning, Temporal, Spatial, Multimedia and Mobile data bases*	2	75	85	H	M	L	M	L	-	-	-	M	M	M	-	-	-	-
CLO-6 :	*Appreciate the concepts of latest Spatial and Geographic data, R Trees and Multimedia databases*	2	80	85	H	M	-	M	L	-	-	-	M	M	M	-	-	-	-

Duration (hour)		9	9	9	9	9
S-1	SLO-1	*Overview of query processing*	*Introduction to Parallel Databases*	*Overview of object based databases*	*Introduction to XML*	*Performance Tuning*
	SLO-2	*Measures of query cost*	*I/O parallelism*	*Complex data types*		*Improving set orientation*
S-2	SLO-1	*Selection Operation*	*Interquery Parallelis*	*Structured types in SQL*	*Motivation*	*Tuning of bulk loads and updates*
	SLO-2	*Sorting*	*Intraquery Parallelism*	*Inheritance in SQL*		*Location of bottlenecks*
S-3	SLO-1	*Join Operation-Nested loop join*	*Intraoperation Parallelism*	*Table inheritance*	*Structure of XML data*	*Tunable parameters*
	SLO-2	*Merge join and Hash join*	*Interoperation Parallelism*			*Tuning of hardware*
S-4	SLO-1	*Projection, set operation, Outer join and Aggregation*	*Query Optimization*	*Array and multiset Types in SQL*	*XML document scheme*	*Tuning of the schema and Indices*
	SLO-2	*Evaluation of Expressions*	*Design of Parallel Systems*			*Tuning of Physical design*
S-5	SLO-1	*Overview of query optimization*	*Homogeneous and heterogeneous database*	*Object –identity and reference Types in SQL*	*Querying and transformation*	*Tuning of concurrent transactions*
	SLO-2	*Transformation of relational expressions -Equivalence Rules*	*Distributed data Storage*			*Introduction to Temporal, Spatial, Multimedia and Mobile data bases*
S-6	SLO-1	*Join Ordering*	*Distributed transactions*	*Implementing O-R features*	*Application program interface to XML*	*Performance benchmarks*
	SLO-2	*Enumeration of Equivalent Expression*	*Commit protocols*			*Time in databases*
S-7	SLO-1	*Estimating statistics of expression results Cataloq Information*	*Concurrency control in distributed databases*	*Persistent programming languages – Persistence of objects*	*Storage of XML data*	*Spatial and Geographic data*
	SLO-2	*Selection Size and Join size Estimation*	*Distributed query processing*	*Object identity and pointers*		*Representation of Geographic data*
S-8	SLO-1	*Size Estimation for other Operation,Estimation of Number of Distinct Values*	*Availability*	*Persistent C++ systems*	*XML applications.*	*Spatial Queries*

	SLO-2	*Choice of evaluation plans-Cost based join order Selection*		*Persistent Java systems*		*Indexing of Spatial Data*
S-9	SLO-1	*Cost based optimization with equivalence rules*	*Heterogeneous distributed databases.*	*Object-relational mapping*	*Evaluation of XML Queries*	*R Trees*
	SLO-2	*Heuristics in optimization, Optimizing Nested Sub queries*		*Object-oriented versus object-relational.*		*Multimedia databases*

Learning Resources	1. Abraham Silberscatz, Henry F Korth, S Sudarshan, "Database System Concepts", McGraw Hill Education –2013 2. RaghuRamakrisgnan,"DatabaseManagementSystems",-McGrawHillEducation-2014	3. Elmasri Navathe, Somayajulu, Gupta, "Fundamentals of Database Systems, Pearson Education, 4th Edition, 2006 4. CJDate,AKannan,SSwamynathan,"AnIntroductiontoDatabaseSystems",PearsonEducation,8th Edition, 2006

Learning Assessment

	Bloom's Level of Thinking	Continuous Learning Assessment (50% weightage)								Final Examination (50% weightage)	
		CLA – 1 (10%)		CLA – 2 (15%)		CLA – 3 (15%)		CLA – 4 (10%)#			
		Theory	Practice	Theory	Practice	Theory	Practice	Theory	Practice	Theory	Practice
Level 1	Remember Understand	*40 %*	-	*30 %*	-	*30 %*	-	*30 %*	-	*30%*	-
Level 2	Apply Analyze	*40 %*	-	*40 %*	-	*40 %*	-	*40 %*	-	*40%*	-
Level 3	Evaluate Create	*20 %*	-	*30 %*	-	*30 %*	-	*30 %*	-	*30%*	-
	Total	100 %		100 %		100 %		100 %		100 %	

CLA – 4 can be from any combination of these: Assignments, Seminars, Tech Talks, Mini-Projects, Case-Studies, Self-Study, MOOCs, Certifications, Conf. Paper etc.,

Course Designers

Experts from Industry	Experts from Higher Technical Institutions	Internal Experts
1. Dr.Mariappan Vaithilingam, Engineering Leader Amazon, dr.v.m@ieee.org		*1. Mr. Elizer, SRMIST*
2. Mr. Badinath, SDET, Amzon, sbadhrinath@gmail.com		*2. Mrs. Sasi Rekha Sankar, SRMIST*
		3. Ms. Hemavathy, SRMIST

Course Code	18CSE447T	Course Name	EDGE COMPUTING	Course Category	E	Professional Elective	L	T	P	C
							3	0	0	3

Pre-requisite Courses	Nil	Co-requisite Courses	Nil	Progressive Courses	Nil
Course Offering Department	Computer Science and Engineering	Data Book / Codes/Standards	Nil		

Course Learning Rationale (CLR):	*The purpose of learning this course is to:*	Learning			Program Learning Outcomes (PLO)														
		1	2	3	1	2	3	4	5	6	7	8	9	10	11	12	13	14	15
CLR-1 :	*Understand the concepts of IoT*	Level of Thinking (Bloom)	Expected Proficiency (%)	Expected Attainment (%)	Engineering Knowledge	Problem Analysis	Design & Development	Analysis, Design, Research	Modern Tool Usage	Society & Culture	Environment & Sustainability	Ethics	Individual & Team Work	Communication	Project Mgt. & Finance	Life Long Learning	PSO - 1	PSO - 2	PSO – 3
CLR-2 :	*Understand the IoT and M2M Communication*																		
CLR-3 :	*Understand the protocols and standards of IoT*																		
CLR-4 :	*Understand the Fog computing Architecture and its components*																		
CLR-5 :	*Understand the integration of Fog and Cloud Computing*																		
CLR-6 :	*Understand the concepts of IoT*																		
Course Learning Outcomes (CLO):	*At the end of this course, learners will be able to:*																		
CLO-1 :	*Apply concepts of IoT*	*3*	*80*	*70*	*H*	*L*	*H*	*M*	*H*	*H*	*H*	*H*	*H*	*H*	*M*	*H*	*H*	*H*	*H*
CLO-2 :	*Apply the M2M protocol in IoT.*	*3*	*85*	*75*	*H*	*L*	*H*	*M*	*H*	*H*	*H*	*H*	*H*	*H*	*M*	*H*	*H*	*H*	*H*
CLO-3 :	*Equip themselves familiar with Fog computing in IoT*	*3*	*75*	*70*	*H*	*L*	*H*	*M*	*H*	*H*	*H*	*H*	*H*	*H*	*M*	*H*	*H*	*H*	*H*
CLO-4 :	*Familiarize with IoT standard and protocols*	*3*	*85*	*80*	*H*	*L*	*H*	*M*	*H*	*H*	*H*	*H*	*H*	*H*	*M*	*H*	*H*	*H*	*H*
CLO-5 :	*Acquaint with Fog and Cloud computing in IoT*	*3*	*85*	*75*	*H*	*L*	*H*	*M*	*H*	*H*	*H*	*H*	*H*	*H*	*M*	*H*	*H*	*H*	*H*
CLO-6 :	*Apply concepts of IoT*	*3*	*80*	*70*	*H*	*L*	*H*	*M*	*H*	*H*	*H*	*H*	*H*	*H*	*M*	*H*	*H*	*H*	*H*

Duration (hour)		9	9	9	9	9
S-1	SLO-1	*Introduction to IoT*	*IoT Architecture*	*Fog Computational Model*	*BIG DATA*	*Case Study-1: Edge analytics in Irrigation System*
	SLO-2	*Technologies in IoT*	*Data Acquisition, Data Aggregation and Data Analysis*	*Fog Simulators*	*Data Types in Big data*	*Machine Learning in Edge for automation in Irrigation system*
S-2	SLO-1	*IoT Applications- Smart Home, Wearable, Connected Cars, Industrial IoT*	*IoT Protocols- COAP, MQTT*	*iFogSim*	*Characteristics of BIG DATA*	*Case study 2: Edge analytics for Water Quality Monitoring*
	SLO-2	*Smart Cities, Agriculture, Smart Retail, smart Grid, Healthcare*	*XMPP, AMQP, Low power Lossy Network routing*	*FogTorch*	*Benefits of Big Data*	*Machine Learning in Edge for automation in water quality monitoring*
S-3	SLO-1	*Challenges in IoT- Delivering Value to Customers, Hardware Compatibility Issues, Data Connectivity Issues*	*Communication Methods- Bluetooth, Zigbee Z-wave, 6LowPAN*	*Cisco IoX and Fog Application*	*Big Data Application-*	*Case Study 3: IoT- Edge system for Hydroponics system*
	SLO-2	*Incorrect Data Capture Capabilities, Analytic Challenges, Data Security challenges,*	*Wireless Fidelity*	*Contiki/Cooja*	*Layered Big Data Architecture- Data Ingestion, Data collection, Data Processing Layer*	*Deep Learning in Edge for automation in hydroponics system*
S 4-5	SLO-1 SLO-2	*Introduction to Edge Computing*	*4G*	*NS3*	*Data storage, Data Query and Visualization Layer*	*Case Study 4: IoT-Edge for Smart Energy Management*
S-6,7	SLO-1	*Need for Edge Computing- Improved Performance , Compliance, Data Privacy, And Data Security*	*Sigfox, NeUL*	*Software Defined Multi-Tier Fog Architecture*	*Big Data Implementation- Hortonworks, Cloudera, MAP R*	*Case Study 5: IoT- Edge for water demand forecasting*
	SLO-2	*Reduced Operational Cost*	*LoRaWAN*	*PVFOg simulator*	*Apache Projects for Big Data*	*Demand forecasting at Edge*
S-8,9	SLO-1	*Challenges in Edge/Fog Computing*	*5G*	*System Model analysis*	*Edge Computing for Big Data*	

Learning Resources	1. Ashton Kevin, (2009), "That Internet of Things Thing," RFID Journal, pp. 4986. 2. Maria Rita Palattella et al., (2013), "Standardized protocol stack for the internet of (important) things," IEEE Communications Surveys and Tutorials, 15(3), pp. 1389–1406. 3. D. Airehrour, J. Gutierrez and S. K. Ray, (2016), "Secure routing for internet of things: A survey," Journal of Network and Computer Applications, 66, pp. 198–213. 4. Reem Abdul Rahman and Babar Shah, (2016), "Security analysis of IoT protocols: A focus in CoAP," 2016 3rd MEC International Conference on Big Data and Smart City, ICBDSC 2016, pp. 172–178.. 5. Flavio Bonomi, Rodolfo Milito, Jiang Zhu and Sateesh Addepalli, (2012), "Fog Computing and Its Role in the Internet of Things," Proceedings of the first edition of the MCC workshop on Mobile cloud computing, pp. 13–16. 6. Weisong Shi, Jie Cao, Quan Zhang, Youhuizi Li and Lanyu Xu, (2016), "Edge Computing: Vision and Challenges," IEEE Internet of Things Journal, 3(5), pp. 637–646. 7. M. Mukherjee et al., (2017), "Security and Privacy in Fog Computing: Challenges," IEEE Access, 5, pp. 19293–19304. 8. Jie Cao, Quan Zhang and Weisong Shi, (2018), "Challenges and opportunities in edge computing," SpringerBriefs in Computer Science, pp. 59–70. 9. Martina Marjanovic, Aleksandar Antonic and Ivana Podnar Zarko, (2018), "Edge computing architecture for mobile crowd sensing," IEEE Access, 6, pp. 10662–10674. 10. Hesham El-Sayed et al., (2017), "Edge of Things: The Big Picture on the Integration of Edge, IoT and the Cloud in a Distributed Computing Environment," IEEE Access, 6, pp. 1706–1717 11. Huaqing Zhang, Yong Xiao, Shengrong Bu, Dusit Niyato, F. Richard Yu and Zhu Han, (2017), "Computing Resource Allocation in Three-Tier IoT Fog Networks: A Joint Optimization Approach Combining Stackelberg Game and Matching," IEEE Internet of Things Journal, 4(5), pp. 1204–1215 12. Veeramanikandan M. and Suresh Sankaranarayanan, (2019), "Publish/subscribe based multi-tier edge computational model in Internet of Things for latency reduction," Journal of Parallel and Distributed Computing, 127, pp. 18–27. 13. Ashfaq Farooqui, Kristofer Bengtsson, Petter Falkman and Martin Fabian, (2019), "From factory floor to process models: A data gathering approach to generate, transform, and visualize manufacturing processes," CIRP Journal of Manufacturing Science and Technology, 24, pp. 6–16. 14. Hongbing Wang, Chao Yu, Lei Wang and Qi Yu, (2018), "Effective BigDataspace service selection over trust and heterogeneous QoS preferences," IEEE Transactions on Services Computing, 11(4), pp. 644–657. 15. Pekka Pääkkönen and Daniel Pakkala, (2015), "Reference Architecture and Classification of Technologies, Products and Services for Big Data Systems," Big Data Research, 2(4), pp. 166–186 16. Tom White, (2015), "Hadoop: The Definitive Guide, 4th Edition," O'Reilly Media, Inc., (2015). 17. Team Hortonworks, "Hortonworks," [Online]. Available: https://hortonworks.com/. 18. Cloudera, "Cloudera," [Online]. Available: https://www.cloudera.com/about.html. 19. The Apache Software Foundation, "Apache Ni-Fi," [Online]. Available: https://nifi.apache.org/. 20. The Apache Software Foundation, "Apache Kafka," [Online]. Available: https://kafka.apache.org/. 21. The Apache Software Foundation, "Kafka Use cases," [Online]. Available: https://kafka.apache.org/uses. 22. The Apache Software Foundation, "Apache Storm," [Online]. Available: https://storm.apache.org/. 23. The Apache Software Foundation, "Apache Hive," Apache. [Online]. Available: https://hive.apache.org/. 24. The Apache Software Foundation, "Apache Pig." [Online]. Available: https://pig.apache.org/. 25. Alan Gates and Daniel Dai, (2016),"Programming Pig: Dataflow Scripting with Hadoop," Shroff/O'Reilly. 26. The Apache Software Foundation, "Zookeeper," [Online]. Available: https://zookeeper.apache.org/ 27. Shangguang Wang, Yali Zhao, Jinlinag Xu, Jie Yuan and Ching Hsien Hsu, (2019), "Edge server placement in mobile edge computing," Journal of Parallel and Distributed Computing, 127, pp. 160–168. 28. Yuthika, S, Ekta Dagur, Sourabh Mishra, Rijo Jackson Tom, Veeramanikandan,M and Suresh,S, "Intelligent IoT Based Automated Irrigation System", International Journal of Applied Engineering and Research, Vol.12(18), pp.7306-7320, 2017 29. Soundarya, P, Parthyusha, V, Niharika, A .V, Karthick, T and Suresh,S, "Intelligent IoT Based Water Quality Monitoring System", International Journal of Applied Engineering and Research, Vol.12(16), pp.5447-5454, 2017 30. Manav,M, Sameer,S, Suresh,S, Tom, R J and Veeramanikandan,M, "IoT Based Hydroponics System using Deep Neural Networks", Journal of Computers and Electronics in Agriculture, Vol.155,pp.473-486, 2018, Elsvier Publishing 31. Vignesh, M , Lavanya, V, Abhilasha,K, Gunasekhar,A and Suresh, S, "IoT Based Smart Energy Management System", International Journal of Applied Engineering and Research, Vol.12(16), pp.5455-5462, 2017

Learning Assessment

	Bloom's Level of Thinking	Continuous Learning Assessment (50% weightage)								Final Examination (50% weightage)	
		CLA – 1 (10%)		CLA – 2 (15%)		CLA – 3 (15%)		CLA – 4 (10%)#			
		Theory	Practice	Theory	Practice	Theory	Practice	Theory	Practice	Theory	Practice
Level 1	Remember Understand	40 %	-	30 %	-	30 %	-	30 %	-	30%	-
Level 2	Apply Analyze	40 %	-	40 %	-	40 %	-	40 %	-	40%	-
Level 3	Evaluate Create	20 %	-	30 %	-	30 %	-	30 %	-	30%	-
	Total	100 %		100 %		100 %		100 %		100 %	

CLA – 4 can be from any combination of these: Assignments, Seminars, Tech Talks, Mini-Projects, Case-Studies, Self-Study, MOOCs, Certifications, Conf. Paper etc.,

Course Designers

Experts from Industry	Experts from Higher Technical Institutions	Internal Experts
Dr.Madan Lakshmanan	Dr.Subra Ganesan	Dr.S.Suresh
Senior Scientist	Professor, Department of Electrical and Computer Engineering	Dr.J. Sujithra
CEERI, CSIR, Chennai (R&D Industry)	Oakalnd University, USA	

Course Code	18CSE448T	Course Name	ENERGY MANAGEMENT FOR IoT DEVICES	Course Category	E	Professional Elective	L	T	P	C
							3	0	0	3

Pre-requisite Courses	Nil	Co-requisite Courses	Nil	Progressive Courses	Nil
Course Offering Department		Computer Science and Engineering	Data Book / Codes/Standards	Nil	

Course Learning Rationale (CLR):	*The purpose of learning this course is to:*
CLR-1 :	*Understand the rudiments of energy conservation and IoT*
CLR-2 :	*Gain the knowledge on various energy conservation schemes in IoT*
CLR-3 :	*Utilize the conventional and optimization algorithms for conserving energy in IoT devices*
CLR-4 :	*Understand the various techniques of green IoT and impact of conventional techniques of IoT*
CLR-5 :	*Gain the knowledge on existing energy efficient architecture for energy conservation and harvesting*
CLR-6 :	*Gain the knowledge on low energy Bluetooth devices and its importance*

Course Learning Outcomes (CLO):	*At the end of this course, learners will be able to:*	Learning 1 Level of Thinking (Bloom)	2 Expected Proficiency (%)	3 Expected Attainment (%)	Program Learning Outcomes (PLO) 1 Engineering Knowledge	2 Problem Analysis	3 Design & Development	4 Analysis, Design, Research	5 Modern Tool Usage	6 Society & Culture	7 Environment & Sustainability	8 Ethics	9 Individual & Team Work	10 Communication	11 Project Mgt. & Finance	12 Life Long Learning	13 PSO - 1	14 PSO - 2	15 PSO – 3
CLO-1 :	*Acquire the knowledge on IoT and energy conservation approaches in IoT*	*2*	*80*	*85*	*H*	*M*	*M*	*M*	-	-	-	-	-	-	-	-	-	-	-
CLO-2 :	*Identify and choose appropriate energy conservation component for real world problems*	*2*	*75*	*80*	*H*	*M*	*M*	-	-	-	-	-	-	-	-	-	-	-	-
CLO-3 :	*Design and develop energy conservation algorithms for improving the lifetime of IoT devices*	*2*	*85*	*80*	*H*	*H*	*H*	*H*	-	-	-	-	-	-	-	-	-	-	-
CLO-4 :	*Compare and contrast of various green IoT techniques and able to design green IoT for real world problems*	*2*	*80*	*75*	*H*	*M*	*H*	*H*	-	-	-	-	-	-	-	*M*	-	-	-
CLO-5 :	*Design and develop energy efficient architecture for real world problems*	*2*	*75*	*85*	*H*	*H*	*H*	*H*	-	-	-	-	-	-	-	*M*	-	-	-
CLO-6 :	*Design and develop energy efficient architecture for real world problems using low energy Bluetooth devices*	*2*	*80*	*85*	*H*	*M*	*M*	*M*	-	-	-	-	-	-	-	-	-	-	-

Duration (hour)		9	9	9	9	9
S-1	SLO-1	*Introduction to IoT*	*Energy conservation schemes*	*Static energy efficient algorithms*	*Green IoT an Overview*	*Designing energy efficient IoT based Intelligent Transport System*
	SLO-2	*Architecture of IoT*	*Sleep/wakeup scheme*	*Exact allocation algorithm*	*Smart Homes, Smart Cities*	*Intelligent Transport System*
S-2	SLO-1	*Components of IoT*	*Data driven scheme*	*Best Fit Heuristic Algorithm*	*Energy Efficient smart health care*	*Motivations for IoT in Transportation*
	SLO-2	*Applications of IoT*	*Mobility based scheme*	*Dynamic energy efficient algorithms*	*Importance of Green IOT*	*Communication Technology and Related Power Issues*
S-3	SLO-1	*Challenges in IOT*	*Load balancing*	*Hardware Level Solution*	*Taxonomy of green IoT techniques*	*Information Extraction and Underlying Power Issues*
	SLO-2	*Energy Management in IoT*	*Working of load balancing*	*Dynamic Voltage Frequency Scaling (DVFS)*	*Various Approaches to Achieve Green IoT*	*Energy Efficiency Challenges and Corresponding Solutions, Further Challenges and Opportunities*
S-4	SLO-1	*Energy harvesting*	*Hardware based load balancing*	*Software Level Solution*	*software based green IoT techniques*	*Capacity Estimation of Electric Vehicle Aggregator for Ancillary Services*
	SLO-2	*Block diagram of energy harvesting*	*Software Based Load Balancing*	*First Fit Decreasing algorithm (FFD)*	*Hardware based green IoT techniques*	*Development of Electric Vehicles*
S-5	SLO-1	*Various ambient energies*	*Compare hardware and software based load balancing techniques*	*Modified Best Fit Decreasing algorithm (MBFD)*	*Policy based techniques*	*Motivation for Vehicle to Everything (V2X) and V2G Technology*
	SLO-2	*Energy harvesting schemes*	*Load balancing algorithms*	*Genetic Algorithm (GA)*	*Awareness based Approach - Toward Green IoT, Energy Awareness*	*Electric Vehicles and Solar Power Plants in Smart Grid Environment*
S-6	SLO-1	*Harvesting modules*		*Particle Swarm Optimization (PSO)*	*IoT Based Smart Metering*	*Potential of EV to Grid Connection, Capacity Estimation of Aggregator*
	SLO-2	*Rectenna Model*	*Static Algorithms, Dynamic Algorithms*	*Ant Colony Optimization (ACO)*	*Communication Technology Creating Awareness About Green Information, PromotingRecycling*	*Battery Management System, Grid Connection and Performance Testing of V2G*

S-7	SLO-1	*Sensing antenna*	*Issues of energy conservation in IoT*	*Simulated Annealing (SA)*	*Habitual Based Techniques*	*Weather monitoring using Bluetooth Low Energy (BLE) in warehouses*
	SLO-2	*DC-DC Converter*		*Cat Swarm Optimization(CSO)*	*Comparative analysis of different green IoT approaches*	*BLE Introduction*
S-8	SLO-1	*Wireless energy harvesting*	*Basic model of smart home system*	*Hybrid Genetic Algorithm and Cat Swarm Optimization (HGACSO)*	*Case study: impact of smart phones on the environment in present and future trends*	*BLE importance*
	SLO-2	*Near Field Communication, Inductive coupling*	*Energy Conservation in Smart Home and IoT*	*Hybrid Genetic Algorithm, Particle Swarm Optimization and Simulated annealing(HGAPSOSA)*	*Reduce the environmental impact life cycle assesment of smatphones, smart phone emission and selling rate*	
S-9	SLO-1	*Paradigmatic view of energy efficient IoT*	*Automation and Sensors in Smart Home*	*Comparison of dynamic energy efficient algorithms*	*Promoting the Usage of Sensor Cloud: a step toward green IoT.*	*Design weather monitoring using BLE*
	SLO-2	*Pragmatic energy efficient IoT system architecture*	*Case study: energy conservation component for smart home.*	*Compare and contrast static and dynamic energy efficient algorithms*	*Creating Awareness Through Prototyping: A Green IoT-Based Smart*	

Learning Resources	1. *."EnergyConservationforIoTDevicesConcepts,ParadigmsandSolutions",MamtaMittal,Sudeep Tanwar,BasantAgarwal,LalitMohanGoyal,StudiesinSystems,DecisionandControl 206,2019.* 2. *"IOTprojectswithBluetoothLowEnergy-Harnessthepowerofconnectedthings",Madhur*	3. *1Green IoT: An Investigation on Energy Saving Practices for 2020 and Beyond, Rushan Arshad, Saman Zahoor, Munam Ali Shah , Abdul Wahid, and Hongnian Yu, special section on future networks: architectures,protocols,andapplications,2017.*

Learning Assessment

	Bloom's Level of Thinking	Continuous Learning Assessment (50% weightage)								Final Examination (50% weightage)	
		CLA – 1 (10%)		CLA – 2 (15%)		CLA – 3 (15%)		CLA – 4 (10%)#			
		Theory	Practice	Theory	Practice	Theory	Practice	Theory	Practice	Theory	Practice
Level 1	Remember Understand	*40 %*	-	*30 %*	-	*30 %*	-	*30 %*	-	*30%*	-
Level 2	Apply Analyze	*40 %*	-	*40 %*	-	*40 %*	-	*40 %*	-	*40%*	-
Level 3	Evaluate Create	*20 %*	-	*30 %*	-	*30 %*	-	*30 %*	-	*30%*	-
	Total	100 %		100 %		100 %		100 %		100 %	

CLA – 4 can be from any combination of these: Assignments, Seminars, Tech Talks, Mini-Projects, Case-Studies, Self-Study, MOOCs, Certifications, Conf. Paper etc.,

Course Designers

Experts from Industry	Experts from Higher Technical Institutions	Internal Experts
1.Mr.Anantha Velavan , Principal Validation Engineer, Micro chip	*Dr. Divya Udayan J, PhD(S.Korea)| MIEEE | MACM | MIDF, Associate Professor, VIT University, Vellore*	*Dr.T.Sujithra,SRMIST*
2.Mr.GaneshSKandha, Senior Applications Engineer, Micro chip	*Dr.Masoodhu Banu, Professor/Head of Bio Medical, Veltech University,*	*Dr.Kayalvizhi Jayavel, SRMIST*
		Mrs.Anitha,SRMIST

Course Code	18CSE367T	Course Name	REQUIREMENTS ENGINEERING	Course Category	E	Professional Elective	L	T	P	C
							3	0	0	3

Pre-requisite Courses	Nil	Co-requisite Courses	Nil	Progressive Courses	Nil
Course Offering Department	Computer Science and Engineering	Data Book / Codes/Standards	Nil		

Course Learning Rationale (CLR):	The purpose of learning this course is to:
CLR-1 :	*Identify the sources, collect, organize and classify the requirements*
CLR-2 :	*Improve their ability to choose the appropriate Elicitation Techniques for any systems*
CLR-3 :	*Familiarize with the various requirements documentation and validation techniques*
CLR-4 :	*Familiarize with the various requirements quality drivers, Traceability models and requirements change control techniques*
CLR-5 :	*Expose to the Conflits, Escalation model , Settlements and Analytics of Cost Benefit analysis*
CLR-6 :	*Expose to the latest requirements engineering tools*

Course Learning Outcomes (CLO):	At the end of this course, learners will be able to:	Learning 1: Level of Thinking (Bloom)	Learning 2: Expected Proficiency (%)	Learning 3: Expected Attainment (%)	PLO 1: Engineering Knowledge	PLO 2: Problem Analysis	PLO 3: Design & Development	PLO 4: Analysis, Design, Research	PLO 5: Modern Tool Usage	PLO 6: Society & Culture	PLO 7: Environment & Sustainability	PLO 8: Ethics	PLO 9: Individual & Team Work	PLO 10: Communication	PLO 11: Project Mgt. & Finance	PLO 12: Life Long Learning	PLO 13: PSO - 1	PLO 14: PSO - 2	PLO 15: PSO – 3
CLO-1 :	*Acquire the knowledge on identifying the Source, organising and classifying requirements*	2	80	85	H	H	L	M	-	L	L	M	H	H	M	L	-	-	-
CLO-2 :	*Acquire the ability to identify and Apply the appropriate Elicitation Techniques for any systems*	2	75	80	H	H	H	L	-	L	-	L	H	H	H	L	-	-	-
CLO-3 :	*Understand the basic ideas about various requirements documentation and validation techniques*	2	85	80	H	L	L	L	M	-	-	M	M	M	M	-	-	-	-
CLO-4 :	*Apply the knowledge on various requirements quality drivers, Traceability models and requirements change control techniques for any system*	2	80	75	H	H	L	M	H	M	-	M	M	L	L	M	-	-	-
CLO-5 :	*Appreciate the concepts of Conflict, Escalation model , Settlements and Analytics of Cost Benefit analysis*	2	75	85	H	H	-	H	H-	-	-	M	L	M	M	-	-	-	-
CLO-6 :	*Appreciate the concepts of latest requirements engineering tools*	2	70	70	H	L	L	M	H	-	L	L	L	L	M	M	-	-	-

Duration (hour)		9	9	9	9	9
S-1	SLO-1	*Introduction to Requirements and Requirements Engineering*	*Requirement Inception*	*Introduction to Requirement Document, Structure of Document*	*Business drivers of Quality-components of Integrated Quality approach*	*Conflict types*
	SLO-2	*Requirements Types*	*sources of requirements*			
S-2	SLO-1	*Classification of Requirements*	*Introduction to requirement Elicitation*	*Vision, Scope and Elicitation notes*	*Quality improvement techniques, Requirements Quality Assurance*	*Mastering and using detection of the 5conflicts types on the basis of indication in project*
	SLO-2	*Requirements Gathering relevant to Software Life Cycle Models*				
S-3	SLO-1	*Stakeholders in the requirements process*	*Classical Elicitation Techniques-Interview, Questionnaire, Social analysis*	*Requirement Specification techniques*	*PDCA Cycle*	*Glasl's conflicts escalation model*
	SLO-2					
S-4	SLO-1	*Requirements Engineering Process Framework, Requirements Engineering Maturity Model*	*Modern Elicitation Techniques-Brainstorming,*	*Introduction to requirement validation-Classical Requirement Validation techniques-Inspection, Simple Check*	*Introduction to Requirement Management-Requirement Identification-Requirements traceability*	*Conflicts Settlement techniques*
	SLO-2	*Generic Process for requirements Engineering*				
S-5	SLO-1	*Levels of Requirements Engineering*	*Modern Elicitation Techniques-Prototyping, Use Centered Design,*	*. Introduction to requirement validation-Classical Requirement Validation techniques-Desk Check, Walkthrough*	*Requirement Tracebility models, Traceability Matrix- Traceability List & Tree*	*Conflicts Settlement techniques*

	SLO-2	*System Model for Requirements Engineering*				
S-6	SLO-1	*Representation of Requirements-Data Flow, ER Diagram*	*Modern Elicitation Techniques-Walkthrough, Use case Joint Application Development*	*Format review*	*Introduction to RequirementTraceability-Requirement traceability methods*	*Analytic Methods – Mastering and using Consider All Facts (CAF)*
	SLO-2	*View Point Controlled Requirements*				
S-7	SLO-1	*Structured Analysis and Design Technique, Viewpoint Oriented Requirements Definition*	*Requirement reuse*	*Prototype & Enactments, Functional test Design*		*Analytic Methods – Plus –Minus-Intresting(PMI)*
	SLO-2					
S-8	SLO-1	*0bject Oriented Methods of Requirements Engineering*	*Feature Oriented Domain Analysis*	*Development of User manual*	*Advance Traceability*	*Analytic Methods – Cost Benefit Analysis*
	SLO-2					
S-9	SLO-1	*Case Study : For the given application identify the stakeholders, gather and classify the requirements according to the types*	*Case Study: For the given application apply various techniques and Elicitation the requirements*	*Case study. For the given application validate and document the specifications*	*Requirement Change Control*	*Case study : Requirement Engineering Tools*
	SLO-2					

Learning Resources	1. *ElizabethHull,KenJackson,JeremyDick,RequirementsEngineering,Springer,2013* 2. *RalphR.Young,"TheRequirmentsENgineeringHandbook",2004*	3. *AxelvanLamsweerde,"RequirementsEngineering:FromSystemGoalstoUMLModelstoSoftware Specifications" , Wiley,2014* 4. *KarlWiegers,JoyBeatty,SoftwareRequirements(DeveloperBestPractices),(3rdEdition),MicrosoftPress, 2014.*

Learning Assessment

	Bloom's Level of Thinking	Continuous Learning Assessment (50% weightage)								Final Examination (50% weightage)	
		CLA – 1 (10%)		CLA – 2 (15%)		CLA – 3 (15%)		CLA – 4 (10%)#			
		Theory	Practice	Theory	Practice	Theory	Practice	Theory	Practice	Theory	Practice
Level 1	Remember Understand	*40%*	-	*30%*	-	*30%*	-	*30%*	-	*30%*	-
Level 2	Apply Analyze	*40%*	-	*40%*	-	*40%*	-	*40%*	-	*40%*	-
Level 3	Evaluate Create	*20%*	-	*30%*	-	*30%*	-	*30%*	-	*30%*	-
	Total	100 %		100 %		100 %		100 %		100 %	

CA – 4 can be from any combination of these: Assignments, Seminars, Tech Talks, Mini-Projects, Case-Studies, Self-Study, MOOCs, Certifications, Conf. Paper etc.,

Course Designers

Experts from Industry	Experts from Higher Technical Institutions	Internal Experts
1. Dr.Mariappan Vaithilingam, Engineering Leader Amazon, dr.v.m@ieee.org		*1. Mrs. Sasi Rekha Sankar, SRMIST*
2. Mr. Badinath, SDET, Amzon, sbadhrinath@gmail.com		*2. Mrs. Geetha.G, SRMIST*
		3 Dr. S.Thenmalar, SRMIST

Course Code	18CSE368T	Course Name	SOFTWARE ARCHITECTURE AND DESIGN	Course Category	E	Professional Elective	L	T	P	C
							3	0	0	3

Pre-requisite Courses	Nil	Co-requisite Courses	Nil	Progressive Courses	Nil
Course Offering Department	Computer Science and Engineering	Data Book / Codes/Standards	Nil		

Course Learning Rationale (CLR):	*The purpose of learning this course is to:*
CLR-1 :	*Classify the essential elements of software architecture*
CLR-2 :	*Understand the issues related to architecting a large-scale software system*
CLR-3 :	*Understand different software architectures views and styles*
CLR-4 :	*Able to use the four-views approach for developing and documenting a software architectures*
CLR-5 :	*Understand the implications of different design patterns*
CLR-6 :	*working as part of a team, develop, analyze and critique an architecture of a software system*

Course Learning Outcomes (CLO):	*At the end of this course, learners will be able to:*	Learning 1	2	3	Program Learning Outcomes (PLO) 1	2	3	4	5	6	7	8	9	10	11	12	13	14	15
		Level of Thinking (Bloom)	Expected Proficiency (%)	Expected Attainment (%)	Engineering Knowledge	Problem Analysis	Design & Development	Analysis, Design, Research	Modern Tool Usage	Society & Culture	Environment & Sustainability	Ethics	Individual & Team Work	Communication	Project Mgt. & Finance	Life Long Learning	PSO - 1	PSO - 2	PSO – 3
CLO-1 :	*Describe different approaches to design software application*	3	80	75	H	H	-	-	L	-	-	-	-	L	-	H	-	-	-
CLO-2 :	*Analyze specifications and identify appropriate design strategies.*	3	85	80	M	H	H	H	-	-	-	-	M	M	M	H	-	-	-
CLO-3 :	*Develop an appropriate design for a given set of requirements*	3	75	75	M	H	H	H	-	-	-	-	-	M	M	H	-	-	-
CLO-4 :	*Identify applicable design patterns for the solution*	3	85	80	H	H	H	H	-	-	-	-	-	L	L	H	-	-	-
CLO-5 :	*Abstract and document reusable design patterns*	3	80	70	M	H	H	-	L	-	-	-	M	M	M	H	-	-	-
CLO-6 :	*Evaluate a given design against the specifications*	3	80	70	M	H	-	-	-	-	-	-	M	M	M	H	-	-	-

Duration (hour)		9	9	9	9	9
S-1	SLO-1	*Software Architecture –Software Design*	*Software Architectural Patterns & Styles*	*Evaluating a Software Architecture*	*Introduction to Design Process*	*Introduction to Design Pattern*
	SLO-2	*Importance and Need of Software Architecture*	*Types of Architectural Styles*	*Why- When -Who evaluate Architecture*	*Design Strategy*	*Component of Design Pattern - Types*
S-2	SLO-1	*4 +1 View Model*	*Layered pattern*	*What Qualities Can We Evaluate an Architecture?*	*Describing the design process the D-Matrix*	*Creational Design Patten - Abstract Factory Pattern*
	SLO-2	*Activities in Software Architecture*	*Merits and Demerits of Layered Pattern*		*Views associated with D-matrix*	*Factory Method*
S-3	SLO-1	*Fundamental design issues*	*Pipe-Filter pattern*	*Outputs of an Architecture Evaluation*	*Design by top-down decomposition*	*Singleton Pattern*
	SLO-2		*Merits and Demerits of Pipe and Filter*			*Structural design Pattern - Types*
S-4	SLO-1	*Understanding quality attributes -*	*Shared Data Pattern*	*Evaluating the Architecture - ATAM*	*Design by composition*	*Adaptor pattern*
	SLO-2	*Six parts of Quality Scenario*	*Merits and Demerits of Shared Data Pattern*	*Participants and Outputs of ATAM*		*Decorator Pattern*
S-5	SLO-1	*Design for quality attributes - Availability (General Scenario, Tactics)*	*Client Server pattern*	*Phases of ATAM*	*Function-oriented design*	*Proxy Pattern*
	SLO-2		*Merits and Demerits of Client Server*	*CASE Study for ATAM*		*Behavioral Design Pattern - Types*
S-6	SLO-1	*Design for quality attributes - Modifiability (General Scenario, Tactics)*	*Blackboard Architectural Pattern*	*Evaluating the Architecture - CBAM*	*Object-oriented design*	*Observer Pattern*
	SLO-2		*Merits and Demerits*	*Decision-Making Context*		*Strategy Pattern*
S-7	SLO-1	*Design for quality attributes - Security (General Scenario, Tactics)*	*Flight Simulation: A Case Study in an Architecture for Integrability*	*Basis for the CBAM - Case Study*	*Aspect Oriented Design*	*Iterator pattern*
	SLO-2		*Relationship to the Architecture Business*			*Introduction to ADL*

			Cycle			
S-8	SLO-1	*Design for quality attributes - Usability (General Scenario, Tactics)*	*Requirements and Qualities related to flight simulation*	*Evaluating Software Architecture - SAAM*	*Design Metrics - Need for Metrics*	*Components of ADL- Example*
	SLO-2			*SAAM Evaluation Process*	*WMC -DIT*	
S-9	SLO-1	*Design for quality attributes - Testability (General Scenario, Tactics)*	*Architectural Solution for flight simulation*	*Evaluating Software Architecture - ARID*	*NOC - CBC*	*Future Directions in Architecture*
	SLO-2			*ARID Evaluation Process*	*RFC- LCOM*	

Learning Resources	1. *Len Bass, Paul Clements, & Rick Kazman. Software Architecture in Practice (Third Edition). Addison-Wesley,2013* 2. *Humberto Cervantes, Rick Kazman ,Designing Software Architectures: A Practical Approach. Pearson Education,2016* 3. *CarlosOtero,"SoftwareEngineeringDesign:TheoryandPractice",CRCPress,2012*	4. *Paul Clements , Rick Kazman , Mark Klein, Evaluating Software Architectures: Methods and Case Studies. Addison Wesley; 1 edition (22 October2001)* 5. *Jason McC. Smith, “Elemental design Patterns”,. Addison Wesley,2012* 6. *VasudevaVarma,SoftwareArchitecture:ACaseBasedApproach.PearsonEducation,2009.*

Learning Assessment

	Bloom’s Level of Thinking	Continuous Learning Assessment (50% weightage)								Final Examination (50% weightage)	
		CLA – 1 (10%)		CLA – 2 (15%)		CLA – 3 (15%)		CLA – 4 (10%)#			
		Theory	Practice	Theory	Practice	Theory	Practice	Theory	Practice	Theory	Practice
Level 1	Remember Understand	*40 %*	-	*30 %*	-	*30 %*	-	*30 %*	-	*30%*	-
Level 2	Apply Analyze	*40 %*	-	*40 %*	-	*40 %*	-	*40 %*	-	*40%*	-
Level 3	Evaluate Create	*20 %*	-	*30 %*	-	*30 %*	-	*30 %*	-	*30%*	-
	Total	100 %		100 %		100 %		100 %		100 %	

CLA – 4 can be from any combination of these: Assignments, Seminars, Tech Talks, Mini-Projects, Case-Studies, Self-Study, MOOCs, Certifications, Conf. Paper etc.,

Course Designers		
Experts from Industry	Experts from Higher Technical Institutions	Internal Experts
		Mr.C.Arun, SRMIST

Course Code	18CSE369T	Course Name	SOFTWARE MODELING AND ANALYSIS	Course Category	E	Professional Elective	L	T	P	C
							3	0	0	3

Pre-requisite Courses	Nil	Co-requisite Courses	Nil	Progressive Courses	Nil
Course Offering Department	Computer Science and Engineering	Data Book / Codes/Standards	Nil		

Course Learning Rationale (CLR):	The purpose of learning this course is to:
CLR-1 :	*Select a suitable modeling method according to problem area and assignment, and can justify their choice.*
CLR-2 :	*Formulate models of a system to describe the system on different levels of abstraction and from different viewpoints.*
CLR-3 :	*Identify the Formal models used in software development*
CLR-4 :	*Define model checking concepts using tools*
CLR-5 :	*Model the software system and analyze its characteristics and correctness.*

Course Learning Outcomes (CLO):	At the end of this course, learners will be able to:	Learning 1: Level of Thinking (Bloom)	Learning 2: Expected Proficiency (%)	Learning 3: Expected Attainment (%)	PLO 1: Engineering Knowledge	PLO 2: Problem Analysis	PLO 3: Design & Development	PLO 4: Analysis, Design, Research	PLO 5: Modern Tool Usage	PLO 6: Society & Culture	PLO 7: Environment & Sustainability	PLO 8: Ethics	PLO 9: Individual & Team Work	PLO 10: Communication	PLO 11: Project Mgt. & Finance	PLO 12: Life Long Learning	PLO 13: PSO - 1	PLO 14: PSO - 2	PLO 15: PSO – 3
CLO-1 :	*Implement the appropriate modeling method for the given problem*	2	80	85	H	-	-	-	-	-	-	-	-	-	-	-	-	-	-
CLO-2 :	*Explain the system abstraction in different levels*	2	75	80	H	H	-	-	-	-	-	-	-	-	-	-	-	-	-
CLO-3 :	*Apply the Formal models in the software development*	2	85	80	H	-	-	-	-	-	-	-	-	-	-	-	-	-	-
CLO-4 :	*Apply tools to check model checking properties of a system*	2	80	75	H	H	-	-	-	-	-	-	-	-	-	-	-	-	-
CLO-5 :	*Analyze the characteristics and correctness of software system*	2	75	85	H	-	-	H	-	-	-	-	-	-	-	-	-	-	-

Duration (hour)		9	9	9	9	9
S-1	SLO-1	*Introduction to software modelling*	*Representing domain concepts by conceptual objects*	*Modeling system agents, Characterizing agents.*	*Correctness of Object Oriented Programs Design by Contract, The Class Invariant*	*Introduction to Kripke Structures*
S-2	SLO-1	*Modeling principles*	*Entities, Association, Attributes*	*Representing agent models,Refinement of abstract agents*	*Example - correctness of stack application*	*Modeling System Design as Kripke Structure*
S-3	SLO-1	*Goal features as model annotations,Goal refinement*	*Built–in associations for structuring object models*	*Building Agent models*	*A real–time temporal logic for specifying model annotations*	*Exercise on Kripke Modelling, Recap to Kripke Structures*
S-4	SLO-1	*Representing conflicts among goals,Connecting the goal model with other system views.*	*Class Diagrams, Heuristic rules for building object models*	*Modelling system operations, Characterizing system operations*	*Specifying goals in the goal model.*	*Exercises on system modeling using kripke structures, Introduction to LTL*
S-5	SLO-1	*Modelling alternative options, Goal diagrams as AND/OR graphs.*	*Object or Attribute Entity, association, agent or event?*	*Goal Operationalization, Goals, agents, objects and operations*	*Specifying descriptive properties in the object model*	*Properties of a system, Liveness and Safety properties , Exercise on specifying properties as LTL formula*
S-6	SLO-1	*Documenting goal refinements and assignments with annotations*	*Attribute of a linked object or of the linking association Specialization and generalizing concepts Avoiding common*	*Representing object models, Building operation models*	*Specifying operationalization's in the operation model*	*Introduction to NuSMV tool, Model Checking using NuSMV,Introduction to SPIN CHECKER tool*
S-7	SLO-1	*Building goal models: Heuristic rules and reusable patterns*	*Aggregation or association? Avoiding common pitfalls*	*Modelling System behaviour, Modelling instance behaviours*	*Checking goal refinements deriving goal operations*	*Model Checking using SPIN checker tool*
S-8	SLO-1	*Goal obstruction by obstacles*	*Specialization and generalizing concepts Avoiding common pitfalls*	*Modelling class behaviours*	*Generating obstacles for risk analysis Generating anti goals for security analysis*	*System Property as first order logic formula Proof of correctness using theorem prover*

S-9	SLO-1	*Modelling obstacles, Obstacle ananlysis for a more robust goal model*	*Case Study*	*Building behaviour models*	*Formal conflict analysis. Synthesizing behaviour models for animation and model checking.*	*Introduction Isabelle tool, Theorem proving using Isabelle*

Learning Resources	1. *AxelvanLamsweerde"RequirementsEngineering:FromSystemGoalstoUMLModelstoSoftware Specifications"ISBN:978-0-470-01270-3February9,2009Wiley* 2. *http://www.bowdoin.edu/~allen/courses/cs260/readings/ch12.pdf*	*3. Gerard J. Holzmann, "The SPIN Model Checker: Primer and Reference Manual" ISBN-13: 978-0321773715 , AT&T Bell Labs Murray Hill New Jersey ©2004 | Addison-Wesley Professional*

Learning Assessment

	Bloom's Level of Thinking	Continuous Learning Assessment (50% weightage)								Final Examination (50% weightage)	
		CLA – 1 (10%)		CLA – 2 (15%)		CLA – 3 (15%)		CLA – 4 (10%)#			
		Theory	Practice	Theory	Practice	Theory	Practice	Theory	Practice	Theory	Practice
Level 1	Remember Understand	*40 %*	-	*30 %*	-	*30 %*	-	*30 %*	-	*30%*	-
Level 2	Apply Analyze	*40 %*	-	*40 %*	-	*40 %*	-	*40 %*	-	*40%*	-
Level 3	Evaluate Create	*20 %*	-	*30 %*	-	*30 %*	-	*30 %*	-	*30%*	-
	Total	100 %		100 %		100 %		100 %		100 %	

CLA – 4 can be from any combination of these: Assignments, Seminars, Tech Talks, Mini-Projects, Case-Studies, Self-Study, MOOCs, Certifications, Conf. Paper etc.,

Course Designers

Experts from Industry	Experts from Higher Technical Institutions	Internal Experts
1. Ms T Vijayalakshmi Priyadharsini, Senior Manager, Cognizant Technology Solutions, Chennai	*1. Dr.Kumudha Padmanaban, Associate Professor, Coimbatore Institute of Technology, kumudha@cit.edu.in*	*1. Mr Ramraj S, SRMIST*
	2. Dr M Sangeetha, Coimbatore Institute of Technology, citcsesangi@gmail.com	*2. Ms A NithyaKalyani, SRMIST*

Course Code	18CSE370T	Course Name	DESIGN PATTERNS	Course Category	E	Professional Elective	L	T	P	C
							3	0	0	3

Pre-requisite Courses	Nil	Co-requisite Courses	Nil	Progressive Courses	Nil
Course Offering Department	Computer Science and Engineering	Data Book / Codes/Standards	Nil		

Course Learning Rationale (CLR):	*The purpose of learning this course is to:*
CLR-1 :	*Conceive the importance of reuse of solution for common problems in software development.*
CLR-2 :	*Identify the appropriate patterns for design problems.*
CLR-3 :	*Implement the various design pattern solution for appropriate scenarios*
CLR-4 :	*Refactoring the badly designed program properly using patterns.*

Course Learning Outcomes (CLO):	*At the end of this course, learners will be able to:*	Learning 1: Level of Thinking (Bloom)	Learning 2: Expected Proficiency (%)	Learning 3: Expected Attainment (%)	PLO 1: Engineering Knowledge	PLO 2: Problem Analysis	PLO 3: Design & Development	PLO 4: Analysis, Design, Research	PLO 5: Modern Tool Usage	PLO 6: Society & Culture	PLO 7: Environment & Sustainability	PLO 8: Ethics	PLO 9: Individual & Team Work	PLO 10: Communication	PLO 11: Project Mgt. & Finance	PLO 12: Life Long Learning	PLO 13: PSO - 1	PLO 14: PSO - 2	PLO 15: PSO – 3
CLO-1 :	*To create software designs that are scalable and easily maintainable*	2	80	85	H	-	-	-	-	-	-	-	-	-	-	-	-	-	-
CLO-2 :	*Use creational design patterns in software design for class instantiation*	2	75	80	H	H	-	-	-	-	-	-	-	-	-	-	-	-	-
CLO-3 :	*Use structural design patterns for better class and object composition*	2	85	80	H	-	-	-	-	-	-	-	-	-	-	-	-	-	-
CLO-4 :	*Use behavioral patterns for better organization and Communication between the objects*	2	80	75	H	H	-	-	-	-	-	-	-	-	-	-	-	-	-

Duration (hour)		9	9	9	9	9
S-1	SLO-1 SLO-2	*Basics of UML Class Diagram, Interaction Diagram*	*Strategy pattern- Intent, Motivation, Applicability, Structure, Participants, collaborations, consequences Strategy pattern- Implementation and sample code*	*Abstract factory- Intent, Motivation, Applicability, Structure, Participants, collaborations, consequences Abstract factory- Implementation and sample code*	*Adapter- Intent, Motivation, Applicability, Structure, Participants, collaborations, consequences Adapter- Implementation and sample code*	*What to Expect from Design Patterns The Pattern Community An Invitation*
S-2	SLO-1 SLO-2	*Object design, Reuse Concepts, Solution Objects Inheritance & Design Patterns*	*Mediator - Intent, Motivation, Applicability, Structure, Participants, collaborations, consequences Mediator- Implementation and sample code*	*Singleton pattern- Intent, Motivation, Applicability, Structure, Participants, collaborations, consequences Singleton pattern Implementation and sample code*	*Bridge- Intent, Motivation, Applicability, Structure, Participants, collaborations, consequences Bridge- Implementation and sample code*	*A Parting Thought A Case Study : Designing a Document Editor : Design Problems, Document Structure*
S-3	SLO-1 SLO-2	*Principle and Strategies Open/Closed principle Designing from context, Encapusulating Variation*	*Template Method- Intent, Motivation, Applicability, Structure, Participants, collaborations, consequences Template Method- Implementation*	*Factory method pattern- Intent, Motivation, Applicability, Structure, Participants, collaborations, consequences Factory method pattern Implementation*	*Decorator, Facade- Intent, Motivation, Applicability, Participants, collaborations, consequences Structure Decorator, Facade- Implementation*	*A Case Study : Designing a Document Editor : Design Problems, Document Structure Formatting, Embellishing the User Interface*
S-4	SLO-1 SLO-2	*Abstract classes and Interfaces Design patterns and Architecture*	*Template Method- sample code Case study: Identify which pattern is applicable for the given case study and justify*	*Factory method pattern sample code Case study: Identify which pattern is applicable for the given case study and justify*	*Decorator, Facade- Sample Code Case study: Identify which pattern is applicable for the given case study and justify*	*Supporting Multiple Look-and-Feel Standards Supporting Multiple Window Systems*
S-5	SLO-1 SLO-2	*Gand of Four Patterns Basics of UML*	*Case study: Identify which pattern is applicable for the given case study and justify Strategy pattern- Intent, Motivation, Applicability, Structure, Participants, collaborations, consequences*	*Case study: Identify which pattern is applicable for the given case study and justify Abstract factory- Intent, Motivation, Applicability, Structure, Participants, collaborations, consequences*	*Case study: Identify which pattern is applicable for the given case study and justify Adapter- Intent, Motivation, Applicability, Structure, Participants, collaborations, consequences*	*User Operations Spelling Checking and Hyphenation What to Expect from Design Patterns*
S-6	SLO-1	*Class Diagram, Interaction Diagram*	*Strategy pattern- Implementation and*	*Abstract factory- Implementation and*	*Adapter- Implementation and sample code*	*The Pattern Community An Invitation*

	SLO-2	Object design, Reuse Concepts, Solution Objects	sample code Mediator - Intent, Motivation, Applicability, Structure, Participants, collaborations, consequences	sample code Singleton pattern- Intent, Motivation, Applicability, Structure, Participants, collaborations, consequences	Bridge- Intent, Motivation, Applicability, Structure, Participants, collaborations, consequences	A Parting Thought
S-7	SLO-1	Inheritance & Design Patterns Principle and Strategies Open/Closed principle	Mediator- Implementation and sample code Template Method- Intent, Motivation, Applicability, Structure, Participants, collaborations, consequences	Singleton pattern Implementation and sample code Factory method pattern- Intent, Motivation, Applicability, Structure, Participants, collaborations, consequences	Bridge- Implementation and sample code Decorator, Facade- Intent, Motivation, Applicability, Participants, collaborations, consequences Structure	A Case Study : Designing a Document Editor : Design Problems, Document Structure A Case Study : Designing a Document Editor : Design Problems, Document Structure
	SLO-2					
S-8	SLO-1	Designing from context, Encapusulating Variation Abstract classes and Interfaces	Template Method- Implementation Template Method- sample code	Factory method pattern Implementation Factory method pattern sample code	Decorator, Facade- Implementation Decorator, Facade- Sample Code	Formatting, Embellishing the User Interface Supporting Multiple Look-and-Feel Standards
	SLO-2					
S-9	SLO-1	Design patterns and Architecture	Case study: Identify which pattern is applicable for the given case study and justify	Case study: Identify which pattern is applicable for the given case study and justify	Case study: Identify which pattern is applicable for the given case study and justify	Supporting Multiple Window Systems
	SLO-2					

Learning Resources	1. Bruegge,BerndandAllenH.Dutoit.“Object-OrientedSoftwareEngineering:UsingUML,Patternsand Java”,Pearson: Prentice Hall Publishers2004 2. ErichGamma,RichardHelm,“DesignPatterns:Elementsofreusablesoftware development”, Pearson Education,2005	3. Alan Shalloway, James R Trott "Design pattern explained", Pearson Education,2005. 4. EricFreeman,ElisabethRobson,BertBates,andKathySierra,“HeadFirstDesignPatterns”, O'reilly Publications,2004.

Learning Assessment

	Bloom's Level of Thinking	Continuous Learning Assessment (50% weightage)								Final Examination (50% weightage)	
		CLA – 1 (10%)		CLA – 2 (15%)		CLA – 3 (15%)		CLA – 4 (10%)#			
		Theory	Practice	Theory	Practice	Theory	Practice	Theory	Practice	Theory	Practice
Level 1	Remember Understand	40 %	-	30 %	-	30 %	-	30 %	-	30%	-
Level 2	Apply Analyze	40 %	-	40 %	-	40 %	-	40 %	-	40%	-
Level 3	Evaluate Create	20 %	-	30 %	-	30 %	-	30 %	-	30%	-
	Total	100 %		100 %		100 %		100 %		100 %	

CLA – 4 can be from any combination of these: Assignments, Seminars, Tech Talks, Mini-Projects, Case-Studies, Self-Study, MOOCs, Certifications, Conf. Paper etc.,

Course Designers		
Experts from Industry	Experts from Higher Technical Institutions	Internal Experts
1. Ms T Vijayalakshmi Priyadharsini, Senior Manager, Cognizant Technology Solutions, Chennai	1. Dr.Kumudha Padmanaban, Associate Professor, Coimbatore Institute of Technology, kumudha@cit.edu.in	1. Dr S Sridar SRMIST
	2. Dr M Sangeetha, Coimbatore Institute of Technology, citcsesangi@gmail.com	2. Ramraj S SRMIST

Course Code	18CSE371T	Course Name	USER INTERFACE DESIGN	Course Category	E	Professional Elective	L	T	P	C
							3	0	0	3

Pre-requisite Courses	Nil	Co-requisite Courses	Nil	Progressive Courses	Nil
Course Offering Department	Computer Science and Engineering	Data Book / Codes/Standards	Nil		

Course Learning Rationale (CLR):	*The purpose of learning this course is to:*
CLR-1 :	*Understand the concepts of design; Utilize by learing various color models*
CLR-2 :	*Gain knowledge on the basics of various law in UX*
CLR-3 :	*Construct the task for requirement gathering*
CLR-4 :	*Gain knowledge on how to Design for various domains or applications*
CLR-5 :	*Introducetools for designing various applications*
CLR-6 :	*Utilisedifferent types of design for real-time programming applications*

Course Learning Outcomes (CLO):	*At the end of this course, learners will be able to:*	Learning 1: Level of Thinking (Bloom)	Learning 2: Expected Proficiency (%)	Learning 3: Expected Attainment (%)	PLO 1: Engineering Knowledge	PLO 2: Problem Analysis	PLO 3: Design & Development	PLO 4: Analysis, Design, Research	PLO 5: Modern Tool Usage	PLO 6: Society & Culture	PLO 7: Environment & Sustainability	PLO 8: Ethics	PLO 9: Individual & Team Work	PLO 10: Communication	PLO 11: Project Mgt. & Finance	PLO 12: Life Long Learning	PLO 13: PSO - 1	PLO 14: PSO - 2	PLO 15: PSO – 3
CLO-1 :	*Identify various color models for design*	*2*	*80*	*85*	*H*	-	-	-	-	-	-	-	-	-	-	-	-	-	-
CLO-2 :	*Create the design as per the design law*	*2*	*75*	*80*	*H*	*H*	-	-	-	-	-	-	-	-	-	-	-	-	-
CLO-3 :	*Construct the task for requirement gathering*	*2*	*85*	*80*	*H*	-	-	-	-	-	-	-	-	-	-	-	-	-	-
CLO-4 :	*Create wire frames and prototypes*	*2*	*80*	*75*	*H*	*H*	-	-	-	-	-	-	-	-	-	-	-	-	-
CLO-5 :	*Create the usability constraints and accebility*	*2*	*75*	*85*	*H*	-	-	*H*	-	-	-	-	-	-	-	-	-	-	-
CLO-6 :	*Construct real-time applications using real-time programming applications*	*2*	*80*	*85*	*H*	-	-	-	-	-	-	-	-	-	-	-	-	-	-

Duration (hour)		9	9	9	9	9
S-1	SLO-1	*What is typography-type properties, baseline, cap height*	*Laws of UX designing*	*Introduction to Interaction Design*	*Culture in usability*	*Importance of case studies and guidelines*
	SLO-2	*X-height, ascenders*	*Hicks law*	*Task analysis*	*Universal usability*	*Tracking APP Introduction*
S-2	SLO-1	*Descenders and weight*	*example of hicks law with an application*	*Data collection for gathering user*	*Inclusive interaction*	*Tracking APP Design guidelines*
	SLO-2	*Type classification-Serif*	*Jakob's law*	*Data for task requirements*	*Importance of accessibility*	*Tracking APP demo*
S-3	SLO-1	*sans serif fonts*	*example of jakob's law with an application*	*Requirements gathering*	*principles of accessibility*	*Designing UI*
	SLO-2	*monospace*	*Fitts's Law*	*Eliciting Qualitative data*	*Universal design*	*Redesigning Gmail and making it flash*
S-4	SLO-1	*handwriting and Display*	*example of Fitts's law with an application*	*analyzing qualitative data*	*Accessibility design*	*Design principles*
	SLO-2	*Readability, letter spacing*	*Ockham's Razor*	*Qualitative metrics*	*Font weight, color*	*Redesigning Gmail and making it flash Demo*
S-5	SLO-1	*line height with an example*	*example of Ockham's law with an application*	*User narratives*	*Contrast, Screen readers*	*Introduction of how to Design a new UX concept to reduce driver distraction*
	SLO-2	*Paragraph spacing, power of alignment*	*Pareto Principle*	*Scenario implementation and its challenges*	*Alt text using a tool*	*Designing concepts of Driver distraction*
S-6	SLO-1	*Leading and Kerning*	*example of Pareto principle with an application*	*Wireframes*	*Introduction to Multifaceted Users*	*Demo*
	SLO-2	*Fundamentals of color*	*Weber's law*	*Example on wireframes*	*Designing for Multifaceted Users*	*Importance of User data in UX designing*

S-7	SLO-1	*Color Models Introduction*	*example of Weber's law with an application*	*Prototypes*	*Design guidelines*	*Approach to design without user data*
	SLO-2	*RGB, CMYK*	*Tesler's law*	*Implementation of Prototypes*	*Guidelines for helping adults*	*Designing concept*
S-8	SLO-1	*Color harmony: monochromatic, analogous*	*example of Tesler's law with an application*	*UX design for mobile application*	*Application example*	*Implementation problems without data*
	SLO-2	*Complementary, triadic, double-complementary*	*Law of proximity*	*Application design example*	*Virtual third eye simulator introduction*	*Dynamic webpages*
S-9	SLO-1	*Meaning of colors*	*example of proximity*	*Responsive Design*	*Web accessibility guide*	*Demo*
	SLO-2	*The power of Contrast*	*Law of similarity and human eye*	*Adaptive design and difference with Responsive design*	*Virtual third eye simulator web accessibility*	*Perform UI Case study*

Learning Resources	1. *Jeff Johnson, Kate Finn- "Designing user Interfaces for an aging population towards Universal design- Morgan Kauffman publishers – Elseiver-2017* 2. *ElvisCanziba-"Hands-onUXDesignforDevelopers"–PacktBirminiham,mumbai-2018*	3. *AndrewRogerson-"UserExperienceDesign"–Smashinmedia2012-Freiburg,Germany* 4. *BarbaraBallard,"Designingthemobileuserexperience"Wileypublicatoins2007* 5. *https://uxdesign.cc/tagged/case-study*

Learning Assessment

	Bloom's Level of Thinking	Continuous Learning Assessment (50% weightage)								Final Examination (50% weightage)	
		CLA – 1 (10%)		CLA – 2 (15%)		CLA – 3 (15%)		CLA – 4 (10%)#			
		Theory	Practice	Theory	Practice	Theory	Practice	Theory	Practice	Theory	Practice
Level 1	Remember Understand	*40%*	-	*30%*	-	*30%*	-	*30%*	-	*30%*	-
Level 2	Apply Analyze	*40%*	-	*40%*	-	*40%*	-	*40%*	-	*40%*	-
Level 3	Evaluate Create	*20%*	-	*30%*	-	*30%*	-	*30%*	-	*30%*	-
	Total	100 %		100 %		100 %		100 %		100 %	

CA – 4 can be from any combination of these: Assignments, Seminars, Tech Talks, Mini-Projects, Case-Studies, Self-Study, MOOCs, Certifications, Conf. Paper etc.,

Course Designers		
Experts from Industry	Experts from Higher Technical Institutions	Internal Experts
		1. Mr.S.Karthick, SRMIST
		2.Mrs.Akilandeswari, SRMIST

Course Code	18CSE372T	Course Name	VISUAL PROGRAMMING	Course Category	E	Professional Elective	L	T	P	C
							3	0	0	3

Pre-requisite Courses	Nil	Co-requisite Courses	Nil	Progressive Courses	Nil
Course Offering Department	CSE	Data Book / Codes/Standards	Nil		

Course Learning Rationale (CLR):	*The purpose of learning this course is to:*
CLR-1 :	*Gain knowledge about basics of C# and .NET framework*
CLR-2 :	*Utilize object-oriented aspects of C# to develop applications*
CLR-3 :	*Utilize forms, menus etc. to design Windows applications*
CLR-4 :	*Utilize ActiveX Data Objects to create Database applications*
CLR-5 :	*Utilize web forms to develop Web based applications*

Course Learning Outcomes (CLO):	At the end of this course, learners will be able to:	Learning 1: Level of Thinking (Bloom)	Learning 2: Expected Proficiency (%)	Learning 3: Expected Attainment (%)	PLO 1: Engineering Knowledge	PLO 2: Problem Analysis	PLO 3: Design & Development	PLO 4: Analysis, Design, Research	PLO 5: Modern Tool Usage	PLO 6: Society & Culture	PLO 7: Environment & Sustainability	PLO 8: Ethics	PLO 9: Individual & Team Work	PLO 10: Communication	PLO 11: Project Mgt. & Finance	PLO 12: Life Long Learning	PLO 13: PSO - 1	PLO 14: PSO - 2	PLO 15: PSO – 3
CLO-1 :	*Understand the basics of C# and .NET framework*	2	80	85	-	-	-	-	H	-	-	-	-	-	-	-	-	-	-
CLO-2 :	*Develop applications using object-oriented aspects of C#*	2	75	80	H	-	M	-	H	-	-	-	-	-	-	H	-	-	-
CLO-3 :	*Design Windows applications*	2	85	80	H	-	M	M	H	L	L	-	H	-	-	H	-	-	-
CLO-4 :	*Create Database applications using ActiveX Data Objects*	2	80	75	H	H	M	-	H	L	L	-	H	-	-	H	-	-	-
CLO-5 :	*Develop Web based applications*	2	75	85	H	-	M	M	H	L	L	M	H	M	L	H	M	H	H

Duration (hour)		10	10	9	8	8
S-1	SLO-1, SLO-2	*Introducing C# - Understanding .NET Framework*	*Class – Objects*	*Building Windows Application*	*Accessing data with ADO.NET: DataSet*	*Programming Web Application with Web Forms*
S-2	SLO-1	*Overview of C# - Literals – Variables*	*Constructors – Types of Constructors*	*Examples: Windows Applications*	*Accessing data with ADO.NET: Typed Dataset*	*Introduction to ASP.NET,*
	SLO-2	*Data Types – Operators – Constants - Expressions*				
S-3	SLO-1, SLO-2	*Program Control Statements: Branching*	*Inheritance and its types*	*Creating Window Forms with Events and Controls*	*Data Adapter*	*Working with XML and .NET*
S-4	SLO-1, SLO-2	*Program Control Statements: Looping*	*Examples - Inheritance*	*Examples: Window Forms with Events and Controls*	*Updating Database using Stored Procedures*	*Creating Virtual Directory and Web Application*
S-5	SLO-1, SLO-2	*Casting - Methods*	*Indexers and Properties*	*Menu and Toolbar*	*SQL Server with ADO.NET*	*Session Management*
S-6	SLO-1, SLO-2	*Arrays: Array Class*	*Polymorphism – Operator Overloading*	*Delegates - Inheriting Window Forms*	*Handling Exceptions*	*Web Services – web.config*
S-7	SLO-1, SLO-2	*Array List*	*Polymorphism – Method Overloading*	*SDI Application*	*Validating Controls*	*Web Services – Passing Datasets and Returning Datasets from Web Services*
S-8	SLO-1, SLO-2	*String*	*Interfaces, Abstract Class*	*MDI Application*	*Windows Application Configuration*	*Transaction Handling, Exception Handling – Returning Exceptions from SQL Server*
S-9	SLO-1, SLO-2	*String Builder*	*Event Handling*	*Dialog Box: Modal and Modeless*		
S-10	SLO-1, SLO-2	*Structures - Enumerations*	*Errors and Exception Handling*			

Learning Resources	3. *Herbert Schildt, "The Complete Reference: C# 4.0", Tata McGraw Hill, 2012.* 4. *Andrew Troelsen, Philip Japikse, "C# 6.0 and the .NET 4.6 Framework", Seventh Edition, Apress, 2015*	5. *Christian Nagel et al. "Professional C# 2012 with .NET 4.5", Wiley India, 2012.* 6. *Andrew Troelsen, Philip Japikse , "Pro C# 7 with .NET and .NET Core", Eigth Edition, Apress, 2017* 7. *Stephen C. Perry, "Core C# and .NET", Prentice Hall, 2005*

Learning Assessment

	Bloom's Level of Thinking	Continuous Learning Assessment (50% weightage)								Final Examination (50% weightage)	
		CLA – 1 (10%)		CLA – 2 (15%)		CLA – 3 (15%)		CLA – 4 (10%)#			
		Theory	Practice	Theory	Practice	Theory	Practice	Theory	Practice	Theory	Practice
Level 1	Remember Understand	*40%*	-	*30%*	-	*30%*	-	*30%*	-	*30%*	-
Level 2	Apply Analyze	*40%*	-	*40%*	-	*40%*	-	*40%*	-	*40%*	-
Level 3	Evaluate Create	*20%*	-	*30%*	-	*30%*	-	*30%*	-	*30%*	-
	Total	100 %		100 %		100 %		100 %		100 %	

CA – 4 can be from any combination of these: Assignments, Seminars, Tech Talks, Mini-Projects, Case-Studies, Self-Study, MOOCs, Certifications, Conf. Paper etc.,

Course Designers

Experts from Industry	Experts from Higher Technical Institutions	Internal Experts
1. Mr. Prakas, Associate Consultant, Virtusa, Chennai	*1.*	*1. Dr. M.S. Abirami, SRMIST*
2. Mr. S. Padmanabhan, Associate Vice President, Intellect, Chennai	2.	*2, Ms. Nagadevi SRMIST* *3. Mr. K. Navin*

Course Code	18CSE373T	Course Name	PROGRAMMING IN JAVASCRIPT	Course Category	E	Professional Elective	L	T	P	C
							3	0	0	3

Pre-requisite Courses	Nil	Co-requisite Courses	Nil	Progressive Courses	Nil
Course Offering Department	CSE	Data Book / Codes/Standards	Nil		

Course Learning Rationale (CLR):	*The purpose of learning this course is to:*
CLR-1 :	*Understand scripting language basics for web development*
CLR-2 :	*Develop familiarity with the JavaScript language – Arrays, Objects, Functions*
CLR-3 :	*Understand concepts like HTML, CSS , DOM,*
CLR-4 :	*Acquire knowledge of jQuery , DOM events etc.*
CLR-5 :	*Apply in AJAX and learn the usage of Closures*

Course Learning Outcomes (CLO):	At the end of this course, learners will be able to:	Learning 1: Level of Thinking (Bloom)	Learning 2: Expected Proficiency (%)	Learning 3: Expected Attainment (%)	PLO 1: Engineering Knowledge	PLO 2: Problem Analysis	PLO 3: Design & Development	PLO 4: Analysis, Design, Research	PLO 5: Modern Tool Usage	PLO 6: Society & Culture	PLO 7: Environment & Sustainability	PLO 8: Ethics	PLO 9: Individual & Team Work	PLO 10: Communication	PLO 11: Project Mgt. & Finance	PLO 12: Life Long Learning	PLO 13: PSO - 1	PLO 14: PSO - 2	PLO 15: PSO – 3
CLO-1 :	*Learn the basics of Scripting language*	2	80	85	H	-	-	-	-	-	-	-	-	-	-	-	-	-	-
CLO-2 :	*Ability to use Javascript in applications*	2	75	80	H	H	-	-	-	-	-	-	-	-	-	-	-	-	-
CLO-3 :	*Ability to apply HTML, CSS and DOM*	2	85	80	H	-	-	-	-	-	-	-	-	-	-	-	-	-	-
CLO-4 :	*Ability to Apply jQuery concepts in applications*	2	80	75	H	H	-	-	-	-	-	-	-	-	-	-	-	-	-
CLO-5 :	*Understand the AJAX environment and Closure concept*	2	75	85	H	-	-	H	-	-	-	-	-	-	-	-	-	-	-

Duration (hour)		9	9	9	9	
S-1	SLO-1	*Learn concept of Scripting languages*	*Arrays. Array insertion and deletion*	*HTML and CSS and*	*jQuery , Overview of jQuery*	*AJAX.*
	SLO-2	*Compiled vs interpreter a comparison*	*. Array length*	*The Document Object Model , Tags*	*Examples*	*Asynchronous Communication*
S-2	SLO-1	*Understand Web development basics*	*Sparse arrays*	*Document structure.*	*Cross-browser compatibility*	*Callback functions.*
	SLO-2	*Acquire basic knowledge on Server side programming*	*Multidimensional arrays*	*Elements. Text, forms, images,blocks and frames.*	*The $ function object*	*The get and post formats.*
S-3	SLO-1	*Understand concept of dynamic interactive web pages.*	*Objects as unordered maps. Object creation,*	*Selectors*	*Element selectors.*	*Same-origin policy.*
	SLO-2	*Overview of JavaScript , Brief history*	*modification and lookup syntax. Nested objects. Object methods.*	*Cascading and inheritence*	*Tree traversal.*	*Cross-origin requests with JSONP*
S-4	SLO-1	*Common use-cases. Runtime environments, Overview of language features.*	*The delete keyword.*	*Text and color tyles.*	*Node creation, insertion, modification and deletion.*	*AJAX polling.*
	SLO-2	*Running JavaScriptDebugging JavaScript in the browser. The console and REPL in the browser and at the command line*	*The for... in statement, and the hasOwnProperty method.*	*The box model.*	*Getting and setting attributes,*	*Context Object method invocation as method passing*

S-5	SLO-1	*Values and literals. Primitive types. Numbers. Integer and floating point as a single type Rounding errors.*	*The global window object. Object references*	*Layout.*	*styles and class.*	*The this variable as an implicit parameter variable.*
	SLO-2	*. Special floating point numbers.*	*Aliasing. Pass-by-reference-copy semantics.*	*The DOM as an document API. Browser information*	*Wrapping and unwrapping DOM raw objects.*	*Problems with methods in event handlers and callbacks*
S-6	SLO-1	*The Math library. Strings. Immutability of strings.*	*Functions :Function declaration and invocation syntax.*	*The setTimer and setTimeout*		*Usage of call and apply*
	SLO-2	*+ and [] operatorsCommon string utilities*	*Anonymous functions.*	*Element lookup*	*The chaining pattern*	*Binding context.*
S-7	SLO-1	*Booleans. Ternary operator.*	*Functions as data.*	*Tree traversal.*	*Event handling.*	*The new keyword.*
	SLO-2	*Regular expressions. Truth-y and False-y values. null and undefined.*	*The arguments object.*	*Attribute getting and setting*	*bind and unbind.*	*Closures Lexical scope. Inner functions*
S-8	SLO-1	*Dynamic typing. Weak typing. The typeof operator.*	*Variadic functions. Optional parameters.*	*Creating and deleting nodes.*	*Keyboard and mouse events.*	*Closure scope. Examining closure scope in the debugger*
	SLO-2	*The === and !== operators.*	*Named parameters. Function overloading.*	*Events.*	*Event delegation and bubbling.*	*Functors.*
S-9	SLO-1	*Control statements.*	*Duck typing.*	*Case studies*	*Animation.*	*Simulation of private object properties.*
	SLO-2	*Examples*	*Examples*	*Case Studies*	*Examples*	*Simulation of namespaces.*

Learning Resources	***1.*** *Don Gosselin , JavaScript Fifth Edition, Thomson Learning., Web Technology Series* ***2.*** *Nicholas C Zakas, Professional JavaScript for Web Developers , Wrox Professional Guide, 2012*	***3.*** *Laura Lemay, Rafe Colburn, Jennifer Kyrnin, "Mastering HTML, CSS & Javascript", Web Publishing, 2016*

Learning Assessment

	Bloom's Level of Thinking	Continuous Learning Assessment (50% weightage)								Final Examination (50% weightage)	
		CLA – 1 (10%)		CLA – 2 (15%)		CLA – 3 (15%)		CLA – 4 (10%)#			
		Theory	Practice	Theory	Practice	Theory	Practice	Theory	Practice	Theory	Practice
Level 1	Remember Understand	*40%*	-	*30%*	-	*30%*	-	*30%*	-	*30%*	-
Level 2	Apply Analyze	*40%*	-	*40%*	-	*40%*	-	*40%*	-	*40%*	-
Level 3	Evaluate Create	*20%*	-	*30%*	-	*30%*	-	*30%*	-	*30%*	-
	Total	100 %		100 %		100 %		100 %		100 %	

CA – 4 can be from any combination of these: Assignments, Seminars, Tech Talks, Mini-Projects, Case-Studies, Self-Study, MOOCs, Certifications, Conf. Paper etc.,

Course Designers		
Experts from Industry	Experts from Higher Technical Institutions	Internal Experts
	1.	*1. Prof.S.S.Sridhar, SRMIST*

Course Code	18CSE374T	Course Name	SOFTWARE ENGINEERING TOOLS	Course Category	E	Professional Elective	L	T	P	C
							3	0	0	3

Pre-requisite Courses	Nil	Co-requisite Courses	Nil	Progressive Courses	Nil
Course Offering Department	CSE	Data Book / Codes/Standards	Nil		

Course Learning Rationale (CLR):	*The purpose of learning this course is to:*
CLR-1 :	*Understand the software engineering process and the tools used to support this process to deliver the quality software product*
CLR-2 :	*Know the process, tools and methods used for software requirements modeling and the designing process*
CLR-3 :	*Study the various software development approaches, tools and to install and use some software development tools*
CLR-4 :	*Know about different web application development technologies and tools used to support the quick development process*
CLR-5 :	*Understand the software testing process used in the industry and various test related tools used for the different task in the testing*
CLR-6 :	*Study the functionalities of different testing tools used in the software maintenance and engineering process*

		Learning			Program Learning Outcomes (PLO)														
		1	2	3	1	2	3	4	5	6	7	8	9	10	11	12	13	14	15
Course Learning Outcomes (CLO):	*At the end of this course, learners will be able to:*	Level of Thinking (Bloom)	Expected Proficiency (%)	Expected Attainment (%)	Engineering Knowledge	Problem Analysis	Design & Development	Analysis, Design, Research	Modern Tool Usage	Society & Culture	Environment & Sustainability	Ethics	Individual & Team Work	Communication	Project Mgt. & Finance	Life Long Learning	PSO - 1	PSO - 2	PSO – 3
CLO-1 :	*Use automated tools to develop the quality software product in by following engineering process*	2	80	85	H	-	-	-	-	-	-	-	-	-	-	-	-	-	-
CLO-2 :	*Design the specification of software using various techniques and tools*	2	75	80	H	H	-	-	-	-	-	-	-	-	-	-	-	-	-
CLO-3 :	*Create application using latest tools, code generators and IDEs*	2	85	80	H	-	-	-	-	-	-	-	-	-	-	-	-	-	-
CLO-4 :	*Apply the various web technologies and tools to develop the web application*	2	80	75	H	H	-	-	-	-	-	-	-	-	-	-	-	-	-
CLO-5 :	*Know the various testing tools and apply it during the software testing process*	2	75	85	H	-	-	H	-	-	-	-	-	-	-	-	-	-	-
CLO-6 :	*Use the tools for process management and to gain the knowledge of various tools used for different task in maintenance activities*	2	80	85	H	-	-	-	-	-	-	-	-	-	-	-	-	-	-

Duration (hour)		9	9	9	9	9
S-1	SLO-1	*Introduction to Software Engineering Process*	*Software Construction Tools*	*Web Application Development Tools*	*Software Testing Process*	*Software Engineering Process Tools*
	SLO-2	*Need of Tools in the Software Engineering Process*	*Program editors*	*Tools for Front End Developers*	*Software Testing Tools*	*Process modeling tools*
S-2	SLO-1	*Requirement Engineering Process*	*Compilers*	*TypeScript*	*Need for Automated Testing Tools*	*Process management tools*
	SLO-2	*Software Requirements Tools*	*Compiler types*	*Installing TypeScript*	*Taxonomy of Testing Tools*	*Integrated CASE environments*
S-3	SLO-1	*Requirements modeling tools*	*code generators*	*AngularJS*	*Functional/Regression Testing Tools*	*Process-centered software engineering environments*
	SLO-2	*Traceability tools*	*Tools for JAVA code generator*	*AngularJS Architecture and Features*	*Performance Testing Tools*	*Software Configuration Management Tools*
S-4	SLO-1	*Desirable Features of Requirement Management Tools*	*Comparison of code generation tools*	*Tools for Back End Developers*	*Testing Management Tools*	*Defect, enhancement, issue and problem tracking tools*
	SLO-2	*Some Requirement Management Tools Available*	*Interpreters*	*PHP*	*Source Code Testing Tools*	*Version management tools*
S-5	SLO-1	*Tools Description*	*Difference between Compiler and Interpreters*	*Ruby on Rails*	*How to Select a Testing Tool?*	*Software Engineering Management Tools*
	SLO-2	*Software Design Process*	*Debuggers*	*Laravel*	*Test execution frameworks*	*Project planning and tracking tools*
S-6	SLO-1	*Steps in Software Design*	*Integrated Development Environment*	*Overview of Content Management System (CMS)*	*Re-engineering tools*	*Risk management tools*
	SLO-2	*Software Modeling Languages*	*Comparison of IDE*	*WordPress*	*WinRunner*	*Infrastructure Support Tools*
S-7	SLO-1	*Unified Modeling Language*	*ATOM Tool*	*WordPress - Features*	*Overview of WinRunner*	*Interpersonal Communication tools*
	SLO-2	*Behavior Trees*	*Features of ATOM Tool*	*WordPress – Installation*	*LoadRunne - Overview*	*Information retrieval tools*

S-8	SLO-1	*C-K theory*	*Installing Atom*	*Joomla - Overview*	*QTP - Overview*	*System administration and support tools*
	SLO-2	*IDEF, Object-Role Modeling*	*NetBeans*	*Joomla – Features*	*Junit - Overview*	*Miscellaneous Tool Issues*
S-9	SLO-1	*Petri nets*	*Features of NetBeans*	*Joomla – Installation*	*Testing Java Code using Junit*	*Tool integration techniques*
	SLO-2	*Software Design Tools*	*Cloud Based Development tools*	*Drupal – Overview and Architecture*	*Examples*	*Tool evaluation*

Learning Resources	1. *RogerSPressman,"SoftwareEngineering–APractitioner'sApproach",7thedition,TataMcGrawHill Education,2014.* 2. *IanSomerville"SoftwareEngineering",9thedition,PearsonEducation,2010.* 3. *https://atom.io/*	4. *SwapnaKishoreandRajeshNaik,"SoftwareRequirementsandEstimation",TataMcGrawHill,2003* 5. *K.V.K.K.Prasad,"SoftwareTestingTools",DreamtechPress,2010* 6. *https://www.w3schools.com* 7. *https://www.joomla.org/*

Learning Assessment

	Bloom's Level of Thinking	Continuous Learning Assessment (50% weightage)								Final Examination (50% weightage)	
		CLA – 1 (10%)		CLA – 2 (15%)		CLA – 3 (15%)		CLA – 4 (10%)#			
		Theory	Practice	Theory	Practice	Theory	Practice	Theory	Practice	Theory	Practice
Level 1	Remember Understand	*40%*	-	*30%*	-	*30%*	-	*30%*	-	*30%*	-
Level 2	Apply Analyze	*40%*	-	*40%*	-	*40%*	-	*40%*	-	*40%*	-
Level 3	Evaluate Create	*20%*	-	*30%*	-	*30%*	-	*30%*	-	*30%*	-
	Total	100 %		100 %		100 %		100 %		100 %	

CA – 4 can be from any combination of these: Assignments, Seminars, Tech Talks, Mini-Projects, Case-Studies, Self-Study, MOOCs, Certifications, Conf. Paper etc.,

Course Designers		
Experts from Industry	Experts from Higher Technical Institutions	Internal Experts
1. R.Tamilanban, Senior Software Engineer, Altimetrik India Pvt. Ltd.	*1.*	*1. S.KALIRAJ, SRMIST*
2.	*2.*	*2. R.ANITA, SRMIST*

Course Code	18CSE466T	Course Name	SOFTWARE VERIFICATION AND VALIDATION	Course Category	E	Professional Elective	L	T	P	C
							3	0	0	3

Pre-requisite Courses	Nil	Co-requisite Courses	Nil	Progressive Courses	Nil
Course Offering Department	COMPUTER SCIENCE AND ENGINEERING	Data Book / Codes/Standards	Nil		

Course Learning Rationale (CLR):	*The purpose of learning this course is to:*
CLR-1 :	*Provide an understanding of concepts and techniques for testing software*
CLR-2 :	*Prepare test plan based on the requirement document ,design test plans and document test plans*
CLR-3 :	*Design test cases suitable for a software development in various domains*
CLR-4 :	*Validate and document test cases, assuring software component or system satisfies its requirements and meets stakeholder expectations*
CLR-5 :	*Use of automation testing tools*

Course Learning Outcomes (CLO):	*At the end of this course, learners will be able to:*	Learning 1: Level of Thinking (Bloom)	2: Expected Proficiency (%)	3: Expected Attainment (%)
CLO-1 :	*Identify, design different types of test cases for software development in any domain*	*2*	*80*	*85*
CLO-2 :	*Design, develop, implement, validate and document test plans at various levels*	*3*	*80*	*80*
CLO-3 :	*Develop Test cases for a given Software/System Specification*	*2*	*90*	*85*
CLO-4 :	*Validate Test Cases with the Requirement Specifications*	*2*	*80*	*80*
CLO-5 :	*Use various automation tools to implement test cases*	*3*	*75*	*80*

Program Learning Outcomes (PLO)

	1 Engineering Knowledge	2 Problem Analysis	3 Design & Development	4 Analysis, Design, Research	5 Modern Tool Usage	6 Society & Culture	7 Environment & Sustainability	8 Ethics	9 Individual & Team Work	10 Communication	11 Project Mgt. & Finance	12 Life Long Learning	13 PSO - 1	14 PSO - 2	15 PSO – 3
CLO-1	H	H	H	H	H	M	M	H	H	H	M	H	H	H	H
CLO-2	H	H	H	H	M	M	M	H	H	H	M	H	H	H	H
CLO-3	H	H	H	H	M	-	M	H	H	M	M	H	H	H	H
CLO-4	H	H	H	M	M	-	M	H	H	H	M	H	H	H	H
CLO-5	H	M	H	H	H	M	M	H	H	M	H	H	H	H	H

Duration (hour)		8	10	8	9	10
S-1	SLO-1	*Fundamentals of Testing: Necessity of Testing-Case Studies on "Impact of Software bugs"*	*Test Case Design Strategies: Introduction to basic design strategies*	*The need for levels of testing, Unit Testing: Planning, Test Harness*	*Test Management: Choice of Standards*	*Software Test Automation: Skills and Scope Design*
	SLO-2	*Objectives of Testing, Basics Definitions*		*Running the tests Recording Results*	*Infrastructure Management, Test People Management*	
S-2	SLO-1	*Testing Principles-Illustrations*	*White Box Strategies - Peer Reviews, Inspections, Walkthrough*	*Integration Testing: Goals, Design and Plan*	*Test Plan Components*	*Architecture for Automation*
	SLO-2		*Comparative Analysis*		*Test Plan Attachments*	
S-3	SLO-1	*Fundamental Test Process, The tester's role in a software development organization*	*Static Analysis Tools: Coding Standards, Code Metrics, Code Structure*	*System Testing goals, Types of System Testing: Functional Testing*	*Locating Test Items, Managing Issues*	*Requirements for a test tool, Process Model for Automation, Selecting the test tool*
	SLO-2	*Test planning*	*Activity: Static Analysis of a source code*	*Performance Testing, Stress Testing*	*Addressing Perception, Taking team together*	
S-4	SLO-1	*Establishing Test Policy, Structured approach to testing Test Factors*	*Coverage and Control Flow Graphs*	*Configuration Testing*	*Documentation uses*	*Demonstration of a Functional Testing Tool*
	SLO-2	*Eleven Step software testing process*	*Activity: Calculate Complexity for a given source code*	*Security Testing*	*Documentation Types*	
S-5	SLO-1	*Origin of Defects, Defect Repository and Test Design*	*Paths Code Complexity*	*Recovery Testing, Reliability Testing*	*Test Analysis report Documentation,*	*Demonstration of a Web Testing Tool*
	SLO-2	*Developer/Tester support of developing a defect repository*	*Activity: Calculate Path Code Complexity for a given source code*	*Usability Testing*	*Analyze reports and Problem tracking,*	
S-6	SLO-1	*Defect Examples, Case Studies – "Identify the defect"*	*Evaluating test adequacy criteria, Case Studies-"Applying the suitable White Box Strategy"*	*Regression Testing*	*Controlling and Monitoring Test Progress*	*Démonstration of an Unit Testing Tool*
	SLO-2			*Alpha, Beta and Acceptance Testing*	*Test Metrics and measurements: Role, need and types*	

S-7	SLO-1	Defect Analysis and Prevention Strategies	Black Box Testing Strategies: Requirements Based Testing, Random Testing	Role of use cases in testing	Project Metrics with Practice	Demonstration of an Defect Tracking Tool
	SLO-2			Applying Testing Skills: Compatibility testing, Internationalization testing		
S-8	SLO-1	Developing adhoc test cases for a case study	Black Box Testing Strategies: Boundary Value Analysis, Equivalence Class Partitioning,	Testing Documentation plan	Progress Metrics with Practice	Demonstration of an Test Management Tool
	SLO-2		Activity: Designing test cases for the given requirement specification using Boundary value analysis and Equivalence Class Partitioning	Recording test cases, Reporting and Measurement of Success		
S-9	SLO-1		Black Box Testing Strategies: Cause Effect graphing		Productivity Metrics with Practice	Challenges in Automation
	SLO-2		Activity: Designing test cases for the given requirement specification using cause effect graphing and developing decision tables			
S-10	SLO1 SLO2		Evaluating test adequacy criteria, Case Studies-"Applying the suitable Black Box Strategy"			The Future: Software Quality Assurance

Learning Resources	1. *Srinivasan Desikan and Gopalaswamy Ramesh, "Software Testing – Principles and Practices", Pearson Education, 2006* 2. *Ron Patton, "Software Testing", Second Edition, Sams Publishing, Pearson Education, 2007.*	3. *Ilene Burnstein, "Practical Software Testing", Springer International Edition, 2003.* 4. *Aditya P. Mathur, "Foundations of Software Testing _ Fundamental Algorithms and Techniques", Dorling Kindersley (India) Pvt. Ltd., Pearson Education, 2008* 5. *RenuRajani, Pradeep Oak, "Software Testing-Effective Methods, Tools and Techniques", Tata McGraw Hill Education, 2011.*

Learning Assessment

	Bloom's Level of Thinking	Continuous Learning Assessment (50% weightage)								Final Examination (50% weightage)	
		CLA – 1 (10%)		CLA – 2 (15%)		CLA – 3 (15%)		CLA – 4 (10%)#			
		Theory	Practice	Theory	Practice	Theory	Practice	Theory	Practice	Theory	Practice
Level 1	Remember Understand	40 %	-	30 %	-	30 %	-	30 %	-	30%	-
Level 2	Apply Analyze	40 %	-	40 %	-	40 %	-	40 %	-	40%	-
Level 3	Evaluate Create	20 %	-	30 %	-	30 %	-	30 %	-	30%	-
	Total	100 %		100 %		100 %		100 %		100 %	

CLA – 4 can be from any combination of these: Assignments, Seminars, Tech Talks, Mini-Projects, Case-Studies, Self-Study, MOOCs, Certifications, Conf. Paper etc.,

Course Designers

Experts from Industry	Experts from Higher Technical Institutions	Internal Experts
1. Mr. ShrikantSatyanarayan, Technical Manager LDRA Technology PVT LTD	1. Dr. N. Bhalaji, Associate Professor, SSN Institutions	1. Mrs. Anupama.C.G, SRMIST
2. Mr. Girish Raghavan, Senior DMTS Manager, Wipro Technologies		2. Mr. Selvin Paul Peter, SRMIST

Course Code	18CSE467T	Course Name	SOFTWARE QUALITY ASSURANCE	Course Category	E	Professional Elective	L	T	P	C
							3	0	0	3

Pre-requisite Courses	Nil	Co-requisite Courses	Nil	Progressive Courses	Nil
Course Offering Department	CSE	Data Book / Codes/Standards	Nil		

Course Learning Rationale (CLR):	*The purpose of learning this course is to:*
CLR-1 :	*Understand the importance of software quality*
CLR-2 :	*Gain knowledge about the components of software quality assurance system*
CLR-3 :	*Gain knowledge on conducting reviews walk through and inspection*
CLR-4 :	*Understand the importance of SCM, procedures, policies in SQA*
CLR-5 :	*Recognize the significance of human components*
CLR-6 :	*Gain Knowledge on measurements and standards*

Course Learning Outcomes (CLO):	*At the end of this course, learners will be able to:*	Learning 1: Level of Thinking (Bloom)	Learning 2: Expected Proficiency (%)	Learning 3: Expected Attainment (%)	PLO 1: Engineering Knowledge	PLO 2: Problem Analysis	PLO 3: Design & Development	PLO 4: Analysis, Design, Research	PLO 5: Modern Tool Usage	PLO 6: Society & Culture	PLO 7: Environment & Sustainability	PLO 8: Ethics	PLO 9: Individual & Team Work	PLO 10: Communication	PLO 11: Project Mgt. & Finance	PLO 12: Life Long Learning	PLO 13: PSO - 1	PLO 14: PSO - 2	PLO 15: PSO – 3
CLO-1 :	*Acquire the knowledge on software quality*	*2*	*80*	*85*		-	-	-	-	-	-		-	-	*M*	-	*H*	-	-
CLO-2 :	*Acquire the ability to identify the dimension of a software project*	*2*	*75*	*80*	*H*	*H*	-	-	-	-	-	-	-	-	-	-	-	-	-
CLO-3 :	*Apply different quality component in different phase of life cycle*	*2*	*85*	*80*	*H*	*H*	-	-	-	-	-	-	-	-	-	-	-	*H*	*H*
CLO-4 :	*Follow procedures, processes, policies and work instructions in software development*	*2*	*80*	*75*		-	-	-	-	-	*M*	*H*	-	-	-	-	-	-	-
CLO-5 :	*Manage risks and handle human components effectively*	*2*	*75*	*85*	*H*	-	-	*H*	-	*M*	-	-	-	*H*	-	-	-	-	-
CLO-6 :	*Apply different measurements and follow standards*	*2*	*80*	*85*		-	*H*	-	*H*	-	-	-	*H*	-	-	*H*	-	-	-

Duration (hour)		9	9	9	9	9
S-1	SLO-1	*Introduction to software Quality*	*Software Quality Assurance System Architecture*	*Check lists*	*Introduction to Risk management*	*Importance of Measurement*
	SLO-2	*Defining software quality and software quality Assurance*	*Components of Software Quality Assurance System*	*Verification and validation*	*Risk management according to the standards and models*	*Measurement according to ISO 9001*
S-2	SLO-1	*Software error, defects and failures*	*Contract Review process and its stages Contract Review objectives*	*Verification and validation*	*Risk management according to the standards and models*	*The practical software and systems measurement method*
	SLO-2	*Software error, defects and failures*	*Implementation of Contract Review, Contract review for internal projects*	*Basics of Software Configuration Management , Benefits of Good configuration Management*	*Risk management according to the standards and models*	*The practical software and systems measurement method*
S-3	SLO-1	*Cost of quality*	*Development plan*	*Activity: Test the functionalities of the given project using any functional testing toot*	*Roles, Measurements*	*Measurement According to the CMMI Model*
	SLO-2	*Cost of quality*	*Quality Plan*	*Activity: Test the functionalities of the given project using any functional testing toot*	*Human factors and risk management*	*Measurement According to the CMMI Model*
S-4	SLO-1	*Quality culture*	*Reviews,Personal review and desk check review*	*SCM Activities, Baselines*	*Introduction to supplier management, Supplier requirements*	*Survey as a measurement tool*

	SLO-2	*Five dimensions of a software project*	*Walk through*	*Software Repository and its branches, Configuration Control*	*Agreement Processes, Supplier agreement management according to the CMMI*	*Survey as a measurement tool*
S-5	SLO-1	*Software Engineering code of Ethics*	*Review standards and Models*	*Configuration Status Accounting*	*Managing suppliers*	*Implementing a measurement program*
	SLO-2	*Software Engineering code of Ethics*	*Review standards and Models*	*Software Configuration Audit, Implementing SCM in very small entities with ISO/IEC29110*	*Software Acquisition life cycle*	*Standards, cost of quality and business models*
S-6	SLO-1	*Software quality models- McCall*	*Inspection*	*Policies*	*Software Contract Types*	*ISO 9000 family*
	SLO-2	*Software quality models- McCall*	*Project Launch reviews and project assessments*	*Process*	*Software Contract Reviews*	*IEEE 730 standard for SQA processes*
S-7	SLO-1	*Software quality models -IEEE 1061*	*Agile Meetings*	*Procedures and work instructions*	*Case Study: Prepare Contract Review Document for a project*	*IEEE 730 standard for SQA processes*
	SLO-2	*Software quality models -EEE 1061*	*Measures*	*Organizational standards*	*Case Study: Prepare Contract Review Document for a project*	*Process Maturity models of the SEI*
S-8	SLO-1	*Software quality models -ISO-25000 set of standards*	*Selecting the type of review,Tools*	*Graphical representation of process and procedures*	*Staff Training and Certification*	*Software Quality Assurance Plan*
	SLO-2	*Software quality models -ISO-25000 set of standards*	*Audits, Types, Audits according to the IEEE 1028 standard*	*Graphical representation of process and procedures*	*Staff Training and Certifications*	*Software Quality Assurance Plan*
S-9	SLO-1	*Case Study: Analyzing quality factors involved in a project*	*Case Study: Prepare a development plan for a project.*	*Preventive and corrective actions*	*Management and its Role in Quality Assurance*	*Case study: Prepare a Software Quality Assurance Plan for –interested project*
	SLO-2	*Case Study: Analyzing quality factors involved in a project.*	*Case Study: Prepare a development plan for a project*	*Document control*	*Management and its Role in Quality Assurance*	*Case study: Prepare a Software Quality Assurance Plan for –interested project*

Learning Resources	1. Claude Y.Laporte, Alain April, Software quality Assurance, First edition , IEEE computer Society and Wiley,2018. 2. DanielGalin,"SoftwareQualityAssurancefromtheorytoimplementation",Pearson,2016	3. G.GordonSchulmeyer, "Hand book of Software Quality Assurance", 4th edition, ARTECH HOUSE INC,2008 4. Allen Gilles, "Software quality: Theory and management" - International Thomson - Computer press, 2011

Learning Assessment

	Bloom's Level of Thinking	Continuous Learning Assessment (50% weightage)								Final Examination (50% weightage)	
		CLA – 1 (10%)		CLA – 2 (15%)		CLA – 3 (15%)		CLA – 4 (10%)#			
		Theory	Practice	Theory	Practice	Theory	Practice	Theory	Practice	Theory	Practice
Level 1	Remember Understand	40 %	-	30 %	-	30 %	-	30 %	-	30%	-
Level 2	Apply Analyze	40 %	-	40 %	-	40 %	-	40 %	-	40%	-
Level 3	Evaluate Create	20 %	-	30 %	-	30 %	-	30 %	-	30%	-
	Total	100 %		100 %		100 %		100 %		100 %	

CLA – 4 can be from any combination of these: Assignments, Seminars, Tech Talks, Mini-Projects, Case-Studies, Self-Study, MOOCs, Certifications, Conf. Paper etc.,

Course Designers

Experts from Industry	Experts from Higher Technical Institutions	Internal Experts
1.Mr. Benet Zacharias, Senior Consultant, Wipro Consulting Services, Chennai	*1. Dr. A. Amuthan, Professor, Dept. of CSE, Pondicherry Engg. College, Pondicherry.*	*1. Dr. T.S.Shiny Angel, Assistant Professor, SRMIST*
		2. Dr. A. Jeyasekar, Associate Professor, SRMIST

Course Code	18CSE468T	Course Name	SOFTWARE MEASUREMENTS AND METRICS	Course Category	E	Professional Elective	L	T	P	C
							3	0	0	3

Pre-requisite Courses	18CSE466T	Co-requisite Courses	Nil	Progressive Courses	NIL
Course Offering Department	Computer Science and Engineering	Data Book / Codes/Standards	Nil		

Course Learning Rationale (CLR):	*The purpose of learning this course is to:*
CLR-1 :	*Familiarize with different metrics used in different process levels*
CLR-2 :	*Apply metrics knowledge to measure Engineering problems.*
CLR-3 :	*Improve their ability in making decisions via continuous practice like assessment and usage of metrics.*
CLR-4 :	*Design, implement and change metrics based on industry practice*

Course Learning Outcomes (CLO):	*At the end of this course, learners will be able to:*	Learning 1: Level of Thinking (Bloom)	2: Expected Proficiency (%)	3: Expected Attainment (%)
CLO-1 :	*Understand and measure the software features*	*3*		
CLO-2 :	*Understand the need of software quality*	*3*		
CLO-3 :	*Will be able to understand the software development tools*	*3*		
CLO-4 :	*Evalaute the stages of process improvement and its necessities in Development Life Cycle*	*3*		

Program Learning Outcomes (PLO)

	1 Engineering Knowledge	2 Problem Analysis	3 Design & Development	4 Analysis, Design, Research	5 Modern Tool Usage	6 Society & Culture	7 Environment & Sustainability	8 Ethics	9 Individual & Team Work	10 Communication	11 Project Mgt. & Finance	12 Life Long Learning	13 PSO - 1	14 PSO - 2	15 PSO – 3
CLO-1	L	H	-	H	L	-	-	-	L	L	-	H	-	-	-
CLO-2	M	M	L	M	L	-	-	-	M	L	-	H	-	-	-
CLO-3	M	M	M	H	L	-	-	-	M	L	-	H	-	-	-
CLO-4	M	H	M	H	L	-	-	M	M	L	-	H	-	-	-

Duration (hour)		9	9	9	9	9
S-1	SLO-1	*Software Sizing Metrics*	*Complexity Metrics and Models*	*Customer Satisfaction Surveys: Methods of survey data collection*	*Software Quality - Five steps to software quality control*	*Conducting In-Process Quality Assessments*
	SLO-2	*Fundamentals in Measurement*		*Sampling Methods*	*Product Quality Metrics with practice*	*The Preparation Phase*
S-2	SLO-1	*Basic Measures*	*Lines of Code*	*Analyzig Satisfaction with practise*	*In-Process Quality Metrics*	*The Evaluation Phase*
	SLO-2	*Reliability and Validity*	*Halstead's Software Science*			*The Summarization Phase*
S-3	SLO-1	*Measurement Errors*	*Cyclomatic Complexity*	*Satisfaction with Company terms*	*Metrics for Software Maintenance*	*Recommendations and Risk Mitigation*
	SLO-2	*Assessing Reliability*	*Syntactic Constructs*			*Conducting Software Project Assessments*
S-4	SLO-1	*Evolution in software Metrics*	*Structure Metrics*	*Metrics for Object-Oriented Projects with tools*	*Ishikawa's Seven Basic Tools with practice*	*Audit and Assessment*
	SLO-2					*Software Process Maturity Assessment and Software Project Assessment*
S-5	SLO-1	*Functional Size Measurements*	*Case Study for the usage of complexity metrics with tools*	*Concepts and Constructs*	*Defect removal Effectiveness*	*Software Process Assessment Cycle*
	SLO-2			*Design and Complexity Metrics*		*Measures and metrics of industry leaders*
S-6	SLO-1	*Cost of counting function point metrics*	*Testing Metrics :Test Progress S Curve*	*Lorenz Metrics and Rules of Thumb*	*The Rayleigh Model*	*Measures and metrics of industry leaders*
	SLO-2					
S-7	SLO-1	*Software measures and metrics not based on function points*	*Testing Defect Arrivals Over Time*	*CK OO Metrics Suite*	*Reliability Growth Models - Jelinski-Moranda Model*	*Measures,Metrics,Innovation*
	SLO-2		*Product Size Over Time*			*Measurements,Metrics and outsource Litigation*
S-8	SLO-1	*Future Technical Developments in Functional Metrics*	*CPU Utilization*	*Productivity Metrics*	*Goel-Okumoto Model*	*Measurements,Metrics and outsource and Behavioral changes*
	SLO-2		*Effort/Outcome Model*			*Software Process Improvement Sequences*
S-9	SLO-1	*Case Study to Measure software size using various size Metrics*	*Case Study to apply Testing metrics*	*Case Study for the usage of Object oriented metrics with tools*	*Musa-Okumoto Model*	*Measuring Process Maturity*
	SLO-2					*Measuring Proess Capability*

Learning Resources	1. *Stephen H. Kan, "Metrics and Models in Software Quality Engineering", Addison Wesley,Second Edition,2017.* 2. *CaperJones,"AppliedSoftwareMeasurement:GlobalAnalysisofProductivityandQuality",Third Edition, McGraw Hill Companies,2008*	3. *MarkLorenz,JeffKidd,"Object-OrientedSoftwareMetrics",PrenticeHall,2000* 4. *NareshChauhan,"SoftwareTestingPrinciplesandPractices",OxfordUniversityPress,2010.* 5. *RavindranathPandianC,"SoftwareMetricsAGuidetoplanning,Analysis,andApplication",Auerbach,First Indian Reprint,2011*

Learning Assessment

	Bloom's Level of Thinking	Continuous Learning Assessment (50% weightage)								Final Examination (50% weightage)	
		CLA – 1 (10%)		CLA – 2 (15%)		CLA – 3 (15%)		CLA – 4 (10%)#			
		Theory	Practice	Theory	Practice	Theory	Practice	Theory	Practice	Theory	Practice
Level 1	Remember Understand	40 %	-	30 %	-	30 %	-	30 %	-	30%	-
Level 2	Apply Analyze	40 %	-	40 %	-	40 %	-	40 %	-	40%	-
Level 3	Evaluate Create	20 %	-	30 %	-	30 %	-	30 %	-	30%	-
	Total	100 %		100 %		100 %		100 %		100 %	

CLA – 4 can be from any combination of these: Assignments, Seminars, Tech Talks, Mini-Projects, Case-Studies, Self-Study, MOOCs, Certifications, Conf. Paper etc.,

Course Designers

Experts from Industry	Experts from Higher Technical Institutions	Internal Experts
1. Bijoymon Soman Sr. Test Analyst UST Global,Philadelphia,PA, USA	*1.Dr.Arun kumar M N, FISAT, Kerala, amrakmar.mn11@gmail.com*	*1. Mrs.B.Jothi, SRMIST*
		2.Ms Aswathy, SRMIST

Course Code	18CSE469T	Course Name	SOFTWARE PROCESS AND AGILE PRACTICES	Course Category	E	Professional Elective	L	T	P	C
							3	0	0	3

Pre-requisite Courses	Nil	Co-requisite Courses	Nil	Progressive Courses	Nil
Course Offering Department	Computer Science and Engineering	Data Book / Codes/Standards	Nil		

Course Learning Rationale (CLR):	*The purpose of learning this course is to:*
CLR-1 :	*Understand the basic concepts of Software process and Agile manifesto*
CLR-2 :	*Comprehend various Agile principles*
CLR-3 :	*Gain knowledge on Agile Methodologies*
CLR-4 :	*Acquire Knowledge on Agile project management and Environment*
CLR-5 :	*Understand the concepts of Test driven development and Feature driven development*
CLR-6 :	*Understand the Agile approach to Quality assurance*

Course Learning Outcomes (CLO):	*At the end of this course, learners will be able to:*	Learning 1: Level of Thinking (Bloom)	2: Expected Proficiency (%)	3: Expected Attainment (%)	PLO 1: Engineering Knowledge	2: Problem Analysis	3: Design & Development	4: Analysis, Design, Research	5: Modern Tool Usage	6: Society & Culture	7: Environment & Sustainability	8: Ethics	9: Individual & Team Work	10: Communication	11: Project Mgt. & Finance	12: Life Long Learning	13: PSO - 1	14: PSO - 2	15: PSO – 3
CLO-1 :	*Acquire the knowledge of best practices involved in Software process*	2	80	85	H	-	-	-	-	-	-	-	-	-	-	-	-	-	-
CLO-2 :	*Acquire the ability to identify the agile principles for software development*	2	75	80	H	H	-	-	-	-	-	-	-	-	-	-	-	-	-
CLO-3 :	*Understand work products, roles and practices of Scrum, XP, UP and EVO*	2	85	80	H	-	-	-	-	-	-	-	-	-	-	-	-	-	-
CLO-4 :	*Apply the knowledge of Agile methodologies in various projects*	2	80	75	H	H	-	-	-	-	-	-	-	-	-	-	-	-	-
CLO-5 :	*Apply the knowledge of Agile project management and practices*	2	75	85	H	-	-	H	-	-	-	-	-	-	-	-	-	-	-
CLO-6 :	*Acquire the knowledge of Agile quality assurance*	2	80	85	H	-	-	-	-	-	-	-	-	-	-	-	-	-	-

Duration (hour)		9	9	9	9	9
S-1	SLO-1	*The nature of Software*	*Agile And Its Significance*	*Agile methodology*	*Agile Project management*	*Agile Quality assurance*
	SLO-2	*Defining Software*	*Agile Story*	*Extreme Programming: Method Overview*	*Multi-team and multi-site development*	*Feature Driven Development*
S-2	SLO-1	*The Software Process*	*Evolutionary delivery, Scrum Demo*	*Life cycle phases*	*Pipelining activities across Iterations*	*Feature Driven Development roles*
	SLO-2	*Software Engineering practice*	*Planning game, Sprint back log, adaptive planning and retrospective*	*Work products*	*Rolling Wave adaptive and predictive planning*	*Feature Driven Development process*
S-3	SLO-1	*Agile Development*	*Agile Motivation*	*Roles and practices*	*Benefits of rolling wave adaptive planning*	*Class Ownership*
	SLO-2	*Agility and the cost of change*	*Challenges With The Waterfall*	*Core practices*	*Agile requirements*	*Reporting*
S-4	SLO-1	*Agile Process*	*Research Evidence*	*Process mixtures*	*Agile modeling*	*Test Driven Development (TDD)*
	SLO-2	*Agile Manifesto & Principles*	*Scrum: Method Overview*	*Strengths of XP*	*Defining and keeping the vision*	*Test Driven Development roles*
S-5	SLO-1	*Software is new product development*	*Life cycle phases*	*Unified process: Method Overview*	*Evolutionary Requirements workshop*	*TDD benefits*
	SLO-2	*Predictable vs. Inventive Projects*	*Work products*	*Work products*	*Gathering requirements*	*TDD Limitations*
S-6	SLO-1	*Iterative and Evolutionary methods*	*Roles and practices*	*Roles and practices*	*Tracking requirement across iterations, Direct user involvement*	*Agile approach to Quality Assurance*
	SLO-2	*Risk driven and client driven planning*	*Core practices*	*Core practices*	*Brainstorming and Brain writing*	*Unscheduled and Scheduled*
S-7	SLO-1	*Time boxed Iterative development*	*Values of Scrum meeting*	*EVO: Method Overview*	*Mind maps, Team rotation writing*	*Status meeting*
	SLO-2	*Evolutionary and Adaptive development*	*Other practices and values*	*Life cycle phases*	*Agile environment*	*Automated unit tests and Acceptance tests*
S-8	SLO-1	*Adaptive Development*	*Common mistakes and*	*Work products*	*Continuous Integration*	*Exploratory Testing*
	SLO-2	*Incremental Delivery, Evolutionary delivery*	*Sample projects*	*Roles and practices*	*Project Wiki webs, Case tools*	*Code review and code metrics*
S-9	SLO-1	*Specific Iterative methods*	*Process mixtures*	*Core practices*	*Caves and common rooms*	*Continuous Integration*
	SLO-2	*Evolutionary methods*	*Strengths and Weakness of Scrum*	*Process mixtures*	*Reverse engineering*	*Informative Workspaces*

Learning Resources	1. *Bruce R. Maxim Roger S. Pressman, "Software Engineering: A Practitioner's Approach", McGraw Hill Education; Eighth edition,2019* 2. *CraigLarman,"AgileandIterativeDevelopment–AManager'sGuide",PearsonEducation–2010*	3. *ElisabethHendricksonQualityTreeSoftwareInc,"AgileTesting"2008* 4. *Chetankumar Patel, Muthu Ramachandran, Story Card Maturity Model (SMM): A Process ImprovementFrameworkforAgileRequirementsEngineeringPractices,JournalofSoftware, Academy Publishers, Vol 4, No 5 (2009), 422-435, Jul2009.*

Learning Assessment

	Bloom's Level of Thinking	Continuous Learning Assessment (50% weightage)								Final Examination (50% weightage)	
		CLA – 1 (10%)		CLA – 2 (15%)		CLA – 3 (15%)		CLA – 4 (10%)#			
		Theory	Practice	Theory	Practice	Theory	Practice	Theory	Practice	Theory	Practice
Level 1	Remember Understand	40 %	-	30 %	-	30 %	-	30 %	-	30%	-
Level 2	Apply Analyze	40 %	-	40 %	-	40 %	-	40 %	-	40%	-
Level 3	Evaluate Create	20 %	-	30 %	-	30 %	-	30 %	-	30%	-
	Total	100 %		100 %		100 %		100 %		100 %	

CLA – 4 can be from any combination of these: Assignments, Seminars, Tech Talks, Mini-Projects, Case-Studies, Self-Study, MOOCs, Certifications, Conf. Paper etc.,

Course Designers

Experts from Industry	Experts from Higher Technical Institutions	Internal Experts
Mr.Harihara prasath venkatraman ,Agile Coach,Renault Nissan Technology & Business Centre India , Hariharaprasath.Venkataraman@rntbci.com	*Dr.N.Prakash ,Associate professor , B.S.A. Crescent Institute of Science and Technology*	*Mr.G.Senthil Kumar, Asst.prof (S.G),SRMIST*
	Dr.K.Kumar,Associate professor,Vellore Institute of technology	*Mr.Gouthaman, Asst.Prof., SRMIST*

Course Code	18CSE470T	Course Name	SOTWARE SECURITY	Course Category	E	Professional Elective	L	T	P	C
							3	0	0	3

Pre-requisite Courses	Nil	Co-requisite Courses	Nil	Progressive Courses	Nil
Course Offering Department	Computer Science and Engineering	Data Book / Codes/Standards	Nil		

Course Learning Rationale (CLR):	*The purpose of learning this course is to:*
CLR-1 :	*Understand the need for Software Security and the threats to software security*
CLR-2 :	*Incorporate security principles to software development lifecycle*
CLR-3 :	*Understand Secure software architecture design and coding*
CLR-4 :	*Gain basic knowledge on web security principles*
CLR-5 :	*Learn risk management and mitigation of risk in software development*
CLR-6 :	*Learn testing types and strategies for secure software*

		Learning			Program Learning Outcomes (PLO)														
		1	2	3	1	2	3	4	5	6	7	8	9	10	11	12	13	14	15
Course Learning Outcomes (CLO):	*At the end of this course, learners will be able to:*	Level of Thinking (Bloom)	Expected Proficiency (%)	Expected Attainment (%)	Engineering Knowledge	Problem Analysis	Design & Development	Analysis, Design, Research	Modern Tool Usage	Society & Culture	Environment & Sustainability	Ethics	Individual & Team Work	Communication	Project Mgt. & Finance	Life Long Learning	PSO - 1	PSO - 2	PSO – 3
CLO-1 :	*Identify security threats and issues in software*	2	80	85	H	-	-	-	-	-	-	-	-	-	-	-	-	-	-
CLO-2 :	*Gather security related requirements during requirement elicitation*	2	75	80	H	H	-	-	-	-	-	-	-	-	-	-	-	-	-
CLO-3 :	*Design software by incorporating security principles*	2	85	80	H	-	-	-	-	-	-	-	-	-	-	-	-	-	-
CLO-4 :	*Understand the issues in web and database security*	2	80	75	H	H	-	-	-	-	-	-	-	-	-	-	-	-	-
CLO-5 :	*Apply risk management strategies and risk mitigation strategies in software development*	2	75	85	H	-	-	H	-	-	-	-	-	-	-	-	-	-	-
CLO-6 :	*Apply testing strategies for secure software development*	2	80	85	H	-	-	-	-	-	-	-	-	-	-	-	-	-	-

Duration (hour)		9	9	9	9	9
S-1	SLO-1	*Introduction to software Security*	*Secure software architecture and design*	*Browser Security Principles*	*Risk Management Framework*	*Software security testing*
	SLO-2	*Software assurance and software security*	*Software security practices for architecture and design*	*Defining the same-origin policy*	*Five stages of activity*	*Contrasting software testing and software security testing*
S-2	SLO-1	*Threats to Software security*	*Software security knowledge for architecture and design*	*Client-side vs. server-side*	*Applying the RMF*	*Functional testing*
	SLO-2	*Sources of Software Insecurity*	*Software characterization*	*Exceptions to the same origin policy*	*Understanding the business context*	*Risk-based testing*
S-3	SLO-1	*Benefits of detecting software security defects early*	*Threat analysis*	*Cross-site scripting*	*Gathering the artifacts, conducting project research*	*Penetration Testing*
	SLO-2	*Managing Secure software development*	*Architectural vulnerability assessment*	*Reflected, POST-based reflected, stored and local XSS*	*Identifying the business and technical risk*	*Security testing consideration throughout the SDLC*
S-4	SLO-1	*Risk Management framework for Software security*	*Risk likelihood determination*	*XSS defense*	*Developing risk questionnaires, interviewing the target project team*	*Unit testing*
	SLO-2	*Software security practices in the development lifecycle*	*Risk Impact Determination*	*Cross-site request forgery*	*Analyzing the research and interview data*	*Testing Libraries*
S-5	SLO-1	*Properties of secure software*	*Risk Mitigation Planning*	*CSRF defense*	*Uncovering technical risks*	*Testing Executable files*
	SLO-2	*Influencing security properties of software*	*Security principles*	*Prevent XSS*	*Analyzing software artifacts*	*Integration testing*
S-6	SLO-1	*Building a security assurance case*	*Security guidelines and attack patterns*	*SQL Injection*	*Synthesizing and ranking the risk*	*System Testing*
	SLO-2	*Incorporating assurance cases into SDLC*	*Secure coding and testing*	*SQL Injection effects*	*Reviewing the risk data*	*Security Failures*
S-7	SLO-1	*Importance of requirements engineering*	*Code analysis*	*Blind SQL Injection*	*Conducting the business and technical peer review*	*Categories of Errors*
	SLO-2	*Security Requirements Engineering*	*common software code vulnerabilities*	*Setting Database Permissions*	*Defining the risk mitigation strategy*	*Attacker Behaviour*
S-8	SLO-1	*The SQUARE Process model*	*Source code review*	*Stored Procedure Security*	*The importance of measurement*	*Functional and attacker perspectives for Security Analysis*
	SLO-2	*SQUARE sample outputs*	*Coding practices*	*SQL Injection in stored procedures*	*Measurement and metrics in the RMF*	*Identity Management and Software development*

S-9	SLO-1	*Requirements elicitation*	*Sources of additional information on secure coding*	*Insecure direct object references*	*The Cigital Workbench*	*System Complexity drivers and security*
	SLO-2	*Requirements prioritization*	*Best practices for secure coding*	*Pre and post authorization checks*	*Risk Management is a framework for Software security*	*Deep Technical Problem Complexity*

Learning Resources	1. GaryMcGraw,SoftwareSecurity–AGuideforProjectManagers,Addison-Wesley Professional,2008,ISBN-13:978-0321509178	2. JamesM.Helfrich,SecurityforSoftwareEngineers,CRCPress,TaylorandFrancisGroup2019 3. JamesRansome,AnmolMisra,CoreSoftwareSecurity,CRCPress,TaylorandFrancisGroup2014.

Learning Assessment

	Bloom's Level of Thinking	Continuous Learning Assessment (50% weightage)								Final Examination (50% weightage)	
		CLA – 1 (10%)		CLA – 2 (15%)		CLA – 3 (15%)		CLA – 4 (10%)#			
		Theory	Practice	Theory	Practice	Theory	Practice	Theory	Practice	Theory	Practice
Level 1	Remember Understand	40 %	-	30 %	-	30 %	-	30 %	-	30%	-
Level 2	Apply Analyze	40 %	-	40 %	-	40 %	-	40 %	-	40%	-
Level 3	Evaluate Create	20 %	-	30 %	-	30 %	-	30 %	-	30%	-
	Total	100 %		100 %		100 %		100 %		100 %	

CLA – 4 can be from any combination of these: Assignments, Seminars, Tech Talks, Mini-Projects, Case-Studies, Self-Study, MOOCs, Certifications, Conf. Paper etc.,

Course Designers		
Experts from Industry	Experts from Higher Technical Institutions	Internal Experts
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2.Mr.Mithun, Cognizant,Mithun.SS@cognizant.com	*2.Dr.KunvarSingh,NITTrichy,kunwar@nitt.edu*	*2.Dr.Usha Krithikka,SRMIST*

Course Code	18CSE471T	Course Name	SOFTWARE MAINTENANCE AND ADMINISTRATION	Course Category	E	Professional Elective	L	T	P	C
							3	0	0	3

Pre-requisite Courses	Nil	Co-requisite Courses	Nil	Progressive Courses	
Course Offering Department	Computer Science and Engineering	Data Book / Codes/Standards	Nil		

Course Learning Rationale (CLR):	*The purpose of learning this course is to:*
CLR-1 :	*Understand the factors that make change of existing systems both technically challenging and risky, and the processes required to control change.*
CLR-2 :	*Acquire a knowledge and understanding of the specific problems inherent in the reengineering and evolution of legacy software systems, and be able to apply some of the techniques that can be of use in comprehending and changing them*
CLR-3 :	*Identify the specific challenges that inherent in the reengineering and evolution of data-intensive systems that are able to apply some of the techniques that can be of use in comprehending and changing them*
CLR-4 :	*Evaluate and understand the specific problems inherent in the reengineering and evolution of package-based software systems, and be able to apply techniques for designing change-resistant systems from pre-packaged code.*
CLR-5 :	*Analyze and apply numerous administration tools and technical concepts that relate to software administration*

Course Learning Outcomes (CLO):	*At the end of this course, learners will be able to:*	Learning 1: Level of Thinking (Bloom)	Learning 2: Expected Proficiency (%)	Learning 3: Expected Attainment (%)	PLO 1: Engineering Knowledge	PLO 2: Problem Analysis	PLO 3: Design & Development	PLO 4: Analysis, Design, Research	PLO 5: Modern Tool Usage	PLO 6: Society & Culture	PLO 7: Environment & Sustainability	PLO 8: Ethics	PLO 9: Individual & Team Work	PLO 10: Communication	PLO 11: Project Mgt. & Finance	PLO 12: Life Long Learning	PLO 13: PSO - 1	PLO 14: PSO - 2	PLO 15: PSO – 3
CLO-1 :	*Explaintermsusedinmakechangeofexistingsystemsbothtechnicallychallengingandrisky,andtheprocesses*	3	80	70	H	H	H	H	H	-	-	-	H	H	-	H	-	-	-
CLO-2 :	*Incorporateaknowledgeandunderstandingofthespecificproblemsinherentinthereengineeringandevolutionof*	3	85	75	M	H	H	M	H	-	-	-	M	H	-	H	-	-	-
CLO-3 :	*Identify challenges that inherent in the reengineering and evolution of data-intensive systems that are able to apply some of the techniques*	3	75	70	M	H	M	H	H	-	-	-	M	H	-	H	-	-	-
CLO-4 :	*Apply techniques for designing change-resistant systems from pre-packaged code.*	3	85	80	M	H	M	H	H	-	-	-	M	H	-	H	-	-	-
CLO-5 :	*Apply numerous administration tools and technical concepts that relate to software administration*	3	85	75	H	H	M	H	H	-	-	-	M	H	-	H	-	-	-

Duration (hour)		9	9	9	9	9
S-1	SLO-1	*Meaning of software maintenance, software change, ongoing support, economic implications of modifying software, the nomenclature and image problem*	*Definition, purposes and objectives*	*Definition for configuration management,*	*Quality Assurance,*	*Analyzing system logs,*
	SLO-2			*change control,*		*operating system updates,*
S-2	SLO-1	*Software maintenance framework,*	*levels of reverse Engineering,*	*documentation*	*fourth generation languages,*	*patches,*
	SLO-2					*configuration changes*
S-3	SLO-1	*Potential solutions to maintenance problem.*	*supports techniques,*	*Management and organizational issues*	*object oriented paradigms*	*Performing backups. Installing*
	SLO-2		*benefits*			*Configuring new hardware and software.*
S-4	SLO-1	*Maintenance process models*	*Reuse and reusability: Definitions,*	*Management responsibilities*	*Maintenance tools*	*Adding,*

	SLO-2	*Definition of critical appraisal of traditional process models,*				*removing,*
S-5	SLO-1	*Maintenance process models.*	*objective and benefit of reuse*	*Enhancing maintenance productivity*	*Criteria for selecting tools,*	*resetting passwords,*
	SLO-2					*System performance tuning*
S-6	SLO-1	*Program understanding: Aims of program comprehension,*	*approach to reuse,*	*maintenance teams*	*taxonomy of tools,*	*updating user account information,*
	SLO-2					
S-7	SLO-1	*maintainers and their information needs*	*Domain Analysis,*	*Personnel Education and Training*	*Program understanding and reverse engineering testing,*	*Performing routine audits of systems and software*
	SLO-2	*comprehension process models*	*Components engineering,*			
S-8	SLO-1	*Mental models, program comprehension strategies, factors that affect understanding,*	*reuse process model,*	*Personnel Education and Training*	*Configuration management, and other tasks.*	*Performing routine audits of software*
	SLO-2		*Factors that impact upon reuse.*			
S-9	SLO-1	*implications of comprehension theories and studies*	*Maintenance measures, Definitions, objectives of software measurement, example measures, guidelines for selecting maintenance measures*	*Organization modes*	*Past, present and future of software maintenance*	*Performing routine audits of systems and software*
	SLO-2					

Learning Resources	*1. Armstrong A Takang and Penny A.Grubb, "Software Maintenance: concepts and Practice", International Thomson Computer press, London,2015*	*1. Roger S Pressman, "Software Engineering", 6th edition, Tata McGraw-Hill, 2004*

Learning Assessment

	Bloom's Level of Thinking	Continuous Learning Assessment (50% weightage)								Final Examination (50% weightage)	
		CLA – 1 (10%)		CLA – 2 (15%)		CLA – 3 (15%)		CLA – 4 (10%)#			
		Theory	Practice	Theory	Practice	Theory	Practice	Theory	Practice	Theory	Practice
Level 1	Remember Understand	40 %	-	30 %	-	30 %	-	30 %	-	30%	-
Level 2	Apply Analyze	40 %	-	40 %	-	40 %	-	40 %	-	40%	-
Level 3	Evaluate Create	20 %	-	30 %	-	30 %	-	30 %	-	30%	-
	Total	100 %		100 %		100 %		100 %		100 %	

CLA – 4 can be from any combination of these: Assignments, Seminars, Tech Talks, Mini-Projects, Case-Studies, Self-Study, MOOCs, Certifications, Conf. Paper etc.,

Course Designers		
Experts from Industry	Experts from Higher Technical Institutions	Internal Experts
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		2., Ms.D.Hema,SRMIST

ACADEMIC CURRICULA

Professional Elective Courses

ELECTRICAL AND ELECTRONICS ENGINEERING

Regulations - 2018

SRM INSTITUTE OF SCIENCE AND TECHNOLOGY

(Deemed to be University u/s 3 of UGC Act, 1956)

Kattankulathur, Kancheepuram, Tamil Nadu, India

Course Code	18EEE301T	Course Name	OPTIMIZATION TECHNIQUES IN POWER ELECTRONICS	Course Category	E	Professional Elective	L	T	P	C
							3	0	0	3

Pre-requisite Courses	Nil	Co-requisite Courses	Nil	Progressive Courses	Nil
Course Offering Department	Electrical and Electronics Engineering	Data Book / Codes/Standards	Nil		

Course Learning Rationale (CLR):	*The purpose of learning this course is to:*
CLR-1 :	*Introduce and classify different conventional optimization techniques.*
CLR-2 :	*Understand the fundamentals of genetic algorithm and to apply appropriate algorithm for Power Electronic Applications.*
CLR-3 :	*Outline the concept of particle swarm optimization and apply it in Power Electronic applications.*
CLR-4 :	*Introduce other modern optimization algorithms for engineering applications.*
CLR-5 :	*Extend multi objective optimization techniques to Power Electronics*
CLR-6 :	*Introduce the concept of optimization design for Power Electronic Applications*

Course Learning Outcomes (CLO):	*At the end of this course, learners will be able to:*	Learning 1: Level of Thinking (Bloom)	Learning 2: Expected Proficiency (%)	Learning 3: Expected Attainment (%)	PLO 1: Engineering Knowledge	PLO 2: Problem Analysis	PLO 3: Design & Development	PLO 4: Analysis, Design, Research	PLO 5: Modern Tool Usage	PLO 6: Society & Culture	PLO 7: Environment & Sustainability	PLO 8: Ethics	PLO 9: Individual & Team Work	PLO 10: Communication	PLO 11: Project Mgt. & Finance	PLO 12: Life Long Learning	PLO 13: PSO - 1	PLO 14: PSO - 2	PLO 15: PSO - 3
CLO-1 :	*Categorize optimization problems and its techniques based on constraints and variables*	*1*	*75*	*75*	*H*	-	-	-	-	-	-	-	-	-	-	-	-	-	-
CLO-2 :	*Correlate Genetic algorithm with various power electronic application.*	*2*	*75*	*75*	*H*	*H*	*M*	*M*	-	-	-	-	-	-	-	-	*H*	*H*	-
CLO-3 :	*Interpret Particle swarm optimization and develop hybrid algorithm for power electronic applications*	*3*	*75*	*75*	*H*	*H*	*H*	*H*	-	-	-	-	-	-	-	-	*H*	*H*	-
CLO-4 :	*Gain knowledge about other modern optimization algorithms and integrate them for power electronic applications*	*3*	*75*	*75*	*H*	*H*	*H*	*H*	-	-	-	-	-	-	-	-	*H*	*H*	-
CLO-5 :	*Formulate multi objective optimization algorithm for power electronic applications.*	*3*	*75*	*75*	*H*	*H*	*H*	*H*	-	-	-	-	-	-	-	-	*H*	*H*	-
CLO-6 :	*Apply optimization techniques in modelling Power Electronic applications*	*3*	*75*	*75*	*H*	*H*	*H*	*H*	-	-	-	-	-	-	-	-	*H*	*H*	-

Duration (hour)		9	9	9	9	9
S-1	SLO-1	*Introduction to optimization*	*Introduction – Genetic Algorithm*	*Particle Swarm Optimization*	*Bacterial foraging-Chemotaxis, Swarming*	*Multiobjective optimization*
	SLO-2	*Design vector – design constraints – constraint surface*	*Encoding – Methods for GA*	*Fundamental principle*	*Operation of Bacterial foraging*	*Concept of pareto optimality*
S-2	SLO-1	*objective function – objective function surfaces*	*Fitness function*	*Velocity updating in PSO -Algorithm*	*Bees colony algorithm-Behavior of Honey bee swarm*	*Classical Methods – Weighted sum method,*
	SLO-2	*Classification of optimization problem*	*Maximization & Minimization*	*Algorithm for PSO*	*Algorithm for Bee colony optimization*	*ε-constraint method*
S-3	SLO-1	*Single variable optimization - optimalityconditions*	*Genetic operators*	*PSO – Parameter Selection*	*Differential evolution-Initialization, Mutation*	*Weighted metric methods,*
	SLO-2	*Single variable (unconstrained optimization) – Exhaustive search method*	*Crossover*	*Pseudocode*	*Recombination, Selection*	*Benson method.*
S-4	SLO-1	*Successive quadratic estimation method*	*Mutation*	*Implementation & Convergence issues in PSO*	*Ant colony optimization-Introduction*	*Multi objectiveGA*
	SLO-2	*Newton Raphson method*	*Parent Selection Roulette wheel selection*	*Advanced operators of PSO*	*Algorithm for Ant colony optimization*	*Fitnessassignment*
S-5	SLO-1	*Multi variable optimization – optimality conditions (unconstrained)*	*Stochastic universal selection,*	*Meta-Optimization- Behavioral parameters*	*Cuckoo Search Optimization*	*Sharing function*
	SLO-2	*Simplex search method*	*Tournament selection*	*Algorithm for Meta-Optimization*	*Algorithm for Cuckoo search Optimization*	*Convergence criterion*
S-6	SLO-1	*Cauchy's method*	*Rank selection*	*Applications of PSO*	*Firefly optimization-Working Principle*	*NSGA-II*
	SLO-2	*Steepest descent method*	*Issues in GA implementation*	*Harmonics Elimination in Inverters*	*Algorithm for Firefly optimization*	*Convergence criterion*
S-7	SLO-1	*Multivariable optimization (Constrained) Kuhn – Tucker Conditions*	*Applications of GA*	*Applications of PSO*	*Flower Pollination optimization-Introduction*	*Applications:Design of AC – DC Grid connected converter using Multi objective optimization*
	SLO-2	*Penalty Function Method*	*Passive Filter design using GA*	*PSO for single phase PWM Inverters*	*Algorithm for Flower pollination optimization*	*Algorithm for Design of AC – DC Grid connected converter*

S-8	SLO-1	*Method of Multipliers*	*Parameter tuning of DC-DC converter using genetic algorithm*	*Control of Dc-DC converters using PSO*	*Grey Wolfe optimization-Introduction*	*Multi objective optimization of power converters (NSGA-II)*
	SLO-2	*Linearized search Technique – Frank Wolfe method*	*Tuning of PI Controllers for Power electronic converters*	*Feedback controller design for boost converters*	*Algorithm for Grey Wolfe Optimization*	*Algorithm for Multi objective optimization of power converters*
S-9	SLO-1	*Non-Linearized Search Technique – Reduced gradient method*	*MPPT in Renewable Energy systems*	*HybridofGAandPSO*	*Comparison of various algorithms*	*Multi objective optimization for design and tuning of PID controllers*
	SLO-2	*Quadraticprogramming*	*Genetic Algorithm for MPPT*	*Algorithm for hybrid GA and PSO for selective harmonic elimination in VSI fed drives*	*Benchmark functions*	*Algorithm for Multi objective optimization for design and tuning of PID controllers*

Learning Resources	1. *SingiresuRaoS. Engineering Optimization–TheoryandPractice, John Wiley & Sons, Inc., New Jersey, 2009.* 2. *Kalyanmoy Deb, Muti-objective Optimization using Evolutionary Algorithms, WileyIndia Private Limited, 2010* 3. *Kalyanmoy Deb, Optimization of Engineering Desig", Prentice Hall of India, second Edition, 2012.* 4. *Jizhong Zhou, Optimization of Power System Operation, IEEE Press, Second Edition, 2015.*	5. *Xin - She Yang, Nature Inspired Optimization algorithms, Elsevier, 2014.* 6. *Chee Peng Lim, Lakhmi C. Jain, Satchidananda Dehuri, Innovations in Swarm Intelligence, Springer, Berlin, Heidelberg, 2009.* 7. *Design of AC – DC Grid connected converter using Multi objective optimization, Electrical Control & Communication Engineering, 2014* 8. *https://engineering.purdue.edu/~sudhoff/ee630/Lecture09.pdf* 9. *https://link.springer.com/content/pdf/10.1007%2F978-3-540-74205-0_68.pdf*

Learning Assessment											
	Bloom's Level of Thinking	Continuous Learning Assessment (50% weightage)								Final Examination (50% weightage)	
		CLA – 1 (10%)		CLA – 2 (15%)		CLA – 3 (15%)		CLA – 4 (10%)#			
		Theory	Practice	Theory	Practice	Theory	Practice	Theory	Practice	Theory	Practice
Level 1	Remember Understand	40 %	-	30 %	-	30 %	-	30 %	-	30%	-
Level 2	Apply Analyze	40 %	-	40 %	-	40 %	-	40 %	-	40%	-
Level 3	Evaluate Create	20 %	-	30 %	-	30 %	-	30 %	-	30%	-
	Total	100 %		100 %		100 %		100 %		100 %	

CLA – 4 can be from any combination of these: Assignments, Seminars, Tech Talks, Mini-Projects, Case-Studies, Self-Study, MOOCs, Certifications, Conf. Paper etc.,

Course Designers		
Experts from Industry	Experts from Higher Technical Institutions	Internal Experts
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Course Code	18EEE302T	Course Name	FINITE ELEMENT ANALYSIS FOR ELECTRICAL MACHINES	Course Category	E	Professional Elective	L	T	P	C
							3	0	0	3

Pre-requisite Courses	Nil	Co-requisite Courses	Nil	Progressive Courses	Nil
Course Offering Department	Electrical and Electronics Engineering	Data Book / Codes/Standards	Nil		

Course Learning Rationale (CLR):	*The purpose of learning this course is to:*
CLR-1 :	*Illustrate the basic concepts of CAD and its design consideration*
CLR-2 :	*Derive the output equation of DC and AC machines*
CLR-3 :	*Compute the torque and force for rotating and linear actuators*
CLR-4 :	*Analyze the finite element method in solving electromagnetic field problem*
CLR-5 :	*Enumerate the design concept of CAD in mathematical modelling*
CLR-6 :	*Build the models of electrical machines*

Course Learning Outcomes (CLO):	*At the end of this course, learners will be able to:*	Learning 1: Level of Thinking (Bloom)	2: Expected Proficiency (%)	3: Expected Attainment (%)	PLO 1: Engineering Knowledge	2: Problem Analysis	3: Design & Development	4: Analysis, Design, Research	5: Modern Tool Usage	6: Society & Culture	7: Environment & Sustainability	8: Ethics	9: Individual & Team Work	10: Communication	11: Project Mgt. & Finance	12: Life Long Learning	13: PSO - 1	14: PSO - 2	15: PSO - 3
CLO-1 :	*Understand the basic design of electrical machines and the need for CAD*	1	75	75	H	M	M	-	-	-	-	-	-	-	-	-	H	M	-
CLO-2 :	*Make use of output equation for calculate main dimension of DC and AC machines*	2	75	75	H	H	M	M	-	-	-	-	-	-	-	-	M	M	-
CLO-3 :	*Deduce the electromagnetic field equations for actuators*	3	75	75	H	H	H	M	-	-	-	-	-	-	-	-	H	M	-
CLO-4 :	*Examine the mathematical and physical basis of finite element method*	3	75	75	H	M	H	M	-	-	-	-	-	-	-	-	H	H	-
CLO-5 :	*Apply the design concept of CAD in mathematical modelling*	3	75	75	H	H	M	M	M	-	-	-	-	-	-	-	H	M	-
CLO-6 :	*Develop the models of switched reluctance motor and rotating actuators*	3	75	75	H	H	M	M	M	-	-	-	-	-	-	-	H	M	-

Duration (hour)		9	9	9	9	9
S-1	SLO-1	*CAD and its objectives*	*Maxwell's Equations*	*Finite element method*	*Organization of CAD package*	*model building*
	SLO-2	*Conventional design procedure of machines*	*integral form and differential form*	*Assumptions in FEM*	*Pre-processor*	*modeling flowchart*
S-2	SLO-1	*Output equation of DC machines.*	*Significance of field equations,*	*Electromagnetic field equations in Finite element*	*solver*	*geometric modeling, drawing edges*
	SLO-2	*Specific loading values for DC machines*	*electromagnetic equation-integral and differential form*	*Finite difference method*	*post-processor in CAD package*	*creating surface and creating components*
S-3	SLO-1	*output equation of AC machines*	*Magnetic vector potential*	*Finite difference method for calculation of magnetic field in a linear medium*	*Applications of finite element analysis*	*selecting edges surfaces and components*
	SLO-2	*Specific loading values for AC machines*	*scalar potential form*	*Assumptions in linear medium*	*Considerations in problem modeling*	*positioning the construction slice materials*
S-4	SLO-1	*Factors affecting the size of rotating machines*	*Energy stored in electromagnetic field*	*Finite difference method for calculation of magnetic field in a non-linear medium*	*stator and rotor model*	*boundary condition*
	SLO-2	*Specific loadings and its dependent factors*	*Energy stored in current carrying coil*	*Assumptions in non-linear medium*	*model replication and air gap discretisation*	*model solving*
S-5	SLO-1	*Variation of output and losses with dimension*	*Energy functional*	*Stiffness matrix*	*Post-processing of results-flux and flux linkage*	*Meshing: 2-D and 3-D*
	SLO-2	*Separation of main dimensions*	*Assumptions in energy functional*	*FEM and FDM functions*	*Numerical and graphical results using processors*	*finite element mesh*
S-6	SLO-1	*Limitations of conventional methods of design*	*Electromechanical energy conversion*	*FEM-mathematical basis*	*Analytical calculation*	*Design of C-cored coil with rotating actuator*
	SLO-2	*Need for field analysis based design*	*Classification of electromechanical energy conversion*	*FEM- physical basis*	*Terminal inductance calculation.*	*Geometric modeling of C-core*
S-7	SLO-1	*Outline of finite element analysis*	*Force and torque calculation from energy*	*Energy functional*	*Co-energy calculation.*	*Design of doubly excited rotating actuator*
	SLO-2	*Necessity of FEA*	*Force and torque calculation from co-energy*	*Non-linear energy functional*	*Force and torque calculation*	*Design procedure and its assumptions*
S-8	SLO-1	*Computers in finite element analysis*	*singly excited linear and rotating actuator*	*discretization*	*virtual work method*	*Design procedure of SRM*
	SLO-2	*Graphical users of FEA*	*doubly excited rotating actuator*	*shape function*	*Maxwell's stress tensor method*	*Geometric modeling*

S-9	SLO-1	*Engineering Optimisation*	*Force calculation on a current carrying conductor*	*Shape triangle calculation*	*Bil method*	*Material assigning*
	SLO-2	*Optimisation Methodology*	*torque calculation on a current carrying conductor*	*Comparison of Finite difference and finite element method*	*Boundary conditions*	*Design of Switched reluctance motor by CAD package*

Learning Resources	1. *Silvester and Ferrari, Finite Elements for Electrical Engineers, Cambridge University press, 2012.* 2. *S.R.H. Hoole, Computer - Aided, Analysis and Design of Electromagnetic Devices, Elsevier, New York, Amsterdam, London, 1989.*	3. *S. Salon, Finite Element Analysis of Electrical Machines, springer, 1995.* 4. *Nicola Bianchi, Electrical Machine Analysis Using Finite Elements,1st Edition, CRC Press,2005.* 5. *https://www.classcentral.com/course/edx--finite-element-method-fem-analysis-and-applications-4064*

Learning Assessment

	Bloom's Level of Thinking	Continuous Learning Assessment (50% weightage)								Final Examination (50% weightage)	
		CLA – 1 (10%)		CLA – 2 (15%)		CLA – 3 (15%)		CLA – 4 (10%)#			
		Theory	Practice	Theory	Practice	Theory	Practice	Theory	Practice	Theory	Practice
Level 1	Remember Understand	40 %	-	30 %	-	30 %	-	30 %	-	30%	-
Level 2	Apply Analyze	40 %	-	40 %	-	40 %	-	40 %	-	40%	-
Level 3	Evaluate Create	20 %	-	30 %	-	30 %	-	30 %	-	30%	-
	Total	100 %		100 %		100 %		100 %		100 %	

CLA – 4 can be from any combination of these: Assignments, Seminars, Tech Talks, Mini-Projects, Case-Studies, Self-Study, MOOCs, Certifications, Conf. Paper etc.,

Course Designers

Experts from Industry	Experts from Higher Technical Institutions	Internal Experts
1. Dr. Bhaskarsahu, Schneider Electric Ltd, Bhaskar.sahu@schneider-electric.com	*1. Dr. K. S. Swarup, IITM, ksswarup@iitm.ac.isn*	*1.Dr. M. Arun Noyal Doss, SRMIST*
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Course Code	18EEE303T	Course Name	POWER CONVERTER ANALYSIS AND DESIGN	Course Category	E	Professional Elective	L	T	P	C
							3	0	0	3

Pre-requisite Courses	18EEC302J	Co-requisite Courses	Nil	Progressive Courses	Nil
Course Offering Department	Electrical and Electronics Engineering	Data Book / Codes/Standards	Nil		

Course Learning Rationale (CLR):	The purpose of learning this course is to:
CLR-1 :	*Enrich the knowledge on design aspects of phase controlled converters*
CLR-2 :	*Acquire knowledge in DC-DC converters and its performance*
CLR-3 :	*Enrich the knowledge of flyback back converter and its design*
CLR-4 :	*Acquire knowledge on the design techniques of the inverters*
CLR-5 :	*Understand the concept of resonant converters and role of reactive elements in UPS*
CLR-6 :	*Gain knowledge on power converter analysis and design*

Course Learning Outcomes (CLO):	At the end of this course, learners will be able to:	Learning 1: Level of Thinking (Bloom)	2: Expected Proficiency (%)	3: Expected Attainment (%)	PLO 1: Engineering Knowledge	2: Problem Analysis	3: Design & Development	4: Analysis, Design, Research	5: Modern Tool Usage	6: Society & Culture	7: Environment & Sustainability	8: Standards & Ethics	9: Individual & Team Work	10: Communication	11: Project Mgt. & Finance	12: Life Long Learning	13: PSO - 1	14: PSO - 2	15: PSO - 3
CLO-1 :	*Design single phase and three phase rectifiers*	3	75	75	H	H	M	M	H	-	-	-	-	-	-	-	M	H	-
CLO-2 :	*Understand the analysis and design aspects of DC-DC converters*	3	75	75	H	H	M	M	H	-	-	-	-	-	-	-	M	H	-
CLO-3 :	*Design flyback back converter and its various topologies*	3	75	75	H	H	M	M	H	-	-	-	-	-	-	-	M	H	-
CLO-4 :	*Design the inverter for various applications*	3	75	75	H	H	M	M	H	-	-	-	-	-	-	-	M	H	-
CLO-5 :	*Apply the knowledge on design concepts of resonant converters and UPS*	3	75	75	H	H	M	M	H	-	-	-	-	-	-	-	M	H	-
CLO-6 :	*Analyze and Design power converters*	3	75	75	H	H	M	M	H	-	-	-	-	-	-	-	M	H	-

Duration (hour)		9	9	9	9	9
S-1	SLO-1	*Introduction to single phase controlled converter (rectifier)*	*Introduction to isolated and non isolated DC-DC converters.*	*Introduction - Linear versus switch mode power supplies.*	*Introduction to inverters for single phase application*	*Introduction to resonant converters*
	SLO-2	*Working principle of single phase full converter*	*Principles of step down converters and step up converters*	*Functional circuit blocks of an offline switches*	*Introduction to inverters for three phase application*	*Classification of resonant converters*
S-2	SLO-1	*Analysis of single phase controlled rectifier for R load*	*Introduction to buck , boost converters*	*Classification of Basics switch mode DC-DC converters:*	*Selection of switching devices*	*Quasi resonant converters: Operating principle*
	SLO-2	*Analysis of single phase controlled rectifier for RLload and RLE load*	*Buck boost converters*	*Switch mode DC-DC converters: Operating principles*	*Introduction to IPM modules*	*Load resonant converters*
S-3	SLO-1	*Introduction to three phase controlled converters*	*Analysis of Buck converter*	*Flyback converters: operating principle*	*PWM techniques for inverter*	*Series Resonant switch converters*
	SLO-2	*Operation & principle of three phase controlled rectifier*	*Buck converter Design*	*Forward Converter: operating principle*	*Impact of PWM techniques on inverter performance*	*Parallel Resonant switch converters*
S-4	SLO-1	*Analysis of three phase controlled rectifier for R Load*	*Analysis of boost converter*	*Half-Bridge converters and, SMPS : Operating principle*	*Protection circuits for switches*	*Concept of Zero Voltage Switching*
	SLO-2	*Analysis of three phase controlled rectifier for RL Load*	*Boost converter design*	*Full Bridge Converters : operating principle*	*Snubber circuit design*	*Concept of Zero Current Switching*
S-5	SLO-1	*Selection of converter components for specified load*	*Analysis of buck-boost converter*	*Push-Pull Converter and its working*	*Thermal design considerations*	*Multi resonant converters*
	SLO-2	*Design of filter circuit for single phase controlled rectifier*	*Buck-Boost converter design*	*SMPS with multiple outputs*	*Heat sink design*	*Zero Voltage Transition converters*
S-6	SLO-1	*Design of filter circuit-three phase converter*	*Introduction to SEPIC converter*	*Magnetic design: Properties of magnetic cores*	*Multilevel Inverter(MLI) concept*	*UPS: offline UPS, Online UPS*
	SLO-2	*Importance of driver circuits*	*Introduction to CUK converter*	*High frequency inductor and transformer design*	*Classification of MLI*	*Filters: Voltage filters*
S-7	SLO-1	*Pulse generation circuits*	*Analysis of SEPIC converter*	*Selection of output filter capacitor*	*Design of MLI*	*Series-parallel resonant filters, filter without series capacitors,*

	SLO-2	*Design of driver circuits*	*Analysis of CUK converter*	*Selection of switches*	*Pulse Width Modulation for MLI*	*current filter, DC filters*
S-8	SLO-1	*Power factor study – Improvement techniques*	*Thermal design: temperature control*	*Snubber circuit design*	*Influence of PWM on inverter performance*	*Design of inductor and transformé of power electronic applications*
	SLO-2	*Harmonic analysis study*	*Heat sink design*	*Design of driver circuits.*	*PWM for low inverter loss*	*Selection of capacitors.*
S-9	SLO-1	*Simulation of fully controlled converters*	*Simulation of basic DC- DC converters*	*Simulation of isolated dc dc converter*	*Simulation of a typical three phase inverter*	*Simulation of resonant and quasi resonant converter*
	SLO-2	*Demonstration of a fully controlled converter for R , RL loads*	*Demonstration of DC DC converters*	*Demonstration on Closed Loop Control of SMPS*	*Demonstration on a three phase inverter*	*Demonstration of resonant converters*

Learning Resources	1. *Robert W. Erickson and Dragan Maksimovic, Fundamentals of Power Electronics, 3rd Ed., Springer (India) Pvt. Ltd., 2011.* 2. *Abraham I. Pressman, Keith Billings, and Taylor Morey, Switching Power Supply Design, 3rd Ed.,McGraw-Hill Professional, 1 May 2009* 3. *Rashid M.H., Power Electronics Circuits, Devices and Applications, Prentice Hall India, Third Edition, New Delhi, 2004.* 4. *V. Ramanarayanan, Switched Mode Power Conversion, 2007*	5. *Umanand L and Bhatt S R, Design of Magnetic Components for Switched Mode Power Converters, Wiley Eastern Publication, 2009.* 6. *Ned Mohan, Tore M. Undeland, William P. Robbins, Power Electronics Converters, Applications, and Design", 3rd Edition, Wiley India Pvt Ltd, 2010.* 7. *Simon Ang, Alejandro Oliva, Power-Switching Converters, Second Edition, CRC Press, Taylor & Francis Group, 2010* 8. *https://nptel.ac.in/courses/108108036/*

Learning Assessment

	Bloom's Level of Thinking	Continuous Learning Assessment (50% weightage)								Final Examination (50% weightage)	
		CLA – 1 (10%)		CLA – 2 (15%)		CLA – 3 (15%)		CLA – 4 (10%)#			
		Theory	Practice	Theory	Practice	Theory	Practice	Theory	Practice	Theory	Practice
Level 1	Remember Understand	40 %	-	30 %	-	30 %	-	30 %	-	30%	-
Level 2	Apply Analyze	40 %	-	40 %	-	40 %	-	40 %	-	40%	-
Level 3	Evaluate Create	20 %	-	30 %	-	30 %	-	30 %	-	30%	-
	Total	100 %		100 %		100 %		100 %		100 %	

CLA – 4 can be from any combination of these: Assignments, Seminars, Tech Talks, Mini-Projects, Case-Studies, Self-Study, MOOCs, Certifications, Conf. Paper etc.,

Course Designers		
Experts from Industry	Experts from Higher Technical Institutions	Internal Experts
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2. Mr.J.Sassikumar, Philips India Pvt Ltd, sassikumar.jj@gmail.com	*2.Dr.R.Ramesh, CEG, rramesh@annauniv.edu*	*2. Dr. K. Mohanraj, SRMIST*

Course Code	18EEE304T	Course Name	SWITCHED MODE POWER CONVERSION	Course Category	E	Professional Elective	L	T	P	C
							3	0	0	3

Pre-requisite Courses	18EEC302J	Co-requisite Courses	Nil	Progressive Courses	Nil
Course Offering Department	Electrical and Electronics Engineering	Data Book / Codes/Standards	Nil		

Course Learning Rationale (CLR):	*The purpose of learning this course is to:*
CLR-1 :	*Review the basics of the power semiconductor devices and their requirements for the design of SMPC.*
CLR-2 :	*Explain the advantage of Switched mode Power supply over linear power Supply and the design of basic switched mode DC-DC converters.*
CLR-3 :	*Illustrate the need of derived / isolated converters and the working of various types of derived converters.*
CLR-4 :	*Introduce the control and compensating schemes for the design of SMPS and the procedure to be followed in the design of magnetic components.*
CLR-5 :	*Demonstrate the use of resonant converters to implement the Zero voltage and Zero current switching concepts.*
CLR-6 :	*Learn the basics and steady state operation of efficient switched mode power conversion and control techniques, including component design.*

		Learning			Program Learning Outcomes (PLO)														
		1	2	3	1	2	3	4	5	6	7	8	9	10	11	12	13	14	15
Course Learning Outcomes (CLO):	*At the end of this course, learners will be able to:*	Level of Thinking (Bloom)	Expected Proficiency (%)	Expected Attainment (%)	Engineering Knowledge	Problem Analysis	Design & Development	Analysis, Design, Research	Modern Tool Usage	Society & Culture	Environment & Sustainability	Ethics	Individual & Team Work	Communication	Project Mgt. & Finance	Life Long Learning	PSO - 1	PSO - 2	PSO - 3
CLO-1 :	*Determine the selection criteria of power semiconductor devices, evaluation of losses and their basic heat sink design.*	*1*	*75*	*75*	*H*	-	-	-	-	-	-	-	-	-	-	-	*M*	*H*	-
CLO-2 :	*Design the basic switched-mode converters for the given design specifications.*	*2*	*75*	*75*	*H*	*M*	*M*	*L*	-	-		-	-	-	-	-	*M*	*H*	-
CLO-3 :	*Understand the steady state analysis and working of the Derived DC-DC isolated Converters.*	*2*	*75*	*75*	*H*	*M*	*M*	*L*	-	-	-	-	-	*M*	-	-	*M*	*H*	-
CLO-4 :	*Analyze of Control and Compensating network for SMPS, design high frequency inductor and transformers to be used with SMPS.*	*3*	*75*	*75*	*H*	*M*	*M*	*L*	-	-	-	-	-	*M*	-	-	*M*	*H*	-
CLO-5 :	*Analyze the working principle of resonant converters and understand the importance of Zero voltage and Zero current switching.*	*2*	*75*	*75*	*H*	*M*	*M*	*L*	-	-	-	-	-	*M*	-	-	*M*	*H*	-
CLO-6 :	*Become proficient with the analysis and design of Switched-Mode Converters, including selection of components based on the specification.*	*2*	*75*	*75*	*H*	*M*	*M*	*L*	-	-	-	-	-	*M*	-	-	*M*	*H*	-

Duration (hour)		9	9	9	9	9
S-1	SLO-1	*Introduction to switched mode power conversion*	*Basic concepts of Switched Mode power converters.*	*DC-DC converters with isolation.*	*Reactive elements in Power Electronic Systems*	*Basic resonant circuit concepts*
	SLO-2	*Industrial relevance of switched mode power conversion*	*Generalized comparison between switched mode and linear voltage regulator.*	*Requirement for isolation in the switch-mode converters*	*Design constraints of reactive elements in Power Electronic Systems*	*SMPS using resonant circuit*
S-2	SLO-1	*Requirements of power conversion system*	*DC-DC converters circuit elements, operating principles*	*Power circuit of flyback converters*	*Design of inductor, transformer and capacitors for power electronic applications*	*Resonant switch converters – Introduction*
	SLO-2	*Requirements of high performance modern power conversion system*	*DC-DC converters Characteristics*	*Steady-state analysis of flyback converters*	*Filter inductor design constraints, Transformer design constraints*	*Resonant switch converters – principle of operation*
S-3	SLO-1	*Review of power diodes, Schottky didoes, power MOSFETs &IGBTs*	*Operation and steady state performance of Buck Converter in continuous-conduction mode (CCM)*	*Power circuit of push-pull converters*	*Modeling of power converters*	*Buck converter with zero current switching*
	SLO-2	*Introduction to power semiconductor devices for SMPS*	*Buck converter - Discontinuous-conduction mode (DCM) and boundary between CCM and DCM operation*	*Steady-state analysis of push-pull converters*	*Generalized State Space Model of the switching power converter*	*Steady state conversion ratio – Buck converters*
S-4	SLO-1	*Recent developments in power devices*	*Operation and steady state performance of Boost Converter in continuous-conduction mode (CCM)*	*Power circuit of forward converters*	*Transfer Function of switching power converters*	*Boost converter with zero voltage switching*

	SLO-2	New devices: GaN & SiC for switch mode power supplies	Boost converter - Discontinuous-conduction mode (DCM) and boundary between CCM and DCM operation	Steady-state analysis of forward converters	EMI and filter design problem	Steady state conversion ratio – Boost converters
S-5	SLO-1	Gate drive basics	Operation and steady state performance of Buck - Boost Converter in continuous-conduction mode (CCM)	Power circuit and steady-state analysis of half-bridge DC-DC converters	Closed loop control of switching power converters	Series resonant DC-DC converters – principle
	SLO-2	Gate drive requirements	Buck - Boost Converter Discontinuous-mode (DCM) and boundary between CCM and DCM operation	Power circuit and steady-state analysis of full bridge DC-DC converters	Selection of controller parameters for converters	Series resonant DC-DC converters – Analysis and operation
S-6	SLO-1	Switching performance and snubber design	Operation and performance of Cuk Converters	Magnetic circuits in isolated topologies	Feedback compensators for converters	Parallel resonant DC-DC converters – principle
	SLO-2	Turn-on and Turn-off snubber	Operation and performance of SEPIC Converters	Utilization of Magnetic circuits in isolated topologies	Design of feedback compensators	Parallel resonant DC-DC converters – Analysis and operation
S-7	SLO-1	Selection of devices	Inductors current ripple design considerations	Comparison of different isolated topologies	Effect of parasitics on the switching converter design	Resonant DC link converters – principle
	SLO-2	Basic heat sink design for the devices	Output voltage ripple design considerations	Selection criteria of different isolated topologies	Stray inductance and inductive coupling effects	Resonant DC link converters – Analysis and operation
S-8	SLO-1	Sources of losses in SMPS	Effect of parasitic elements	Recent advancements of DC –DC converters (current mode, voltage mode)	Digital Control of power converter	Comparison of resonant converter configurations
	SLO-2	Conduction/Switching losses	Choice of switching frequency	Recent advancements of DC –DC converters (multiple output, high frequency output)	Quantization issues in digitally controlled power converters	Selection criteria of resonant converter configurations
S-9	SLO-1	Losses and efficiency in converters	Comparisons of DC –DC converter configurations	Applications of DC-DC converters	Practical issues in controller design	Applications of Resonant converters
	SLO-2	Realistic converter models	Selection criteria of DC –DC converter configurations	Seminar on Recent advancements and applications of DC –DC converters	Seminar on practical issues in controller design for power converters	Seminar on recent advancements and applications of Resonant converters

Learning Resources	1. Ned Mohan, Tore M. Undeland, William P. Robbins, Power Electronics Converters, Applications, and Design, 3rd Edition, Wiley India Pvt Ltd, 2010. 2. Abraham I. Pressman, Keith Billings, and Taylor Morey, Switching Power Supply Design, 3rd Ed.,McGraw-Hill Professional, 1 May 2009.	3. Umanand L and Bhatt S R, Design of Magnetic Components for Switched Mode Power Converters, Wiley Eastern Publication, 2009. 4. S.N.Singh, Electric power generation, transmission and distribution, 2nd ed., PHI, 2011 5. https://nptel.ac.in/courses/108108036/

Learning Assessment

	Bloom's Level of Thinking	Continuous Learning Assessment (50% weightage)								Final Examination (50% weightage)	
		CLA – 1 (10%)		CLA – 2 (15%)		CLA – 3 (15%)		CLA – 4 (10%)#			
		Theory	Practice	Theory	Practice	Theory	Practice	Theory	Practice	Theory	Practice
Level 1	Remember / Understand	40 %	-	30 %	-	30 %	-	30 %	-	30%	-
Level 2	Apply / Analyze	40 %	-	40 %	-	40 %	-	40 %	-	40%	-
Level 3	Evaluate / Create	20 %	-	30 %	-	30 %	-	30 %	-	30%	-
	Total	100 %		100 %		100 %		100 %		100 %	

CLA – 4 can be from any combination of these: Assignments, Seminars, Tech Talks, Mini-Projects, Case-Studies, Self-Study, MOOCs, Certifications, Conf. Paper etc.,

Course Designers

Experts from Industry	Experts from Higher Technical Institutions	Internal Experts
1.Sairajagopal Chandramouli, Armstrong Fluid technology, Canada, bbalaji231@gmail.com	1. Dr B. Chitti Babu, IIITDM Kancheepuram, bcbabu@iiitdm.ac.in	1. Dr L.Padmavathi, SRMIST
2.Jidhun K Murali, Project Engineer, CDAC, Trivandrum, jidhunkm@gmail.com	2. Dr. A. Venkadesan, NIT Puducherry, venkadesan@nitpy.ac.in	2.Dr R Sridhar, SRMIST

Course Code	18EEE305T	Course Name	DESIGN OF ELECTRICAL MACHINES	Course Category	E	Professional Elective	L	T	P	C
							3	0	0	3

Pre-requisite Courses	18EEC204J, 18EEC205J	Co-requisite Courses	Nil	Progressive Courses	Nil
Course Offering Department	Electrical and Electronics Engineering	Data Book / Codes/Standards	Nil		

Course Learning Rationale (CLR):	*The purpose of learning this course is to:*
CLR-1 :	*Enrich the students with basic principles and characteristics of various types of electrical machines.*
CLR-2 :	*Examine the design of armature and field systems for D.C. machines.*
CLR-3 :	*Outline the core, windings and cooling systems of transformers*
CLR-4 :	*Analyze the design of stator and rotor of induction machines*
CLR-5 :	*Understand the design of stator and rotor of synchronous machines and study their thermal behavior.*
CLR-6 :	*Understand the overall design of electrical machines*

Course Learning Outcomes (CLO):	*At the end of this course, learners will be able to:*	Learning			Program Learning Outcomes (PLO)														
		1	2	3	1	2	3	4	5	6	7	8	9	10	11	12	13	14	15
		Level of Thinking (Bloom)	Expected Proficiency (%)	Expected Attainment (%)	Engineering Knowledge	Problem Analysis	Design & Development	Analysis, Design, Research	Modern Tool Usage	Society & Culture	Environment & Sustainability	Ethics	Individual & Team Work	Communication	Project Mgt. & Finance	Life Long Learning	PSO - 1	PSO - 2	PSO - 3
CLO-1 :	*Understand the mmf calculation and thermal rating of various types of electrical machines.*	*2*	*80*	*75*	*H*	*H*	*H*	*H*	*L*	-	-	*L*	-	-	-	-	*M*	*M*	*L*
CLO-2 :	*Design DC machine parts such as armature, field, commutator and brushes.*	*3*	*80*	*75*	*H*	*H*	*H*	*H*	*L*	-	-	-	-	-	-	-	*M*	*M*	-
CLO-3 :	*Acquire knowledge on the design of transformers and its operating characteristics.*	*3*	*80*	*75*	*H*	*H*	*H*	*H*	*L*	-	-	-	-	-	-	-	*M*	*M*	-
CLO-4 :	*Interpret the induction motor stator and rotor design equations and magnetic leakage calculations.*	*3*	*80*	*75*	*H*	*H*	*H*	*M*	*L*	-	-	-	-	-	-	-	*M*	*M*	-
CLO-5 :	*Design the components of synchronous motor*	*3*	*80*	*75*	*H*	*H*	*H*	*H*	*L*	-	-	-	-	-	-	-	*M*	*M*	-
CLO-6 :	*Design the components of DC and AC machines*	*3*	*80*	*75*	*H*	*H*	*H*	*H*	*L*	-	-	*L*	-	-	-	-	*M*	*M*	*L*

Duration (hour)		9	9	9	9	9
S-1	SLO-1	*Major considerations, Design factors and limitations in machine design*	*Output Equation of DC machine*	*kVA output for single transformers*	*Output equation of three phase induction motor*	*Output equation of synchronous machine*
	SLO-2	*Limitations in machine design*	*Classification of magnetic materials*	*kVA output for three phase transformers*	*Main dimensions of induction motor*	*Main dimensions and pole constructions in synchronous machine*
S-2	SLO-1	*Electrical Engineering Materials introduction*	*Choice of Specific Electric Loading*	*Window space factor*	*Choice of Specific Electric Loading*	*Choice of Specific Electric and Magnetic Loading*
	SLO-2	*Electrical Engineering Materials classification*	*Choice of Specific Magnetic Loading*	*Core area factor*	*Choice of Specific Magnetic Loading*	*Influence of runaway speed*
S-3	SLO-1	*Magnetic Circuits Calculations*	*Problems with main dimensions*	*Design problems of core dimension for single phase transformer*	*Problems with main dimensions*	*Problems in main dimensions including runaway speed*
	SLO-2	*Problems under MMF Calculation*	*Problems with specific loading*	*Design problems of window dimension for single phase transformer*	*Problems with specific loading*	*Problems in main dimensions including pole constructions*
S-4	SLO-1	*Carter's Coefficient and net length of iron*	*Selection of number of poles*	*Design of core and winding*	*Influence of Length of air gap*	*Short Circuit Ratio (SCR) and Effect of SCR on machine performance*
	SLO-2	*Problems under net length of Iron*	*Design problems including pole design*	*design problems in core and winding*	*Design problems including air gap length*	*Estimation of length of air gap*
S-5	SLO-1	*Real and Apparent flux densities*	*Armature Design procedure*	*Design of three phase transformer winding*	*Selecting rotor slots of squirrel cage machines*	*Problems in MMF*
	SLO-2	*Problems based on real and apparent flux densities*	*Problems in designing of armature*	*Problems on three phase transformer design*	*Design procedure of rotor bars, slots and end ring*	*Problems in SCR and air gap length*
S-6	SLO-1	*Temperature gradients in cores and conductors*	*Design of Commutator*	*Temperature rise in Transformers*	*Design procedure of slots*	*Armature design in synchronous machine*
	SLO-2	*Thermal resistivity of winding*	*Design of brushes*	*Transformer Tank design Procedure*	*Design procedure of end ring*	*Problems in armature design*

S-7	SLO-1	*Problems in temperature gradients*	*Problems in designing of commutator*	*Transformer Cooling tube design Procedure*	*Design problems in squirrel cage rotor*	*Procedure for Estimation of air gap length*
	SLO-2	*Problems in thermal resistivity*	*Problems in designing of brushes*	*Transformer Cooling tube design problems*	*Design procedure for wound rotor*	*Problems in air gap length*
S-8	SLO-1	*Indian Standard Specification for conductor, transformer*	*Computer Aided Design of DC machines – Main dimensions*	*Computer Aided Design of transformer-Core design*	*Computer Aided Design of three phase induction motor – Main dimension, stator design, squirrel cage rotor design*	*Overall design of stator*
	SLO-2	*International Electro- Technical commission Publications 34-1, 34-2*	*Computer Aided Design of DC machines – number of poles*	*Computer Aided Design of transformer-winding design*	*Computer Aided Design of three phase induction motor –squirrel cage rotor design*	*Overall design of rotor*
S-9	SLO-1	*Computer Aided Design introduction and uses*	*CAD – Armature design*	*CAD – Tank design*	*Design practices with software tools for stator design*	*CAD – Stator design*
	SLO-2	*Different approaches in Computer Aided Design*	*CAD – Field design*	*CAD – Cooling tube design*	*Design practices with software tools for rotor design*	*CAD – Rotor design*

Learning Resources	1. *Sawhney, A.K., A Course in Electrical Machine Design, Dhanpat Rai & Sons, New Delhi, 1984.* 2. *Deshpande, M. V.,Design and Testing of Electrical Machine Design, Wheeler Publications, 2010*	3. *Sen, S.K., Principles of Electrical Machine Designs with Computer Programmes, Oxford and IBH Publishing Co. Pvt. Ltd., New Delhi, 1987.* 4. *https://ocw.mit.edu/courses/electrical-engineering-and-computer-science/6-685-electric-machines-fall-2013/*

Learning Assessment											
	Bloom's Level of Thinking	Continuous Learning Assessment (50% weightage)								Final Examination (50% weightage)	
		CLA – 1 (10%)		CLA – 2 (15%)		CLA – 3 (15%)		CLA – 4 (10%)#			
		Theory	Practice	Theory	Practice	Theory	Practice	Theory	Practice	Theory	Practice
Level 1	Remember Understand	40 %	-	30 %	-	30 %	-	30 %	-	30%	-
Level 2	Apply Analyze	40 %	-	40 %	-	40 %	-	40 %	-	40%	-
Level 3	Evaluate Create	20 %	-	30 %	-	30 %	-	30 %	-	30%	-
	Total	100 %		100 %		100 %		100 %		100 %	

CLA – 4 can be from any combination of these: Assignments, Seminars, Tech Talks, Mini-Projects, Case-Studies, Self-Study, MOOCs, Certifications, Conf. Paper etc.,

Course Designers		
Experts from Industry	Experts from Higher Technical Institutions	Internal Experts
1.Mr. A.Kannan, Seshasayee paper and board limited akannan@sbppapers.com	*1. Dr.Chandramohan, CEG, Anna University. c_dramo@annauniv.edu*	*1. Dr. C. Subramani, SRMIST*
2. Mr.Muralikrishna, National Instruments, emkkrishnan@gmail.com	*2. Dr. A. Venkadesan, NIT Puducherry, venkadesan@nitpy.ac.in*	*2. Dr. Arun Noyal Doss, SRMIST*

Course Code	18EEE306T	Course Name	SPECIAL ELECTRICAL MACHINES	Course Category	E	Professional Elective	L	T	P	C
							3	0	0	3

Pre-requisite Courses	Nil	Co-requisite Courses	Nil	Progressive Courses	Nil
Course Offering Department	Electrical and Electronics Engineering	Data Book / Codes/Standards	Nil		

Course Learning Rationale (CLR):	The purpose of learning this course is to:
CLR-1 :	*Acquire knowledge on Stepper motor and its characteristics*
CLR-2 :	*Understand the concepts of switched reluctance motor and its control.*
CLR-3 :	*Gain knowledge on Permanent magnet DC and BLDC Motors*
CLR-4 :	*Analyze the working principle , operation and control of permanent magnet synchronous motor*
CLR-5 :	*Gain knowledge on the basics of various application based motors*
CLR-6 :	*Understand the overall concepts of various special electrical machines*

Course Learning Outcomes (CLO):	At the end of this course, learners will be able to:	Learning 1: Level of Thinking (Bloom)	2: Expected Proficiency (%)	3: Expected Attainment (%)	PLO 1: Engineering Knowledge	2: Problem Analysis	3: Design & Development	4: Analysis, Design, Research	5: Modern Tool Usage	6: Society & Culture	7: Environment & Sustainability	8: Ethics	9: Individual & Team Work	10: Communication	11: Project Mgt. & Finance	12: Life Long Learning	13: PSO - 1	14: PSO - 2	15: PSO - 3
CLO-1 :	*Analyze the working and control of Stepper moor*	3	75	75	H	M	-	-	-	-	-	-	-	-	-	-	H	H	-
CLO-2 :	*Illustrate the operation and characteristics of SRM*	2	75	75	H	-	-	-	-	-	-	-	-	-	-	-	L	L	-
CLO-3 :	*Interpret knowledge on PMDC and BLDC motors for real time applications.*	2	75	75	H	-	-	-	-	-	-	-	-	-	-	-	L	L	-
CLO-4 :	*Evaluate the performance of PMSM*	3	75	75	H	M	-	-	M	-	-	-	-	-	-	-	H	H	-
CLO-5 :	*Understand the characteristics of application based motors*	2	75	75	H	-	-	-	-	-	-	-	-	-	-	-	L	L	-
CLO-6 :	*Summarize the characteristics of various special electrical machines.*	2	75	75	H	M	-	-	M	-	-	-	-	-	-	-	M	M	-

Duration (hour)		9	9	9	9	9
S-1	SLO-1	*Introduction to Stepper motor*	*Introduction to Switched reluctance motor.*	*Construction of PMDC motor*	*Construction, and types of PMSM*	*Construction of repulsion motors*
	SLO-2	*Variable reluctance motor-Construction-Single Stack*	*Elementary operation of SRM*	*Principle of Working PMDC motor*	*Operation of PMSM*	*working and types of repulsion motors*
S-2	SLO-1	*Single Stack-Modes of Excitation-single phase*	*Machine topology*	*Moving Coil motors*	*EMF equation of PMSM*	*Torque equation of repulsion motor*
	SLO-2	*Half Step On mode*	*Operation of Linear SRM*	*Printed coil motors*	*Torque equation of PMSM*	*Phasor diagram of repulsion motor*
S-3	SLO-1	*Multi Stack Motor-Construction*	*Non Linear Analysis of SRM*	*Shell type motor*	*Voltage equation of PMSM*	*Characteristics of repulsion motor*
	SLO-2	*Modes of Excitation*	*Torque Production -SRM*	*BRUSHLESS –Classification of BLDC motor*	*Phasor diagram*	*Applications of repulsion motor*
S-4	SLO-1	*Hybrid stepper Motor-construction-working*	*Voltage and torque equation of SRM*	*Construction and operation of BLDC MOTOR*	*Performance Characteristics Characteristics of PMSM*	*Universal motor-construction and operation*
	SLO-2	*Types of Stepper motors-single phase stepper motor-Disc magnet type-Claw tooth stepper motor*	*Converter Circuit For SRM With Bifilar Winding*	*Equivalent Circuit And Torque Equation*	*Control of PMSM-Vector control*	*Speed control of universal motor*
S-5	SLO-1	*Torque Equation Of stepper Motor*	*Split Link Circuit -SRM*	*Performance Characteristics of BLDC motor*	*Self control of PMSM*	*Linear induction motor – construction*
	SLO-2	*Windings in stepper motor-Unipolar and Bipolar winding*	*C- Dump Circuit-SRM*	*BRUSHLESS –Classification of BLDC motor*	*Microprocessor based control of PMSM*	*Equivalent Circuit of LIM*
S-6	SLO-1	*Static Characteristics of stepper Motor*	*Converter topology - N + 1, (N +1) diodes*	*Construction and operation of BLDC MOTOR*	*Sensorless control of PMSM*	*characteristics of LIM*
	SLO-2	*Dynamic Characteristics of stepper Motor*	*Control Of SRM -Rotor Position Sensor-Optical Position*	*Electronic commutation -180˚ with magnetic arc and 120˚ with square wave phase currents -star connection*	*POWER controllers - PMSM*	*Control of Linear Induction Motor*
S-7	SLO-1	*Open loop Control of Stepper motors*	*Hall Effect Sensing*	*Electronic commutation -180˚ with square wave phase currents and 120˚ with magnetic arc -Delta connection*	*Operation of PMSM using DC-AC Converter with 120° Mode*	*Linear Reluctance motor- Construction*

	SLO-2	*Closed loop Control of Stepper motors*	*Current Regulators-Hysteresis*	*Control of BLDC motor*	*Operation of PMSM using DC-AC Converter with 180° Mode*	*Linear Reluctance motor – working Principle*
S-8	SLO-1	*Microprocessor –based control of stepper motor*	*Voltage –PWM type regulators*	*Microprocessor based control of BLDC motor*	*Modelling of PMSM Using simulaton tool*	*, Linear Reluctance motor Applications*
	SLO-2	*Problem Solving- torque- stepper motor*	*Microprocessor Based Control Of SRM*	*Comparison-Conventional and BLDC*	*Problem Solving - torque-PMSM*	*Ac Servo motors*
S-9	SLO-1	*Problem Solving- step angle-stepper motor*	*Advantages of SRM over other machines*	*Sensor -less Control of BLDC Motors*	*Problem Solving - speed- PMSM*	*Construction and Working*
	SLO-2	*Applications of Stepper Motors*	*, Applications of SRM motors*	*Applications of BLDC Motors*	*Applications of PMSM*	*Torque speed characteristics of servomotor*

Learning Resources	*1. T.J.E. Miller, Permanent Magnet and Reluctance Motor Drives, Clarendon Press, Oxford.* *2. T. Kenjo, Stepping Motors and Their Microprocessor Controls, Clarendon Press London, 2000.* *3. R.Krishnan, Switched Reluctance Motor Drives – Modeling, Simulation, Analysis, Design and Application, CRC Press, New York, 2005.*	*4. P.P. Acarnley, Stepping Motors – A Guide to Motor Theory and Practice', Peter Perengrinus London, 4th edition 2001.* *5..D.P.Kothari and I.J.Nagrath, Electric machines, Tata Mc Graw hill publishing company, New Delhi, Third Edition, 2004.* *6. https://www.coursera.org/learn/motors-circuits-design*

Learning Assessment											
	Bloom's Level of Thinking	Continuous Learning Assessment (50% weightage)								Final Examination (50% weightage)	
		CLA – 1 (10%)		CLA – 2 (15%)		CLA – 3 (15%)		CLA – 4 (10%)#			
		Theory	Practice	Theory	Practice	Theory	Practice	Theory	Practice	Theory	Practice
Level 1	Remember Understand	40 %	-	30 %	-	30 %	-	30 %	-	30%	-
Level 2	Apply Analyze	40 %	-	40 %	-	40 %	-	40 %	-	40%	-
Level 3	Evaluate Create	20 %	-	30 %	-	30 %	-	30 %	-	30%	-
	Total	100 %		100 %		100 %		100 %		100 %	

CLA – 4 can be from any combination of these: Assignments, Seminars, Tech Talks, Mini-Projects, Case-Studies, Self-Study, MOOCs, Certifications, Conf. Paper etc.,

Course Designers		
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Course Code	18EEE401T	Course Name	SOLID STATE DRIVES	Course Category	E	Professional Elective	L	T	P	C
							3	0	0	3

Pre-requisite Courses	18EEC302J	Co-requisite Courses	Nil	Progressive Courses	Nil
Course Offering Department	Electrical and Electronics Engineering	Data Book / Codes/Standards	Nil		

Course Learning Rationale (CLR):	*The purpose of learning this course is to:*
CLR-1 :	*Understand the basics of electric drives*
CLR-2 :	*Explain the working of converter/ chopper fed DC drives*
CLR-3 :	*Design controllers for closed loop operation of DC motor drive*
CLR-4 :	*Acquire knowledge on operation and performance of induction motor drives*
CLR-5 :	*Enumerate the different control strategies of synchronous motor drive*
CLR-6 :	*Expose the students to various power converters associated with DC and AC drives*

		Learning			Program Learning Outcomes (PLO)														
		1	2	3	1	2	3	4	5	6	7	8	9	10	11	12	13	14	15
Course Learning Outcomes (CLO):	*At the end of this course, learners will be able to:*	Level of Thinking (Bloom)	Expected Proficiency (%)	Expected Attainment (%)	Engineering Knowledge	Problem Analysis	Design & Development	Analysis, Design, Research	Modern Tool Usage	Society & Culture	Environment & Sustainability	Ethics	Individual & Team Work	Communication	Project Mgt. & Finance	Life Long Learning	PSO - 1	PSO - 2	PSO - 3
CLO-1 :	*Enrich the basics of electric drives, multi-quadrant operation*	2	75	75	H	M	M	-	-	-	-	-	-	-	-	-	M	M	-
CLO-2 :	*Study and analyze the operation of four quadrant chopper / rectifier and solve simple problems*	3	75	75	H	M	M	M	M	-	-	-	-	-	-	-	M	M	-
CLO-3 :	*Model closed loop DC motor drive and design the current and speed controllers*	3	75	75	H	M	M	M	-	-	-	-	-	-	-	-	M	M	-
CLO-4 :	*Analyze the power electronic converter used for the speed control of induction motor drives*	3	75	75	H	M	M	M	M	-	-	-	-	-	-	-	M	M	-
CLO-5 :	*Analyze the various control schemes for the speed control of synchronous motor drives*	3	75	75	H	M	M	M	M	-	-	-	-	-	-	-	M	M	-
CLO-6 :	*Analyse the operation of DC and AC drives*	3	75	75	H	M	M	M	M	-	-	-	-	-	-	-	M	M	-

Duration (hour)		9	9	9	9	9
S-1	SLO-1	*ElectricDrives: Classification, advantages*	*Review of emf, torque and speed equations*	*Closed loop control of DC drive*	*Review of induction motor torque-speed characteristic*	*Review of synchronous motor torque-speed characteristic*
	SLO-2	*Components of electric drive*	*Review of torque-speed characteristics of DC machine*	*Separately excited DC motor transfer function*	*Equivalent circuit of Induction motor*	*control of synchronous motor*
S-2	SLO-1	*Thermal loading*	*Conventional speed control techniques*	*Modelling closed loop speed control of DC drive using armature voltage control*	*Conventional speed control techniques-Stator side control*	*Separate control of Synchronous motor*
	SLO-2	*Thermal model of motor for heating and cooling*	*Armature and field side control*	*Block diagram of closed loop speed control of DC drive*	*Rotor side control*	*self-control of synchronous motor*
S-3	SLO-1	*Classesofdutycycle*	*DC chopper control strategy*	*Modelling closed loop speed control with inner current controller(P)*	*Inverter control techniques: three-phase PWM generation*	*V/f control of synchronous motor*
	SLO-2	*Determinationofmotor rating – Continuous and intermittent duty*	*Constant and variable frequency control strategies*	*Block diagram of closed loop speed control with inner current controller(P)*	*Sinusoidal modulation*	*VSI fed synchronous motor drive*
S-4	SLO-1	*Simple problems on power rating estimation with Continuous and intermittent duty*	*chopper fed dc motor for speed control- One,two quadrant operation*	*Modelling closed loop speed control with inner current controller(PI)*	*Introduction to vector control*	*Definition of marginal angle*
	SLO-2	*Determinationofmotor rating – short time duty*	*chopper fed dc motor for speed control- four quadrant operation*	*Block diagram of closed loop speed control with inner current controller(PI)*	*Vector control of Induction motor drives*	*Marginal angle control*
S-5	SLO-1	*Determinationofmotor rating – intermittent periodic duty*	*Harmonics and ripple in motor current*	*Modelling closed loop speed control of DC drive with load torque disturbance*	*Conventional space vector modulation.*	*Power factor control*
	SLO-2	*Frequen2cy of operation subjected to intermittent loads*	*Effect on motor performance*	*Block diagram of closed loop speed control of DC drive with load torque disturbance*	*SVPWM for three phase VSI*	*Block diagram for power factor control*
S-6	SLO-1	*Equations governing motor load dynamics*	*Single phase full converter fed separately excited DC motor*	*Modelling DC series motor*	*Introduction to FPGA*	*Recap of single and three phase cycloconverters*

	SLO-2	*Steady state stability at various operating points on Speed –Torque curve*	*Steady state analysis of the drive– continuous conduction*	*Block diagram of DC series motor*	*PWM pulse generation using FPGA*	*Cycloconverter fed synchronous motor*
S-7	SLO-1	*Multi-quadrant Operation*	*Single phase full converter fed separately excited DC motor*	*System response with filters*	*Squirrel cage induction motor: constant V/f control of induction motor*	*Comparison of VSI and CSI fed drives*
	SLO-2	*Real time example for four quadrant operation*	*Steady state analysis of the drive– discontinuous conduction*	*Phase locked loop control*	*Steady-state performance analysis based on equivalent circuit.*	*CSIfed synchronous motor*
S-8	SLO-1	*Components of Load Torques*	*three phase full converter fed separately excited DC motor drive*	*Design of speed controller*	*Impact of rotor resistance on speed torque characteristics – rotor resistance control*	*Permanent magnet synchronous motor*
	SLO-2	*Nature and Classification of Load Torques*	*Steady state analysis of the drive - continuous conduction.*	*Simple problems*	*Derivation for equivalent resistance*	*Closed loop control of PMSM*
S-9	SLO-1	*Need for closed loop control*	*Introduction to software simulation of DC drives.*	*Design of current controller*	*slip power*	*Simulation of induction motor characteristics*
	SLO-2	*Closed loop speed control of drives*	*Chopper based simulation*	*Simple problems*	*slip power recovery schemes - Kramer's drive,Scherbius drive*	*Introduction to software simulation of AC drives.*

Learning Resources	1. *G.K. Dubey, Fundamentals of Electrical Drives, CRC Press,2nd edition, 2015* 2. *Ion Boldea, S.ANasar, Electric Drives, Third edition, CRC Press 2016.* 3. *R. Krishnan, Electric Motor Drives: Modeling, Analysis and Control, Prentice Hall,2001* 4. *S.K.Pillai, Analysis Of Thyristor Power-Conditioned Motors, Universities press,2005*	5. *G.K. Dubey, Power Semiconductor Controlled Drives, Prentice Hall, 1989.* 6. *W. Leonhard, Control of Electric Drives, Springer Science & Business Media, 2001.* 7. *P.C.Sen,Thyristor DC Drives,A Wiley-Interscience Publication* 8. *https://nptel.ac.in/courses/108104011/*

Learning Assessment

	Bloom's Level of Thinking	Continuous Learning Assessment (50% weightage)								Final Examination (50% weightage)	
		CLA – 1 (10%)		CLA – 2 (15%)		CLA – 3 (15%)		CLA – 4 (10%)#			
		Theory	Practice	Theory	Practice	Theory	Practice	Theory	Practice	Theory	Practice
Level 1	Remember Understand	40 %	-	30 %	-	30 %	-	30 %	-	30%	-
Level 2	Apply Analyze	40 %	-	40 %	-	40 %	-	40 %	-	40%	-
Level 3	Evaluate Create	20 %	-	30 %	-	30 %	-	30 %	-	30%	-
	Total	100 %		100 %		100 %		100 %		100 %	

CLA – 4 can be from any combination of these: Assignments, Seminars, Tech Talks, Mini-Projects, Case-Studies, Self-Study, MOOCs, Certifications, Conf. Paper etc.,

Course Designers

Experts from Industry	Experts from Higher Technical Institutions	Internal Experts
1. Dr.S.Paramasivam, Danfoss, Industries Pvt Ltd.,paramsathya@yahoo.com	*1. Dr.R.Subha,, Sir MVIT, Bangalore, subha.mvit@gmail.com*	*1. Ms.D.Anitha, SRMIST*
2. Mr. A.Kannan, Seshasayee paper and board limited akannan@sbppapers.com (machines)	*2. Dr. A. Venkadesan, NIT Puducherry, venkadesan@nitpy.ac.in*	*2. Dr.K.Mohanraj, SRMIST*

Course Code	18EEE402T	Course Name	MODELLING AND ANALYSIS OF ELECTRICAL MACHINES	Course Category	E	Professional Elective	L	T	P	C
							3	0	0	3

Pre-requisite Courses	18EEC204J, 18EEC205J	Co-requisite Courses	Nil	Progressive Courses	Nil
Course Offering Department	Electrical & Electronics Engineering	Data Book / Codes/Standards	Nil		

Course Learning Rationale (CLR):	The purpose of learning this course is to:
CLR-1 :	*Illustrate the reference frame theory*
CLR-2 :	*Formulate the concept of modelling of DC machines*
CLR-3 :	*Understand the theoretical model of synchronous machine*
CLR-4 :	*Derive the mathematical model of poly phase induction machines*
CLR-5 :	*Explain the generalized theory model of a single phase induction machine*
CLR-6 :	*Derive the mathematical model of DC and AC machines*

Course Learning Outcomes (CLO):	At the end of this course, learners will be able to:	Learning 1: Level of Thinking (Bloom)	Learning 2: Expected Proficiency (%)	Learning 3: Expected Attainment (%)	PLO 1: Engineering Knowledge	PLO 2: Problem Analysis	PLO 3: Design & Development	PLO 4: Analysis, Design, Research	PLO 5: Modern Tool Usage	PLO 6: Society & Culture	PLO 7: Environment & Sustainability	PLO 8: Ethics	PLO 9: Individual & Team Work	PLO 10: Communication	PLO 11: Project Mgt. & Finance	PLO 12: Life Long Learning	PLO 13: PSO - 1	PLO 14: PSO - 2	PLO 15: PSO - 3
CLO-1 :	*Outline the basics of rotating reference frame- synchronously and arbitrarily rotating reference frame transformation*	1	75	75	H	H	-	-	-	-	-	-	-	-	-	-	-	-	-
CLO-2 :	*Interpret the modelling of DC machines for dynamic and steady state operation*	2	75	75	H	H	H	M	M	-	-	-	-	-	-	-	M	H	-
CLO-3 :	*Construct the mathematical modelling of three phase synchronous machine*	3	75	75	H	H	H	M	H	-	-	-	-	-	-	-	M	H	-
CLO-4 :	*Inspect the mathematical model of poly phase induction machine for electrical simulation studies*	3	75	75	H	H	H	M	H	-	-	-	-	-	-	-	M	H	-
CLO-5 :	*Apply the generalized theory concept for the modelling of single phase induction machine*	3	75	75	H	H	H	M	H	-	-	-	-	-	-	-	M	H	-
CLO-6 :	*Develop a mathematical model of different types of DC and AC machines*	3	75	75	H	H	H	M	H	-	-	-	-	-	-	-	M	H	-

Duration (hour)		9	9	9	9	9
S-1	SLO-1	*Theory of transformation*	*Introduction to DC machine*	*Introduction to Three phase synchronous machine*	*Three phase induction machine- Types*	*Development of generalized theory*
	SLO-2	*Different reference frames*	*Back EMF equation*	*RMF, MMF waveform*	*MMF waveform*	*The general machine representation*
S-2	SLO-1	*Various sign conventions*	*Speed, torque equations*	*Winding model*	*Equivalent circuit*	*Sign Conventions*
	SLO-2	*Reference frame transformations*	*Terminal voltage equations*	*Modelling assumptions*	*Winding model*	*Voltage equations of a general machine*
S-3	SLO-1	*Illustration of how a transformation can result in constant inductances*	*DC machine types*	*Sign convention*	*Modelling assumptions*	*Flux linkage equations of a general machine*
	SLO-2	*Concept of stationary reference frame*	*separately excited, self-excited- Equivalent circuits*	*Stator voltage equations in abc coordinates*	*Sign convention*	*Torque equation of a general machine*
S-4	SLO-1	*Illustration of transformation of stationary circuit variables*	*Speed - torque characteristics*	*Rotor voltage equations in abc coordinates*	*Stator voltage equations in abc coordinates*	*Illustration of application of generalized theory-DC machine model*
	SLO-2	*Concept of synchronously rotating reference frame*	*Electromechanical model of DC machine*	*Stator flux linkage equations in abc coordinates*	*Rotor voltage equations in abc coordinates, Induction machine: torque equations in abc*	*DC machine model-voltage and flux linkage equations*
S-5	SLO-1	*Concept of arbitrarily rotating reference frame*	*State equations of armature current and speed of DC motor*	*Rotor flux linkage equations in abc coordinates*	*Stator flux linkage equations in abc coordinates*	*DC machine model-Torque equation*
	SLO-2	*Transformation: stationary circuit variables to arbitrary reference frame*	*State-space model of DC machines*	*Stator self-inductance calculation*	*Rotor flux linkage equations in abc coordinates*	*Existing theories for explanation of single phase Induction motor operation, revolving field theory*
S-6	SLO-1	*Illustration of transformation of stationary circuit variables-Resistive elements*	*Transfer function model of DC machines*	*Stator to rotor Mutual-inductance calculation*	*Stator self-inductance calculation*	*MMF and Flux waves, Torque components*

	SLO-2	*Illustration of transformation of stationary circuit variables-Inductive elements*	*Steady state response of DC machines*	*Rotor to Stator Mutual-inductance calculation*	*Stator to rotor and Rotor to Stator, Mutual-inductance calculation*	*Application of generalized theory to single-phase induction motor*
S-7	SLO-1	*Illustration of transformation of stationary circuit variables-Capacitive elements*	*Dynamic characteristics of DC machines*	*Rotor self –inductance calculation*	*Rotor self –inductance calculation*	*Voltage equations of single-phase induction machine*
	SLO-2	*Transformations between reference frames x and y*	*The effect on speed for simultaneous change in input voltage and load torque of DC machine*	*Park's transformation*	*Reference frame transformation*	*Flux linkage equations single-phase induction motor*
S-8	SLO-1	*Transformation of a balanced set to an arbitrarily rotating reference frame (ARF)*	*Calculation of efficiency and starting torque of DC separately excited machine.*	*Voltage equations in dqo reference frame (Park's equations)*	*Voltage equations in arbitrary reference frame*	*Torque equation of single-phase induction motor*
	SLO-2	*Numerical example of transformation to arbitrary reference frame*	*Calculation of speed of DC machine from steady state equations*	*Flux linkage equations in (dqo) rotor reference frame*	*Flux linkage equations arbitrary reference frame,*	*Equivalent circuit of single phase induction machine*
S-9	SLO-1	*Transformation to a synchronously rotating reference frame (SRF), Balanced steady-state phasor relationships*	*Calculation of armature torque and load torque of DC separately excited machine*	*Synchronous machine torque equations in abc and dq variables , Steady state equations in dq variables*	*Induction machine: torque equations in reference frame variable, Steady state equations in dq variables*	*Numerical example to illustrate steady-state computation of single phase induction machine*
	SLO-2	*Summary – various reference frames*	*Computer simulation of DC machine dynamics using transfer function*	*Steady State analysis of Synchronous machine using simulation software*	*Computer simulation of induction motor dynamics in arbitrary reference frame*	*Validation of single phase induction machine model using simulation software*

Learning Resources	1. *Paul C. Krause, Oleg Wasyzczuk, Scott D. Sudhoff, Analysis of Electric Machinery and Drive Systems, IEEE Press, Third Edition, 2013.* 2. *R. Ramanujam, Modeling & Analysis of electrical machines."Ik International Publishing House, New Delhi, 2018.* 3. *P. S. Bimbhra, Generalized theory of Electrical Machines, Khanna Publishers, Sixth Edition, 1995.*	4. *R. Krishnan, Electric Motor Drives: Modelling, Analysis and Control, Prentice Hall of India, 2002.* 5. *Ned Mohan. Advanced electric drives: analysis, control, and modeling using MATLAB/Simulink, John wiley & sons; 2014.* 6. *Bernard Adkins, The General Theory of Electrical Machines, Imperial College of Science and Technology, 1974.* 7. *https://nptel.ac.in/courses/108106023/*

Learning Assessment												
	Bloom's Level of Thinking	Continuous Learning Assessment (50% weightage)								Final Examination (50% weightage)	
		CLA – 1 (10%)		CLA – 2 (15%)		CLA – 3 (15%)		CLA – 4 (10%)#			
		Theory	Practice	Theory	Practice	Theory	Practice	Theory	Practice	Theory	Practice
Level 1	Remember Understand	40 %	-	30 %	-	30 %	-	30 %	-	30%	-
Level 2	Apply Analyze	40 %	-	40 %	-	40 %	-	40 %	-	40%	-
Level 3	Evaluate Create	20 %	-	30 %	-	30 %	-	30 %	-	30%	-
	Total	100 %		100 %		100 %		100 %		100 %	

CLA – 4 can be from any combination of these: Assignments, Seminars, Tech Talks, Mini-Projects, Case-Studies, Self-Study, MOOCs, Certifications, Conf. Paper etc.,

Course Designers		
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2.Dr.V.P.Boopathi, Powersys., Chennai, Boopathivp@gmail.com	*2.Prof. R.P.Kumudini Devi, Anna University, kumudini@annauniv.ac.in*	*2. Dr. M. Arun Noyal Doss. SRMIST*

Course Code	18EEE403T	Course Name	HYBRID ELECTRIC VEHICLES	Course Category	E	Professional Elective	L	T	P	C
							3	0	0	3

Pre-requisite Courses	Nil	Co-requisite Courses	Nil	Progressive Courses	Nil
Course Offering Department	Electrical & Electronics Engineering	Data Book / Codes/Standards	Nil		

Course Learning Rationale (CLR):	*The purpose of learning this course is to:*
CLR-1 :	*Classify the various types of EVs and the power flow involved*
CLR-2 :	*Explain and analyze the storage and battery technologies in EVs*
CLR-3 :	*Discuss and design the various power electronic (PE) topologies involved in EVs*
CLR-4 :	*Analyze the machines and its drives for the propulsion of EVs*
CLR-5 :	*Explain the emerging technologies in EVs*
CLR-6 :	*Create an EV with new and advanced PE topologies and storage systems*

Course Learning Outcomes (CLO):	*At the end of this course, learners will be able to:*	Learning 1 Level of Thinking (Bloom)	2 Expected Proficiency (%)	3 Expected Attainment (%)	PLO 1 Engineering Knowledge	2 Problem Analysis	3 Design & Development	4 Analysis, Design, Research	5 Modern Tool Usage	6 Society & Culture	7 Environment & Sustainability	8 Ethics	9 Individual & Team Work	10 Communication	11 Project Mgt. & Finance	12 Life Long Learning	13 PSO - 1	14 PSO - 2	15 PSO - 3
CLO-1 :	*Infer knowledge about the basics of power flow in electric vehicles*	*2*	*75*	*75*	*H*	*L*	*L*	-	-	-	-	-	-	-	-	-	-	*H*	-
CLO-2 :	*Understand and model a battery energy storage system for EV*	*2*	*75*	*75*	*H*	*L*	*M*	*M*	*M*	-	-	-	-	-	-	-	*M*	*H*	*L*
CLO-3 :	*Acquire knowledge and develop the various PE converters involved in EV*	*3*	*75*	*75*	*H*	*M*	*M*	*M*	*M*	-	-	-	*L*	-	-	-	*M*	*H*	-
CLO-4 :	*Analyze the various machines and drives involved in EVs*	*3*	*75*	*75*	*H*	*M*	*L*	*L*	*M*	-	-	-	*M*	-	-	-	*M*	*H*	-
CLO-5 :	*Design and describe the future enhancement in EVs*	*3*	*75*	*75*	*H*	*M*	*M*	*M*	*M*	*L*	*L*	-	*M*	-	-	-	*H*	*H*	*L*
CLO-6 :	*Develop an EV with batteries, new PE topologies and drives*	*3*	*75*	*75*	*H*	*M*	*M*	*M*	*M*	*L*	*L*	-	*M*	-	-	-	*H*	*M*	*L*

Duration (hour)		9	9	9	9	9
S-1	SLO-1	*Introduction to Electric Vehicles*	*Introduction to Energy Storage system*	*Introduction to charging and requirements of a charging system*	*Introduction to starting system*	*Introduction to the emerging trends in EVs*
	SLO-2	*History of electric vehicles and hybrid electric vehicles*	*Battery Requirements for HEVs, PHEVs, and EVs.*	*Principles of charging system*	*Requirements of a starting system*	*Electric Vehicle Supply Equipments*
S-2	SLO-1	*Social and environmental importance of hybrid and electric vehicles*	*Types of batteries*	*Alternators and charging circuits*	*Principles of starting system*	*Smart vehicles in smart grid*
	SLO-2	*Key challenges of hybrid and electric vehicles*	*Battery characterization*	*Diagnosing charging system faults*	*Various drive system for the transmission of EV*	*Smart vehicles in smart grid*
S-3	SLO-1	*Basics of EV*	*Working principle and construction of lead-acid battery*	*Rectifiers/Inverters for HEV*	*DC/DC chopper based two, four quadrant operations of DC drives - Configuration*	*Vehicle-to-grid technologies*
	SLO-2	*Basics of HEV, PHEV*	*Working principle and construction of nickel cadmium battery*	*Battery chargers: High frequency transformer based bidirectional DC-DC converter*	*DC/DC chopper based two, four quadrant operations of DC drives - Control*	*Vehicle-to-grid technologies*
S-4	SLO-1	*Concept of EV*	*Working principle and construction of nickel metal hydride battery*	*Isolated bidirectional DC-DC converter*	*Inverter based V/f Operation (motoring and braking) of induction motor drive system - Configuration*	*Vehicle-to-grid technologies: Unidirectional*
	SLO-2	*Configurations of EV*	*Working principle and construction of lithium ion battery*	*Half bridge DC-DC converter*	*Inverter based V/f Operation (motoring and braking) of induction motor drive system - Control*	*Vehicle-to-grid technologies: Bidirectional*
S-5	SLO-1	*Concept of Series HEV*	*Diagnosing battery faults.*	*Full bridge DC-DC converter*	*Permanent magnet motor based vector control operation – Configuration*	*Charging Station Selection (CSS) server*
	SLO-2	*Configurations of Series HEV*	*Basic battery modeling: Static and dynamic electric circuit model*	*Four quadrant operation of DC-DC converter*	*Permanent magnet motor based vector control operation –Control*	*Need of Charging Station Selection (CSS) server*
S-6	SLO-1	*Concept of Parallel HEV*	*Battery charging control*	*Flyback converter*	*SRM drives – Configuration*	*Smart grid technologies*

	SLO-2	*Configurations of Parallel HEV (Mechanical Coupling)*	*Battery charging control*	*Cell balancing converters: Active and Passive balancing methods*	*SRM drives –Converter and modes of operation*	*Smart grid technologies: Applications and Benefits*
S-7	SLO-1	*Configurations of Parallel HEV (Torque Coupling)*	*Ultra-capacitor: Symmetrical and asymmetrical – Introduction and Operation*	*Wireless Charging –Inductive Charging*	*Types of starters for motors in EV*	*Smart meter*
	SLO-2	*Configurations of Parallel HEV (Speed Coupling)*	*Ultra-capacitor modeling*	*Wireless Charging –Conductive Charging*	*Diagnosing starter faults*	*Smart meter: Purpose and benefits*
S-8	SLO-1	*Power train components*	*Operation of flywheel and fuel cell*	*Advanced charging system technology*	*Advanced starting system technology*	*Smart charger*
	SLO-2	*Vehicle model*	*Operation of hydraulic energy storage system*	*New developments in charging systems*	*New developments in starting systems*	*Smart charger: Purpose and benefits*
S-9	SLO-1	*EV power train component sizing*	*Simulation of battery model*	*Simulation of any PE converter for EV*	*Simulation and implementation of PE converter fed drives for EVs*	*Technical talk on any new emerging trend in EVs*
	SLO-2	*EV power train component sizing*	*Simulation of ultra-capacitor model*	*Simulation of any PE converter for EV*	*Simulation and implementation of PE converter fed drives for EVs*	*Technical talk on any new emerging trend in EVs*

Learning Resources	1. *M. Ehsani, Y. GAO, and A. Emadi, Modern Electric, Hybrid Electric, and Fuel Cell Vehicles: Fundamentals, Theory, and Design, Second Edition, CRC Press, ISBN: 978-1-4200-5398-2, Aug. 2009.* 2. *IqbalHussain, Electric & Hybrid Vehicles – Design Fundamentals, Second Edition, CRC Press, 2011.* 3. *Sheldon S. Williamson, Energy Management Strategies for Electric and Plug-in Hybrid Electric Vehicles, Springer, 2013.*	4. *Chris Mi, M. AbulMasrur, David WenzhongGao, Hybrid Electric Vehicles Principles and Applications With Practical Perspectives, Wiley Publication, 2011.* 5. *Tom Denton, Automobile Electrical and Electronic Systems, Elsevier, Butterworth – Heinemann, Third Edition, 2004* 6. *https://nptel.ac.in/courses/108103009/*

Learning Assessment

	Bloom's Level of Thinking	Continuous Learning Assessment (50% weightage)								Final Examination (50% weightage)	
		CLA – 1 (10%)		CLA – 2 (15%)		CLA – 3 (15%)		CLA – 4 (10%)#			
		Theory	Practice	Theory	Practice	Theory	Practice	Theory	Practice	Theory	Practice
Level 1	Remember Understand	40 %	-	30 %	-	30 %	-	30 %	-	30%	-
Level 2	Apply Analyze	40 %	-	40 %	-	40 %	-	40 %	-	40%	-
Level 3	Evaluate Create	20 %	-	30 %	-	30 %	-	30 %	-	30%	-
	Total	100 %		100 %		100 %		100 %		100 %	

CLA – 4 can be from any combination of these: Assignments, Seminars, Tech Talks, Mini-Projects, Case-Studies, Self-Study, MOOCs, Certifications, Conf. Paper etc.,

Course Designers

Experts from Industry	Experts from Higher Technical Institutions	Internal Experts
1. Dr. S.Archana, Valeo Pvt Ltd, archana.arc19@gmail.com	*1. Dr.G.Uma, CEG, uma@annauniv.edu*	*1.Dr. U. Sowmmiya, SRMIST*
2. Mr. Kopaka Chaitanya, Valeo Pvt Ltd, chaithu.239@gmail.com	*2.Dr.S.Hosimin Thilagar, CEG, shthilagar@gmail.com*	*2.Dr. A.Rathinam, SRMIST*

Course Code	18EEE307T	Course Name	SOLAR PHOTOVOLTAIC SYSTEM	Course Category	E	Professional Elective	L	T	P	C
							3	0	0	3

Pre-requisite Courses	Nil	Co-requisite Courses	Nil	Progressive Courses	Nil
Course Offering Department	Electrical and Electronics Engineering	Data Book / Codes/Standards	Nil		

Course Learning Rationale (CLR):	*The purpose of learning this course is to:*
CLR-1 :	*Learn the fundamental principle and fabrication of PV cell*
CLR-2 :	*Study about PV characteristics and MPPT algorithms*
CLR-3 :	*Utilize the various components and installation of standalone PV system*
CLR-4 :	*Study about the PV integration with utility grid*
CLR-5 :	*Know net metering and applications of Photovoltaic systems*
CLR-6 :	*Model a solar photovoltaic system*

Course Learning Outcomes (CLO):	*At the end of this course, learners will be able to:*	Learning 1: Level of Thinking (Bloom)	2: Expected Proficiency (%)	3: Expected Attainment (%)	PLO 1: Engineering Knowledge	2: Problem Analysis	3: Design & Development	4: Analysis, Design, Research	5: Modern Tool Usage	6: Society & Culture	7: Environment & Sustainability	8: Ethics	9: Individual & Team Work	10: Communication	11: Project Mgt. & Finance	12: Life Long Learning	13: PSO - 1	14: PSO - 2	15: PSO - 3
CLO-1 :	*Understand the basics of PV energy conversion and cell fabrication*	2	80	75	H	M	M	-	-	-	M	-	-	-	-	-	H	M	-
CLO-2 :	*Acquire knowledge about PV module and MPPT techniques*	3	80	75	H	M	M	-	M	-	M	-	-	-	-	-	M	M	-
CLO-3 :	*Design stand-alone PV system*	3	80	75	H	M	M	M	-	-	H	H	M	M	-	-	H	M	M
CLO-4 :	*Analyze grid connected PV system*	3	80	75	H	M	M	M	-	-	-	-	-	-	-	-	H	H	-
CLO-5 :	*Develop a PV system for various applications*	3	80	75	H	M	M	M	-	-	-	-	-	-	-	-	H	M	-
CLO-6 :	*Design a photovoltaic on grid and off grid system*	3	80	75	H	M	M	M	M	-	M	H	M	M	-	-	H	M	M

Duration (hour)		9	9	9	9	9
S-1	SLO-1	*Global energy scenario*	*I-V,PV characteristics of a PV*	*Classification of PV systems*	*Grid Interactive PV System.*	*Need for Metering, Types of metering*
	SLO-2	*Indian energy scenario*	*Modelling of PV*	*Central Power Station System , Distributed PV System*	*Principle components in Grid –PV system*	*Concepts in Grid Tie systems*
S-2	SLO-1	*Historical development of PV*	*Short Circuit, Open Circuit and peak power parameters*	*Stand alone PV System*	*Classification of Grid Tie Inverters*	*Net metering and its importance*
	SLO-2	*Photovoltaic cell technologies*	*Datasheet study, Cell efficiency*	*Components of standalone PV connected system*	*Working Central inverter, String Inverter, Micro Inverter.*	*Net metering benefits, policies*
S-3	SLO-1	*Basics of energy from sun: Insolation, irradiance, Solar constant*	*Effect of irradiation and temperature*	*Charge controllers*	*Grid-connected single phase PV inverter schemes*	*PV potential and facilities in rural areas*
	SLO-2	*Insolation variation with time of day, Earth centric viewpoint and declination*	*Shading impacts ,Fill factor*	*Batteries*	*Grid-connected PV control*	*Electrifying rural and remote areas using PV*
S-4	SLO-1	*Solar geometry*	*Solar PV Module and its parameters*	*Inverter control topologies*	*Power processing schemes based on single string, multi-string*	*Introduction to hybrid PV system*
	SLO-2	*Description of the solar spectrum*	*Specifications of Solar PV Module*	*Stand-alone connection of PV modules to a battery and load*	*AC module technologies*	*Smart grid*
S-5	SLO-1	*Sun position, sun path diagrams, solar and clock times*	*Parallel and series connections. Identical cells Non-identical cells connection*	*Energy storage alternatives for PV systems.*	*Sizing the inverter*	*Case studies on Solar PV Power Plant*
	SLO-2	*Solar radiation measurements, resource of solar data.*	*Protecting cells in series and parallel, Interconnecting modules*	*Storage batteries, lead-acid, nickel-cadmium, nickel-metal-hydride and lithium type batteries.*	*PV system sizing, efficiency*	*Survey on existing solar PV system*
S-6	SLO-1	*Photovoltaic effect - Principle of direct solar energy conversion into electricity in a solar cell system.*	*Estimation and Measurement of PV Module Power*	*Small storage systems employing ultra capacitors, charging and discharging properties*	*Transformer less inverter topologies for grid connected PV applications*	*Design and Development of PV vehicle charging system*
	SLO-2	*Semiconductor properties semiconductor physics*	*Selection of PV Module, Interfacing PV modules to loads*	*Modeling of batteries load estimation, battery sizing*	*Centralized grid-connected three-phase inverters for large PV installations*	*PV powered lighting, Solar Lantern, LED for building etc*

S-7	SLO-1	*Solar cell - p-n Junction, Solar cell- basic structure*	*PV cell simulation*	*Design and Installation of a standalone PV system*	*Design related issues; grounding, dc arcing, islanding*	*PV water pumping, DC and AC pump drive*
	SLO-2	*Solar cell materials ,its properties and construction*	*Simulation of PV cells in series and parallel.*	*Mechanical Considerations for PV installation*	*Harmonic content, reactive power, wiring issues,electro-magnetic interference*	*PV applications in aircraft, power satellites.*
S-8	SLO-1	*Types of solar cells :crystalline, multi-crystalline, thin film silicon solar cells, etc*	*Maximum power point concept*	*Trouble shooting of Standalone Solar PV System*	*Interfacing with the power grid economic considerations*	*Socio-economic and environmental impacts of PV system*
	SLO-2	*Commercial Si solar cells, recent development in materials used for solar cell*	*Power conditioning and maximum power point tracking*	*Maintenance of Solar PV System*	*Energy yield of grid connected PV installation- Cost and Investment*	*PV in portable devices*
S-9	SLO-1	*Solar cells fabrication*	*MPPT basic Algorithms overview*	*Safety in installation of Solar PV System*	*Modeling of stand-alone and grid-connected PV systems*	*Impact of high PV penetration in power system*
	SLO-2	*Process involved solar cell fabrication technologies*	*MPPT algorithms based on buck- and boost-converter topologies*	*Codes and standards Related to PV Systems: National Electric Code(NEC) and IEEE Standard 1547*	*Simulation of stand-alone and grid-connected PV systems*	*Markets for photovoltaic systems*

Learning Resources	1. *Chetan Singh Solanki., Solar Photovoltaic: Fundamentals, Technologies and Application, PHI Learning Pvt., Ltd., 2nd edition 2011.* 2. *Rai, G.D., Solar Energy Utilization, Khanna Publishers, N. Delhi, 2010.*	3. *R. Messenger, J. Ventre, Photovoltaic Systems Engineering, CRC Press 3rd edition.,2010.* 4. *Sukhatme S.P., Solar Energy, Tata McGraw Hills P Co., 3rd Edition, 2008.* 5. *https://nptel.ac.in/courses/117108141/*

Learning Assessment

	Bloom's Level of Thinking	Continuous Learning Assessment (50% weightage)								Final Examination (50% weightage)	
		CLA – 1 (10%)		CLA – 2 (15%)		CLA – 3 (15%)		CLA – 4 (10%)#			
		Theory	Practice	Theory	Practice	Theory	Practice	Theory	Practice	Theory	Practice
Level 1	Remember Understand	40 %	-	30 %	-	30 %	-	30 %	-	30%	-
Level 2	Apply Analyze	40 %	-	40 %	-	40 %	-	40 %	-	40%	-
Level 3	Evaluate Create	20 %	-	30 %	-	30 %	-	30 %	-	30%	-
	Total	100 %		100 %		100 %		100 %		100 %	

CLA – 4 can be from any combination of these: Assignments, Seminars, Tech Talks, Mini-Projects, Case-Studies, Self-Study, MOOCs, Certifications, Conf. Paper etc.,

Course Designers

Experts from Industry	Experts from Higher Technical Institutions	Internal Experts
1.Dr.P.Kanagavel,NIWE,Chennai,pkanagavel.niwe@nic.in	*1. P.Thamizhazhagan,University college of Engineering, Panruti,thamizhme@gmail.com*	*1. Ms A.Lavanya, SRMIST*
2.Mr.Jason Manoraj , L&T Technology Services Limited,Bengaluru, Karnataka,jasonmanoraj@gmail.com	*2. Dr Subhransu Sekhar Dash, Government College of Engineering, Keonjhar, Subhransudash_fee@gcekjr.ac.in*	*2. Dr.R.Sridhar, SRMIST*

Course Code	18EEE308T	Course Name	ENERGY MANAGEMENT SYSTEM AND SCADA	Course Category	E	Professional Elective	L	T	P	C
							3	0	0	3

Pre-requisite Courses	Nil	Co-requisite Courses	Nil	Progressive Courses	Nil
Course Offering Department	Electrical and Electronics Engineering	Data Book / Codes/Standards	Nil		

Course Learning Rationale (CLR):	*The purpose of learning this course is to:*
CLR-1 :	*Impart knowledge on energy management and its planning*
CLR-2 :	*Understand the efficient usage of electric energy for motor driven system*
CLR-3 :	*Identify the strategies and control of energy management systems*
CLR-4 :	*Expose to the concept of supervisory control and data acquisition*
CLR-5 :	*Familiarize about Power System Automation and application of SCADA in power systems.*
CLR-6 :	*Understand the concept of Energy management and SCADA*

Course Learning Outcomes (CLO):	*At the end of this course, learners will be able to:*	Learning 1 Level of Thinking (Bloom)	2 Expected Proficiency (%)	3 Expected Attainment (%)	PLO 1 Engineering Knowledge	2 Problem Analysis	3 Design & Development	4 Analysis, Design, Research	5 Modern Tool Usage	6 Society & Culture	7 Environment & Sustainability	8 Ethics	9 Individual & Team Work	10 Communication	11 Project Mgt. & Finance	12 Life Long Learning	13 PSO - 1	14 PSO - 2	15 PSO - 3
CLO-1 :	*Understand the values, importance, principles and effective utilization of energy*	2	75	75	H	-	-	-	-	-	-	-	-	-	-	-	M	M	-
CLO-2 :	*Apply energy efficient schemes for motor under varying loads*	2	75	75	H	M	-	-	-	-	-	-	-	-	-	-	M	M	-
CLO-3 :	*Implement the energy management control strategies*	2	75	75	H	M	-	-	-	-	-	-	-	-	-	-	M	M	-
CLO-4 :	*Analyze the Functions and features of SCADA*	3	75	75	H	-	-	-	-	-	-	-	-	-	-	-	M	M	-
CLO-5 :	*Infer the Applications and Standards of SCADA*	2	75	75	H	-	-	-	-	-	-	L	-	-	-	-	M	M	L
CLO-6 :	*Apply the knowledge of Energy management and SCADA in Industries*	2	75	75	H	M	-	-	-	-	-	L	-	-	-	-	M	M	L

Duration (hour)		9	9	9	9	9
S-1	SLO-1	*Value of Energy Management*	*Power supply of an electrical motor driven system*	*Introduction to Energy management systems(EMS)*	*Introduction of SCADA*	*Introduction to Power System Automation*
	SLO-2	*Total Quality Management*	*Effects of Unbalanced Voltages on The Performance of Poly-phase Squirrel-Cage Induction Motors*	*Usage of EMS*	*SCADA Systems*	*Benefits of Power System Automation*
S-2	SLO-1	*Energy Management Profession*	*Glossary of frequently occurring motor terms*	*Direct Digital Control*	*Evolution of SCADA*	*Functional structure of Power System Automation*
	SLO-2	*Energy Management skills*	*Design , Load types and torque of motor*	*Objectives of an EMCS using DDC*	*Objectives of SCADA*	*Architecture For Power System Automation*
S-3	SLO-1	*Principles of Energy Management*	*Power factor of motor*	*Hardware used in Energy management systems*	*Benefits of SCADA*	*Classification of Power System Automation- Substation Automation*
	SLO-2	*Some Suggested Principles of Energy Management*	*Benefits and correction of power factor*	*Advantages of Hardware used in Energy management systems*	*SCADA in Process Control*	*Classification of Power System Automation- Distribution Automation*
S-4	SLO-1	*Introduction to Energy Management Program*	*Electric motor design to operate at varying load conditions*	*Software used in Energy management systems*	*Usage of SCADA*	*Implementation Of Power System Automation Using SCADA*
	SLO-2	*Components of Comprehensive Energy Management Program*	*Determining Electric Motor Operating Loads*	*Effectiveness of the Software Control Logic*	*Real-Time Monitoring and Control using SCADA*	*Implementation Of Power System Protection Using SCADA*
S-5	SLO-1	*Organizational Structure*	*Power meter to measure unit operation*	*Control Strategies*	*Functions of SCADA*	*SCADA Based Model for Automation*
	SLO-2	*Energy manager , Team and Employees*	*Selection of Equipment for Power Measurement and Surveys*	*Routines of Control Strategies*	*SCADA Applications*	*SCADA Based Model Digital Protection*
S-6	SLO-1	*Energy Policy Objectives and Accountability*	*Slip measurement of motor*	*Justification of Energy Management Control Systems(EMCSs)*	*SCADA Hardware*	*Introduction to Applications of SCADA*
	SLO-2	*Energy Policy Reporting and Training*	*Amperage Readings*	*EMCSs Functions*	*SCADA Hardware Functions*	*SCADA Applications in Power Systems:*
S-7	SLO-1	*Energy Planning*	*Amperage Readings of Electric motor*	*EMCS opportunity*	*RTU Standards*	*Expected Benefits of SCADA for Power Systems*

	SLO-2	*Audit Planning*	*Electric Motor efficiency*	*EMCS for an building*	*Difference between PLC and RTU*	*SCADA for Power Utility Network*
S-8	SLO-1	*Educational Planning*	*Comparing Motors based on efficiency*	*EMCS Retrofit*	*Features of SCADA*	*Components of SCADA Applications*
	SLO-2	*Strategic Planning*	*Sensitivity of Load To Motor Rpm*	*New Construction EMCS*	*Software of SCADA*	*Introduction to IEC 61850 Standard for SCADA*
S-9	SLO-1	*Energy Reporting*	*Motor Performance Management Process(MPMP)*	*System Integration*	*Protocols of SCADA, DNP (Distributed Network Protocol)*	*Intelligent Electronic Devices (IEDs)*
	SLO-2	*Energy Ownership*	*How To Start MPMP*	*Specifics of Software Logic*	*Protocols of SCADA, IEC (International Electro Technical Commission)*	*Substation Automation System (SAS) using IED:*

Learning Resources	1. *Wayne C. Turner, Steve Doty, Energy Management Hand book, The Fairmont Press, 6th Edition, 2007* 2. *Green, J. N, Wilson, R, Control and Automation of Electric Power Distribution Systems, Taylor and Francis, 2007* 3. *NPTEL Online Courses, Energy Management Systems and SCADA, IIT Madras. Link : “https://nptel.ac.in/courses/108106022/12“*

Learning Assessment											
	Bloom’s Level of Thinking	Continuous Learning Assessment (50% weightage)								Final Examination (50% weightage)	
		CLA – 1 (10%)		CLA – 2 (15%)		CLA – 3 (15%)		CLA – 4 (10%)#			
		Theory	Practice	Theory	Practice	Theory	Practice	Theory	Practice	Theory	Practice
Level 1	Remember Understand	40 %	-	30 %	-	30 %	-	30 %	-	30%	-
Level 2	Apply Analyze	40 %	-	40 %	-	40 %	-	40 %	-	40%	-
Level 3	Evaluate Create	20 %	-	30 %	-	30 %	-	30 %	-	30%	-
	Total	100 %		100 %		100 %		100 %		100 %	

CLA – 4 can be from any combination of these: Assignments, Seminars, Tech Talks, Mini-Projects, Case-Studies, Self-Study, MOOCs, Certifications, Conf. Paper etc.,

Course Designers		
Experts from Industry	Experts from Higher Technical Institutions	Internal Experts
1. Dr.P.Kanakavel,NIWET,pkanagavel.niwet@nic.in	*1. Dr. S. Arul Daniel, NIT Trichy, daniel@nitt.edu*	*1. Dr.S.Vidyasagar, SRMIST*
2. Mr. Tripathi patro,visam pvt ltd,btp@visom.co.in	*2. Dr. P. Somasundaram, CEG, Anna University, mpsomasundaram@annauniv.edu*	*2. Dr.V.Kalyanasundaram, SRMIST*

Course Code	18EEE309T	Course Name	DISTRIBUTED ENERGY RESOURCES	Course Category	E	Professional elective	L	T	P	C
							3	0	0	3

Pre-requisite Courses	Nil	Co-requisite Courses	Nil	Progressive Courses	Nil
Course Offering Department	Electrical and Electronics Engineering	Data Book / Codes/Standards	Nil		

18EEE327T Course Learning Rationale (CLR):	*The purpose of learning this course is to:*
CLR-1 :	*Understand the basic operation of non conventional energy sources*
CLR-2 :	*Gain the knowledge about PV system*
CLR-3 :	*Acquire the knowledge of wind power Generation*
CLR-4 :	*Explain the energy production from Biomass and OTEC*
CLR-5 :	*Describe the working of Battery, Flywheel, Ultra Capacitors, micro-turbines*
CLR-6 :	*Acquire the Knowledge of Nonconventional energy sources*

Course Learning Outcomes (CLO):	*At the end of this course, learners will be able to:*	Learning 1 Level of Thinking (Bloom)	Learning 2 Expected Proficiency (%)	Learning 3 Expected Attainment (%)	PLO 1 Engineering Knowledge	PLO 2 Problem Analysis	PLO 3 Design & Development	PLO 4 Analysis, Design, Research	PLO 5 Modern Tool Usage	PLO 6 Society & Culture	PLO 7 Environment & Sustainability	PLO 8 Ethics	PLO 9 Individual & Team Work	PLO 10 Communication	PLO 11 Project Mgt. & Finance	PLO 12 Life Long Learning	PLO 13 PSO - 1	PLO 14 PSO - 2	PLO 15 PSO - 3
CLO-1 :	*Describe the basic operation of PV,wind,Fuel cell, Micro turbine, Biomass, Tidal power generation*	*1*	*75*	*75*	*H*	-	-	-	-	-	*M*	-	-	-	-	-	*M*	*M*	*L*
CLO-2 :	*Develop the knowledge of PV collector types and know the technical parameters*	*2*	*75*	*75*	*H*	*M*	-	-	-	-	*M*	-	-	-	-	-	*M*	*M*	*L*
CLO-3 :	*Distinguish different types of wind turbine and know the technical parameters*	*2*	*75*	*75*	*H*	*M*	-	-	-	-	*M*	-	-	-	-	-	*M*	*M*	*L*
CLO-4 :	*Summarize the functions of Biomass and OTEC*	*1*	*75*	*75*	*H*	-	-	-	-	-	*M*	-	-	-	-	-	*M*	*M*	*L*
CLO-5 :	*Realize the functions of Battery, Flywheel, Ultra Capacitors, micro-turbines*	*2*	*75*	*75*	*H*	-	-	-	-	-	*M*	-	-	-	-	-	*M*	*M*	*L*
CLO-6 :	*Develop the knowledge of the fundamental operation of unconventional energy sources*	*2*	*75*	*75*	*H*	*M*	-	-	-	-	*M*	-	-	-	-	-	*M*	*M*	*L*

Duration (hour)		9	9	9	9	9
S-1	SLO-1	*Definition, Concepts of Non Conventional Energy Sources*	*Definition, Solar radiation data*	*Energy available from wind*	*Biomass Resources*	*Energy storage, Battery – types*
	SLO-2	*Limitations of Non Conventional Energy Sources*	*solar energy conversion in to heat*	*General formula, Lift and drag etc*	*Biofuels*	*Equivalent circuit*
S-2	SLO-1	*Energy needs of India, and energy consumption patterns*	*Solar Radiation Measurement*	*Basis of Wind energy conversion*	*Biomass Conversion Routes*	*Performance characteristics*
	SLO-2	*Worldwide Potentials of these sources.*	*Types of Measurement*	*Basic components of wind energy conversion*	*Combustion, Gasification*	*Battery design*
S-3	SLO-1	*Energy efficiency and energy security*	*Flat plate and Concentrating collectors*	*Effect of density, Frequency variances,*	*Anaerobic Digestion*	*Charging and charge regulators*
	SLO-2	*Energy and its environmental impacts*	*Principle of natural and forced convection*	*Angle of attack, Wind speed*	*Pyrolysis*	*Battery management*
S-4	SLO-1	*Technical impact of Distributed generation*	*Energy Storage of PV system*	*Choice of generators*	*Cogeneration*	*Flywheel-energy relations*
	SLO-2	*Economical impact of Distributed generation*	*Case studies of Solar thermal systems for residential water heating*	*Turbine rating, electrical load matching*	*Biogas plants*	*Components of Flywheel*
S-5	SLO-1	*Concept of distributed generations, topologies, selection of sources*	*Industrial heating*	*Variable speed operation*	*Energy recovery from Urban waste*	*Benefits over battery*
	SLO-2	*regulatory standards/ framework*	*Solar power generation*	*Maximum power operation*	*.Energy recovery from liquid waste*	*Introduction to Ultra Capacitors*
S-6	SLO-1	*Definition of Distributed Generation*	*Concept of Maximum Power Point Tracking*	*control systems, system design features,*	*Types of Biomass plant*	*Working Principle of Ultra Capacitors*
	SLO-2	*Classification of Distributed Generation*	*Types of MPPT*	*Windmill rotors, Horizontal axis*	*Performance analysis of Biomass*	*Testing of Ultra capacitor*
S-7	SLO-1	*DG installation classes*	*DC Power Conditioning Converters*	*Vertical axis rotors*	*Testing Biomass systems*	*Applications*
	SLO-2	*Security issues in DG implementations.*	*Types of converter*	*Induction type generators,*	*Thermal applications*	*Fuel Cells – Principle of Operation*
S-8	SLO-1	*Distributed Generation Impact on Coordinated Relay Protection*	*AC Power Conditioning –Inverters*	*Working principle of wind power plant*	*Power generation*	*Performance characteristics*

	SLO-2	*Classification of NCES, Solar, Wind,*	*Types of inverter*	*Determination of torque coefficient*	*Principles of tidal and wave power generations*	*Applications*
S-9	SLO-1	*Geothermal, Biomass, Ocean energy sources,*	*Testing of PV systems*	*Standalone connected operations*	*Open cycle OTEC*	*micro-turbines- Principle -of Operation*
	SLO-2	*Comparison of these energy sources*	*Type of testing of PV system*	*Grid connected operations*	*Closed cycle OTEC*	*Advantages and Disadvantages of Microturbine*

Learning Resources	1. *0Rai ,G.D.,Non Conventional sources of Energy, Khanna Publishers ,5th Edition, 2016.* 2. *Rao. S. & Pamlekar Dr.B.B. Energy Technology , Khanna Publishers, 3rd Edition, 2016* 3. *Khan. B.H, Non-Conventional Energy Resources, The McGraw Hills,Second edition, 2016.*	*4.D.P.Kothari, Renewable Energy Sources and Emerging Technologies, PHI Learning Private Limited, 4th Edition 2011.* *5.Bansal NK, Kleeman and Meliss M, Renewable energy sources and conversion Techniques, Tata Mc Graw Hill, 1990 .* *6.https://www.toppr.com/guides/physics/sources-of-energy/non-conventional-sources-of-energy/*

Learning Assessment

	Bloom's Level of Thinking	Continuous Learning Assessment (50% weightage)								Final Examination (50% weightage)	
		CLA – 1 (10%)		CLA – 2 (15%)		CLA – 3 (15%)		CLA – 4 (10%)#			
		Theory	Practice	Theory	Practice	Theory	Practice	Theory	Practice	Theory	Practice
Level 1	Remember Understand	40 %	-	30 %	-	30 %	-	30 %	-	30%	-
Level 2	Apply Analyze	40 %	-	40 %	-	40 %	-	40 %	-	40%	-
Level 3	Evaluate Create	20 %	-	30 %	-	30 %	-	30 %	-	30%	-
	Total	100 %		100 %		100 %		100 %		100 %	

CLA – 4 can be from any combination of these: Assignments, Seminars, Tech Talks, Mini-Projects, Case-Studies, Self-Study, MOOCs, Certifications, Conf. Paper etc.,

Course Designers

Experts from Industry	Experts from Higher Technical Institutions	Internal Experts
1. Dr. Bhaskarsahu, Schneider Electric Ltd, Bhaskar.sahu@schneider-electric.com	*1. Dr. K. S. Swarup, IITM, ksswarup@iitm.ac.isn*	*1.Dr.D.Sattianadan, SRMIST*
2. Dr.P.Kanakavel,NIWET,pkanagavel.niwet@nic.in	*2. Dr. R.Ramesh, CEG, rramesh@annauniv.edu*	*2.Dr.K.Vijayakumar, SRMIST*

Course Code	18EEE404T	Course Name	DISTRIBUTED GENERATION AND MICRO GRID	Course Category	E	Professional elective	L	T	P	C
							3	0	0	3

Pre-requisite Courses	Nil	Co-requisite Courses	Nil	Progressive Courses	Nil
Course Offering Department	Electrical and Electronics Engineering	Data Book / Codes/Standards	Nil		

Course Learning Rationale (CLR):	*The purpose of learning this course is to:*
CLR-1 :	*Understand the basic operation of non-conventional energy sources*
CLR-2 :	*Gain knowledge of IEEE rules applied for distributed generation*
CLR-3 :	*Discuss the concept of microgrid*
CLR-4 :	*Acquire the knowledge on the control algorithms of microgrid*
CLR-5 :	*Examine the behavior of microgrid under Faulty condition*
CLR-6 :	*Acquire the Knowledge of Micro grid*

Course Learning Outcomes (CLO):	*At the end of this course, learners will be able to:*	Learning 1: Level of Thinking (Bloom)	2: Expected Proficiency (%)	3: Expected Attainment (%)	Program Learning Outcomes (PLO) 1: Engineering Knowledge	2: Problem Analysis	3: Design & Development	4: Analysis, Design, Research	5: Modern Tool Usage	6: Society & Culture	7: Environment & Sustainability	8: Ethics	9: Individual & Team Work	10: Communication	11: Project Mgt. & Finance	12: Life Long Learning	13: PSO - 1	14: PSO - 2	15: PSO - 3
CLO-1 :	*Summarize the basic operation of PV, Wind, Fuel cell, Micro turbine, Biomass, Tidal power generation*	*1*	*75*	*75*	*H*	*M*	*M*	-	-	-	*H*	-	-	-	-	-	*M*	*M*	*H*
CLO-2 :	*Interpret the standards required for distributed Generation*	*1*	*75*	*75*	*H*	-	-	-	-	-	*H*	*H*	-	-	-	-	*M*	*M*	*H*
CLO-3 :	*Describe Islanding process and Distributed Generation impact on Coordinated Relay Protection*	*2*	*75*	*75*	*H*	*M*	*M*	-	-	-	*M*	-	-	-	-	-	*M*	*M*	*M*
CLO-4 :	*Apply the knowledge on the control concept and interface devices*	*2*	*75*	*75*	*H*	-	-	-	-	-	-	-	-	-	-	-	*M*	*M*	-
CLO-5 :	*Analyze protection schemes adopted to the microgrid*	*3*	*75*	*75*	*H*	*M*	*M*	*L*	-	-	-	-	-	-	-	-	*M*	*M*	-
CLO-6 :	*Develop the knowledge of fundamental operation of Micro grid*	*3*	*75*	*75*	*H*	*M*	*M*	*L*	-	-	*H*	*M*	-	-	-	-	*M*	*M*	*H*

Duration (hour)		9	9	9	9	9
S-1	SLO-1	*Conventional power generation: advantages and disadvantages*	*Concept of distributed generations*	*Concept and definition of microgrid*	*Typical structure and configuration of a microgrid*	*Modelling of Microgrid*
	SLO-2	*Energy crises, Nonconventional energy (NCE) resources*	*topologies, selection of sources, regulatory standards/ framework*	*microgrid drivers and benefits*	*AC and DC microgrids*	*Concept of per unit*
S-2	SLO-1	*Review of Solar PV*	*Classification of Distributed Generation*	*review of sources of microgrids*	*Control techniques applied to micrgrid*	*DC Microgrid*
	SLO-2	*Solar Radiation Measurement*	*DG installation classes*	*P-f and Q-V control*	*Concept of Space Vector Modulation*	*AC Microgrid*
S-3	SLO-1	*Introduction to Wind Energy systems*	*IEEE 1547 – Standard for Interconnecting Distributed Resources with Electric Power Systems*	*ISLANDING - Significance of Islanding Detection*	*Concept of synchronizing*	*Technical issues of Micro grid*
	SLO-2	*Basic components of wind energy conversion*	*Purpose and Limitations*	*Effects of Islanding Phenomena*	*Synchronizing methods*	*Power loss and Voltage raise*
S-4	SLO-1	*Types of wind energy collectors*	*IEEE 1547.1 standard Conformance Test*	*Islanding Detection Techniques- Active Detection*	*Enhanced Interface Devices*	*Protection scheme for grid-connected mode*
	SLO-2	*Concept of Maximum Power Point Tracking*	*Purpose and Limitations*	*Passive Detection*	*Dynamic Voltage Restorer*	*Thermal issues*
S-5	SLO-1	*Introduction to fuel cell*	*IEEE 1547.4 – Guide for Design, Operation and Integration*	*Optimal Power Sharing*	*Constant Voltage Transformers*	*Power quality issues in microgrids*
	SLO-2	*Fuel Cells – Principle of Operation*	*Purpose and Limitations*	*Microgrid with Multiple Distributed Generators*	*Noise Filters*	*Solution methods*
S-6	SLO-1	*Introduction to Micro turbines*	*IEEE 1547.8 Recommended practice for Establishing methods and Procedures*	*Optimal sizing and Sitting of DG*	*Isolation Transformers*	*Stability issues in micro grid*
	SLO-2	*Micro-turbines- Principle of Operation*	*Purpose and Limitations*	*Peak Shaving Potential of a Microgrid*	*Static VAR Compensators*	*Solution methods*

S-7	SLO-1	*Biomass- Biomass Resources, Biofuels*	*Energy storage elements - Batteries*	*Operating modes of DG- Grid connected*	*Harmonic Filters*	*Economic impact of DG*
	SLO-2	*Biomass Conversion Technologies*	*Principle of operation*	*Operating modes of autonomous mode*	*Microgrid Operation Strategies*	*Barriers to DG Development*
S-8	SLO-1	*Energy recovery from Urban waste*	*ultra-capacitors*	*Concept of reverse power flow*	*MicroGrids and Traditional Power*	*Configuration of SCADA*
	SLO-2	*.Energy recovery from liquid waste*	*Principle of operation*	*Distributed Generation Impact on Coordinated Relay Protection*	*System Economics*	*Energy Management System*
S-9	SLO-1	*Principles of tidal and wave power generations*	*Flywheels*	*Adaptive relaying*	*Case Studies : Microgrid Economics*	*active distribution networks Distributed control system (DCS)*
	SLO-2	*Open cycle OTEC and closed cycle OTEC*	*Principle of operation*	*Fault Limiters*	*Economic Issues Between MicroGrids and the Bulk Power Systems*	*Impact of EV on micro grid*

Learning Resources	1. *AmirnaserYezdani, and Reza Iravani, Voltage Source Converters in Power Systems: Modeling, Control and Applications, IEEE John Wiley Publications,2009.* 2. *DorinNeacsu, Power Switching Converters: Medium and High Power, CRC Press, Taylor & Francis, 2006.* 3. *Chetan Singh Solanki, Solar Photo Voltaics, PHI learning Pvt. Ltd., New Delhi,2009.*	*4.J.F. Manwell, Wind Energy Explained, theory design and applications, J.G. McGowan Wiley publication,2002.* *5.D. D. Hall and R. P. Grover, Biomass Regenerable Energy, John Wiley, New York, 1987.* *6.S.Chowdhury, S.P. Chowdhury, Microgrids and Active Distribution Networks, IET renewable energy series 6* *7.https://www.powermag.com/the-smart-grid-and-distributed-generation-better-together/*

Learning Assessment

	Bloom's Level of Thinking	Continuous Learning Assessment (50% weightage)								Final Examination (50% weightage)	
		CLA – 1 (10%)		CLA – 2 (15%)		CLA – 3 (15%)		CLA – 4 (10%)#			
		Theory	Practice	Theory	Practice	Theory	Practice	Theory	Practice	Theory	Practice
Level 1	Remember Understand	40 %	-	30 %	-	30 %	-	30 %	-	30%	-
Level 2	Apply Analyze	40 %	-	40 %	-	40 %	-	40 %	-	40%	-
Level 3	Evaluate Create	20 %	-	30 %	-	30 %	-	30 %	-	30%	-
	Total	100 %		100 %		100 %		100 %		100 %	

CLA – 4 can be from any combination of these: Assignments, Seminars, Tech Talks, Mini-Projects, Case-Studies, Self-Study, MOOCs, Certifications, Conf. Paper etc.,

Course Designers

Experts from Industry	Experts from Higher Technical Institutions	Internal Experts
1. Dr. Bhaskarsahu, Schneider Electric Ltd, Bhaskar.sahu@schneider-electric.com	*1. Dr.S.Senthilkumar, NIT Trichy, skumar@nitt.edu*	*1.Dr.D.Sattianadan, SRMIST*
2. Dr.P.Kanakavel,NIWET,pkanagavel.niwet@nic.in	*2. Dr. B. K. Panigrahi, IIT Delhi, bkpanigrahi@ee.iitd.ac.in*	*2.Dr.K.Vijayakumar, SRMIST*

Course Code	18EEE405T	Course Name	POWER ELECTRONICS IN RENEWABLE ENERGY SYSTEM	Course Category	E	Professional Elective	L	T	P	C
							3	0	0	3

Pre-requisite Courses	Nil	Co-requisite Courses	Nil	Progressive Courses	Nil
Course Offering Department	Electrical and Electronics Engineering	Data Book / Codes/Standards	Nil		

Course Learning Rationale (CLR):	The purpose of learning this course is to:
CLR-1 :	*Educate the students on contemporary development in renewable energy studies*
CLR-2 :	*Design and analyze the power converters for PV applications*
CLR-3 :	*Understand the significance of the power converters for wind energy conversion system*
CLR-4 :	*Create insights into the concept of fuel energy system and its power conditioning system*
CLR-5 :	*Enrich the concept of hybrid renewable energy systems and multiport converters*
CLR-6 :	*Create overall structure for integrating renewable electricity on the grid*

Course Learning Outcomes (CLO):	At the end of this course, learners will be able to:	Learning 1: Level of Thinking (Bloom)	2: Expected Proficiency (%)	3: Expected Attainment (%)	PLO 1: Engineering Knowledge	2: Problem Analysis	3: Design & Development	4: Analysis, Design, Research	5: Modern Tool Usage	6: Society & Culture	7: Environment & Sustainability	8: Ethics	9: Individual & Team Work	10: Communication	11: Project Mgt. & Finance	12: Life Long Learning	13: PSO - 1	14: PSO - 2	15: PSO - 3
CLO-1 :	*Acquire knowledge on renewable energy sources and their characteristics*	2	80	75	H	M	M	-	-	-	M	-	-	-	-	-	H	M	-
CLO-2 :	*Select and design the components of a power converter for PV system*	3	80	75	H	M	M	-	M	-	M	-	-	-	-	-	M	M	-
CLO-3 :	*Propose an appropriate power converter for wind energy conversion system*	3	80	75	H	M	M	-	M	-	M	-	-	-	-	-	H	M	-
CLO-4 :	*Choose a suitable converter topology for fuel cell-based energy system*	3	80	75	H	M	M	-	-	-	M	-	-	-	-	-	H	H	-
CLO-5 :	*Analyze various hybrid energy system for various applications*	3	80	75	H	-	-	-	-	-	M	-	-	-	-	-	H	M	-
CLO-6 :	*Design the building blocks of the renewable energy conversion system*	3	80	75	H	M	M	-	M	-	M	-	-	-	-	-	H	M	-

Duration (hour)		9	9	9	9	9
S-1	SLO-1	*Present scenario of renewable energy sources in India*	*Photovoltaic system components*	*Components of a wind energy conversion system*	*Basic overview of fuel cell currently under development*	*Need for Hybrid Systems*
	SLO-2	*Solar, wind, ocean, Biomass, Fuel cell and geothermal resources.*	*Factor influencing output*	*Site selection consideration*	*Applications and markets- Portable and stationary application*	*Types of Hybrid system*
S-2	SLO-1	*Factors influencing the amount of GHG emission*	*Types of PV system*	*Wind generators-Introduction*	*Fuel cell design levels: The unit cell, the stack, and the system*	*wind-diesel hybrid system*
	SLO-2	*Impacts of renewable energy generation on environment*	*Stand-alone PV system and grid connected PV system*	*Classification of wind generators*	*Types of fuel cell and its comparative study*	*PV-Diesel hybrid system*
S-3	SLO-1	*Basic principle of photovoltaic Energy Conversion*	*PV and IV characteristics*	*Power output performance characteristics*	*Chemical reaction in various fuel cell*	*PV-hydro hybrid system*
	SLO-2	*PV materials*	*Modeling of PV system*	*Modeling of wind energy conversion system*	*Components of fuel cell- Electrolytes and catalyst*	*Biomass-PV-diesel hybrid system*
S-4	SLO-1	*Issues associated with the tapping of solar energy*	*Factors to be considered for the selection of inverter and batteries for solar energy conversion*	*Matrix converters*	*Thermodynamic and electrochemical principles of hydrogen fuel cell*	*Economic, technical and sustainability issues involved in the integration of hybrid renewable energy systems*
	SLO-2	*Limitations of solar power*	*Sizing the solar arrays*	*Limitations in the operation of matrix converter.*	*High temperature fuel cell*	*Current status of solar-wind hybrid renewable energy system*
S-5	SLO-1	*Wind resource assessment*	*Batteries for solar panel*	*Synchronized operation with grid supply*	*Fuel cell power system*	*Hybrid system characteristics*
	SLO-2	*wind energy pattern for a particular location*	*various aspects of battery sizing*	*Harmonic distortion*	*MPPT techniques for fuel cell*	*Various power quality issues hybrid renewable power system*
S-6	SLO-1	*Basic principle of wind energy conversion*	*DC power conditioning converters*	*Standards used for grid integration- Grid connection requirement of renewable power system.*	*Design consideration of power electronics converters for fuel cell system*	*Merits of Hybrid RES over the isolated RES*

	SLO-2	*Power in wind –Betz limit*	*AC Power conditioning converters*	*Disturbances from power conditioning devices on the power grid- Power quality issues*	*Power conversion and control strategies*	*Case studies on wind-PV maximum power tracking system*
S-7	SLO-1	*Net metering concept*	*Basic non-isolated converters*	*problems in grid integrated WECS*	*Issues in fuel cell power conditioning system*	*Multi-port DC-DC converter*
	SLO-2	*Repowering concept*	*Isolated dc-dc converters*	*Impact of wind power penetration in power grid*	*Fuel cell power conditioning for electric power applications*	*Flux additive dc-dc converter*
S-8	SLO-1	*Hydrogen energy system*	*Converter dynamics and control*	*Design and optimization of renewable energy system*	*High gain dc-dc converters for fuel cell based electric vehicle*	*Hybrid controller*
	SLO-2	*Hydrogen energy to generate electric power*	*Bidirectional inverter system*	*Simulation software for distributed generation power system*	*Operating principles of high gain dc-dc converter*	*Major features of hybrid system.*
S-9	SLO-1	*Working principle of fuel cell*	*Simulation of PV and IV characteristics*	*Simulation of Sizing, and analysis of WECS*	*Reliability study on fuel cell*	*Merits and demerits of various renewable energy technologies*
	SLO-2	*Fuel cell characteristics*	*Simulation of Sizing, and analysis of photovoltaic systems.*	*Simulation of power electronic converters for WECS*	*Recent research in fuel cell technology*	*Application of various renewable energy technologies.*

Learning Resources	1. *Rashid .M. H, Power Electronics Hand book, Academic press, Second edition, 2006.* 2. *Gray, L. Johnson, Wind energy system, prentice hall linc, 1995*	3. *Fuchs, Ewald F., Masoum, Mohammad A.S, Power Conversion of Renewable Energy Systems, 978-1-4419-7978-0, springer, 2011.S.N.Singh, Electric power generation, transmission and distribution, 2nd ed., PHI, 2011* 4. *Erickson, Robert W., Maksimovic, Dragan Fundamental of Power electronics, springer, 2001.* 1. *https://nptel.ac.in/courses/108108034/*

Learning Assessment											
	Bloom's Level of Thinking	Continuous Learning Assessment (50% weightage)								Final Examination (50% weightage)	
		CLA – 1 (10%)		CLA – 2 (15%)		CLA – 3 (15%)		CLA – 4 (10%)#			
		Theory	Practice	Theory	Practice	Theory	Practice	Theory	Practice	Theory	Practice
Level 1	Remember Understand	40 %	-	30 %	-	30 %	-	30 %	-	30%	-
Level 2	Apply Analyze	40 %	-	40 %	-	40 %	-	40 %	-	40%	-
Level 3	Evaluate Create	20 %	-	30 %	-	30 %	-	30 %	-	30%	-
	Total	100 %		100 %		100 %		100 %		100 %	

CLA – 4 can be from any combination of these: Assignments, Seminars, Tech Talks, Mini-Projects, Case-Studies, Self-Study, MOOCs, Certifications, Conf. Paper etc.,

Course Designers		
Experts from Industry	Experts from Higher Technical Institutions	Internal Experts
1.Dr.P.Kanagavel, Additional Director, R & D, NIWE, Government of India, pkanagavel.niwe@nic.in	*1.Dr Subhransu Sekhar Dash, Government College of Engineering, Keonjhar, Subhransudash_fee@gcekjr.ac.in*	*1. Dr.J.Divya Navamani, SRMIST.*
2.Mr.Jason Mano Raj, Consultant, L& T Technical services, Bangalore jasonmanoraj@gmail.com	*2.Dr.P.Thamizhagan, EEE department,University college of Engineering, Panruti, thamizhme@gmail.com*	*2.Dr.R.Sridhar, SRMIST*

Course Code	18EEE406T	Course Name	WIND AND SOLAR ENERGY SYSTEM	Course Category	E	Professional Elective	L	T	P	C
							3	0	0	3

Pre-requisite Courses	Nil	Co-requisite Courses	Nil	Progressive Courses	Nil
Course Offering Department	Electrical and Electronics Engineering	Data Book / Codes/Standards	Nil		

Course Learning Rationale (CLR):	*The purpose of learning this course is to:*
CLR-1 :	*Learn about PV technology and it principles*
CLR-2 :	*Enrich the solar energy concepts*
CLR-3 :	*Understand the various techniques involved in solar energy*
CLR-4 :	*Gain knowledge in Wind Energy technology*
CLR-5 :	*Acquire knowledge in various design of wind energy*
CLR-6 :	*Apply the concepts of solar and wind power in industrial applications*

Course Learning Outcomes (CLO):	*At the end of this course, learners will be able to:*	Learning 1: Level of Thinking (Bloom)	Learning 2: Expected Proficiency (%)	Learning 3: Expected Attainment (%)	PLO 1: Engineering Knowledge	PLO 2: Problem Analysis	PLO 3: Design & Development	PLO 4: Analysis, Design, Research	PLO 5: Modern Tool Usage	PLO 6: Society & Culture	PLO 7: Environment & Sustainability	PLO 8: Ethics	PLO 9: Individual & Team Work	PLO 10: Communication	PLO 11: Project Mgt. & Finance	PLO 12: Life Long Learning	PLO 13: PSO - 1	PLO 14: PSO - 2	PLO 15: PSO - 3
CLO-1 :	*Explain the principle of solar energy*	2	80	75	H	M	L	-	-	-	L	-	-	-	-	-	H	M	-
CLO-2 :	*Design the Solar PhotoVoltaic and shadow analysis*	3	80	75	H	M	L	-	-	-	L	-	-	-	-	-	H	M	-
CLO-3 :	*Analyze various solar application*	3	80	75	H	M	L	-	-	-	L	-	-	-	-	-	H	M	-
CLO-4 :	*Classify the various wind generators and their control techniques*	3	80	75	H	M	L	-	-	-	L	-	-	-	-	-	H	M	-
CLO-5 :	*Explain the various types of wind generators*	3	80	75	H	M	L	-	-	-	L	-	-	-	-	-	H	M	-
CLO-6 :	*Apply knowledge of solar and wind energy systems for various applications*	3	80	75	H	M	L	-	-	-	L	-	-	-	-	-	H	M	-

Duration (hour)		9	9	9	9	9
S-1	SLO-1	*Solar radiation*	*Solar cell- module-array*	*Battery storage autonomy*	*Wind resources nature*	*Characteristics of WECS*
	SLO-2	*Beam and diffuse radiation*	*Electrical characteristics of the solar cell*	*State of Charge (SOC)*	*Occurrence of wind Power in the wind*	*Principle of operation and analysis of WECS*
S-2	SLO-1	*Solar constant, earth*	*Equivalent circuit*	*Depth of Discharge(DOD)*	*Wind characteristics*	*Types of generators: IG, PMSG, SCIG*
	SLO-2	*Sun angles*	*Modeling of solar cells including the effects of temperature*	*Types of battery*	*Principles of wind energy conversions*	*DFIG*
S-3	SLO-1	*Attenuation of solar radiation*	*Irradiation and series/shunt resistances on the open-circuit voltage*	*Types of mechanical tracking*	*Components of wind energy conversions system (WECS) Aerodynamics of wind turbine*	*Grid Connected WECS*
	SLO-2	*Measurement of solar radiation*	*Irradiation and series/shunt resistances on the short-circuit current.*	*Significance of MPPT*	*Wind data*	*Grid connectors concepts*
S-4	SLO-1	*Local solar time, derived solar angles*	*IV characteristics of solar cell*	*Types of MPPT*	*HAWT, VAWT, power developed,thrust, efficiency*	*Wind farm and its accessories*
	SLO-2	*Sunrise, sunset and day length. Flat plate collectors*	*Shadow effects*	*Mitigation techniques of shadow analysis*	*Rotor selection*	*Systems forfeeding into the grid*
S-5	SLO-1	*Declination angle*	*Bypass diodes*	*Street lighting*	*Rotor design considerations*	*Induction Generators for direct grid coupling*
	SLO-2	*Solar window, cosine law*	*Hot spot problem in a PV module*	*Solar distillation*	*Tip speed ratio*	*Challenges in Grid connected wind power*
S-6	SLO-1	*Calculation of angle of incidence*	*Safe operating area*	*Solar air heaters, types*	*Number of blades, blade profile*	*Asynchronousgenerators in static cascades*
	SLO-2	*Seasonal variations, daily variation*	*Temperature effects of solar PV module*	*Active solar heaters*	*Power regulation*	*Power evacuation issues*
S-7	SLO-1	*hour angle*	*Types of solar panels*	*Passive solar heaters*	*Yaw control, pitch angle control*	*Synchronous generators*
	SLO-2	*Latitude angle*	*Issues in the stand alone solar system*	*Solar pond*	*Stall control*	*Grid related problems*
S-8	SLO-1	*Longitude angle*	*Types of losses in solar panel.*	*Water pumping*	*Schemes for maximum power extraction.*	*Wind generatorcontrolling techniques*

	SLO-2	*Zenith angle*	*Solar Photovoltaic power plant.*	*Domestic lighting*	*Site Selection*	*Issues in hybrid of solar and wind power*
S-9	SLO-1	*Concentrating collectors.*	*Net metering concept*	*Grid connected PV systems*	*Environmental aspects*	*Different schemes*
	SLO-2	*Advantages and disadvantages of solar*	*Design :Panel requirements for a particular load*	*Challenges in Grid connected solar PV*	*Solidity*	*AC voltage controllers*

Learning Resources	1. *Rai ,G.D.,Non-Conventional sources of Energy, 5th Edition, Khanna Publishers , 2016* 2. *Khan. B.H, Non-Conventional Energy Resources, 2nd Edition,The McGraw Hills, , 2016* 3. *Rai, G.D.,Non-Conventional sources of Energy, 5th Edition, Khanna Publishers , 2016.* 4. *Khan. B.H, Non-Conventional Energy Resources, 2nd Edition, The McGraw Hills, 2016.*	5. *Thomas Ackermann, Wind Power in Power Systems, John Wiley & Sons, Ltd, 2005* 6. *Mukund R. Patel, "ind and Solar Power Systems, CRC Press, 1999* 7. *Muhammed H. Rashid, "ower Electronics Handbook" Academic Press, Second* 8. *Bansal N K, Kleeman and Meliss, "enewable energy sources and conversion Techniques, Tata McGraw hill, 1990.* 9. *https://onlinecourses-archive.nptel.ac.in/*

Learning Assessment											
	Bloom's Level of Thinking	Continuous Learning Assessment (50% weightage)								Final Examination (50% weightage)	
		CLA – 1 (10%)		CLA – 2 (15%)		CLA – 3 (15%)		CLA – 4 (10%)#			
		Theory	Practice	Theory	Practice	Theory	Practice	Theory	Practice	Theory	Practice
Level 1	Remember Understand	40 %	-	30 %	-	30 %	-	30 %	-	30%	-
Level 2	Apply Analyze	40 %	-	40 %	-	40 %	-	40 %	-	40%	-
Level 3	Evaluate Create	20 %	-	30 %	-	30 %	-	30 %	-	30%	-
	Total	100 %		100 %		100 %		100 %		100 %	

CLA – 4 can be from any combination of these: Assignments, Seminars, Tech Talks, Mini-Projects, Case-Studies, Self-Study, MOOCs, Certifications, Conf. Paper etc.,

Course Designers		
Experts from Industry	Experts from Higher Technical Institutions	Internal Experts
1. Mr.Manjunath rao, Alstrom,manjunath.rao1103@gmail.com	*1. Dr.S.Senthilkumar, NIT Trichy, skumar@nitt.edu*	*1. Dr. K.Saravanan, SRMIST*
2. Mr.Srinath rao, Alstrom,sreenathr.rao@alstrom.com	*2. Dr. S. Ramareddy, Jerusalem College of Engineering,srr.victory@gmail.com*	*2. Dr.R.Sridhar, SRMIST*

Course Code	18EEE310T	Course Name	ENERGY CONSERVATION & AUDITING	Course Category	E	Professional Elective	L	T	P	C
							3	0	0	3

Pre-requisite Courses	Nil	Co-requisite Courses	Nil	Progressive Courses	Nil
Course Offering Department	Electrical and Electronics Engineering	Data Book / Codes/Standards			

Course Learning Rationale (CLR):	*The purpose of learning this course is to:*
CLR-1 :	*Understand the current energy scenario and energy conservation.*
CLR-2 :	*Familiarize the basics of energy and its forms*
CLR-3 :	*Outline the concepts of energy management and audit*
CLR-4 :	*Discuss the methods of improving energy efficiency in different electrical machines*
CLR-5 :	*Describe the methods of improving energy efficiency in different industrial systems*
CLR-6 :	*Obtaining wide knowledge about energy management procedures in industrial system*

Course Learning Outcomes (CLO):	*At the end of this course, learners will be able to:*	Learning 1: Level of Thinking (Bloom)	2: Expected Proficiency (%)	3: Expected Attainment (%)	PLO 1: Engineering Knowledge	2: Problem Analysis	3: Design & Development	4: Analysis, Design, Research	5: Modern Tool Usage	6: Society & Culture	7: Environment & Sustainability	8: Ethics	9: Individual & Team Work	10: Communication	11: Project Mgt. & Finance	12: Life Long Learning	13: PSO - 1	14: PSO - 2	15: PSO - 3
CLO-1 :	*Relate the energy scenario and energy conservation*	2	80	75	H	M	-	-	-	-	-	H	-	-	-	-	-	-	H
CLO-2 :	*Explain about various energies and its conversions*	3	80	75	H	M	-	-	-	-	-	-	-	-	-	-	M	M	-
CLO-3 :	*Implement the procedure for energy audit*	3	80	75	H	H	-	-	-	-	-	-	-	-	-	-	M	M	-
CLO-4 :	*Assess the energy efficiency in electrical components*	3	80	75	H	H	-	-	-	-	H	H	-	-	-	-	H	M	H
CLO-5 :	*Assess the energy efficiency in industrial system*	3	80	75	H	H	M	-	-	-	-	-	-	-	H	-	H	M	-
CLO-6 :	*Apply energy saving concepts in electrical system*	3	80	75	H	H	M	-	-	-	M	H	-	-	H	-	H	M	H

Duration (hour)		9	9	9	9	9
S-1	SLO-1	*Energy Classifications*	*Forms of energy*	*Energy management*	*Introduction to energy policy, synopsis of National energy policies in India, EC Act 2001.*	*Air condition and refrigeration*
	SLO-2	*Primary energy consumption*	*Energy conversion, Grades*	*Energy audit - types*	*ISO-50001, PDCA, PAT scheme*	*Diesel Generator*
S-2	SLO-1	*Indian energy scenario*	*Electrical energy*	*Conservation opportunities*	*BEE & State Development Agencies & EESL Programmes*	*Energy Efficiency in Building*
	SLO-2	*World energy scenario*	*Electrical energy conversion*	*Conservation opportunities*	*Ujala & SEEP Programs*	*Energy Efficiency in Building*
S-3	SLO-1	*Energy needs*	*Electricity Tariff – M.D.,*	*Energy costs, bench marking*	*Municipal & Agriculture DSM Initiatives*	*Savings opportunities in HVAC*
	SLO-2	*Energy pricing*	*Electrical Tariff T.O.D., P.F*	*Energy performance*	*Standards and Labelling Programme EEC initiatives in Other Sectors*	*Fans and blowers*
S-4	SLO-1	*Energy sector reforms*	*Electrical Tariff – two-part tariff and others*	*System efficiencies*	*Energy tariffs*	*Conservation opportunities*
	SLO-2	*Green house, climate change*	*Numerical Examples on electrical basics*	*Energy substitution*	*Energy Instrument*	*Pumps - CASE STUDY*
S-5	SLO-1	*Future effects*	*Numerical Examples on electrical tariff*	*audit instruments*	*Energy Instrument*	*Control strategies*
	SLO-2	*Energy security*	*Thermal energy– temperature, pressure*	*Facility as an energy system*	*Measurement of harmonics*	*Conservation opportunities*
S-6	SLO-1	*Energy conservation*	*Heat transfer*	*Preparing process flow*	*Harmonics Analyzer*	*Cooling Tower -performance*
	SLO-2	*Material and energy balance*	*Latent heat, super heat*	*Energy efficiency in electrical system*	*Power quality analyzer, Thermal Imagining camera, Thermocouple*	*Efficient system operation*
S-7	SLO-1	*Energy balance calculations*	*Humidity*	*Electric motor, compressor, pump.*	*Hot wire anemometer, Energy meter.*	*Efficient system operation*
	SLO-2	*Restructuring energy sector*	*Conduction / convection / radiation / evaporation*	*Power factor improvement,Load management.*	*Combustion analyzer, Airflow meter, Ultrasonic leak detector*	*Validation of energy saving using application software*
S-8	SLO-1	*Energy strategy*	*Units and conversion – pressure, power,*	*Numerical Examples on power factor*	*Occupancy sensors,*	*Energy saving opportunities*
	SLO-2	*Air pollution*	*Units and conversion - energy units*	*Numerical Examples on power factor*	*energy efficient lighting controls*	*Energy saving opportunities*

S-9	SLO-1	*Energy conservation act*	*Numerical example on energies*	*Numerical examples on harmonics*	*Energy saving potential of technology*	*Assessment of cooling towers*
	SLO-2	*Extracted features of the act*	*Numerical example on energies*	*Numerical examples on harmonics*	*Case study on energy saving technologies*	*Assessment of cooling towers*

Learning Resources	*1. Guide books for National Certification Examination for Energy Manager / Energy Auditors Book-1, General Aspects (www.aipnpc.org/GuideBooks.aspx)* *2. Guide books for National Certification Examination for Energy Manager / Energy Auditors Book-3, Electrical Utilities (www.aipnpc.org/GuideBooks.aspx)*	*3. S. C. Tripathy, Utilization of Electrical Energy and Conservation, McGraw Hill, 1991.* *4. Success stories of Energy Conservation by BEE, New Delhi (www.bee-india.org).* *5. Chopra S.K, Energy Policy for India, Oxford & IBH Publishing, ISBN 812041604X* *6. Alagiri, Dhandapani, Energy Security in India, icfai university press, ISBN8131404617*

Learning Assessment

	Bloom's Level of Thinking	Continuous Learning Assessment (50% weightage)								Final Examination (50% weightage)	
		CLA – 1 (10%)		CLA – 2 (15%)		CLA – 3 (15%)		CLA – 4 (10%)#			
		Theory	Practice	Theory	Practice	Theory	Practice	Theory	Practice	Theory	Practice
Level 1	Remember Understand	40 %	-	30 %	-	30 %	-	30 %	-	30%	-
Level 2	Apply Analyze	40 %	-	40 %	-	40 %	-	40 %	-	40%	-
Level 3	Evaluate Create	20 %	-	30 %	-	30 %	-	30 %	-	30%	-
	Total	100 %		100 %		100 %		100 %		100 %	

CLA – 4 can be from any combination of these: Assignments, Seminars, Tech Talks, Mini-Projects, Case-Studies, Self-Study, MOOCs, Certifications, Conf. Paper etc.,

Course Designers

Experts from Industry	Experts from Higher Technical Institutions	Internal Experts
Dr. P.Dharmalingam, Former Director, NPC	*Dr.M.Premalatha , Professor, DEE,NIT-Trichy, latha@nitt.edu*	*Mr.D.Ravichandran,SRMIST*
Mr.J.Sathiyanarayanan,Senior engineer, Southern Railway, Railwayengineer1990@gmail.com	*Dr.Ruben sudhakar D, Assist. Prof.Grade-I,DEE, NIT-Trichy rubensudhakar@nitt.edu*	*Dr.C.Naveen,SRMIST*

Course Code	18EEE311T	Course Name	INDUSTRIAL POWER SYSTEM	Course Category	E	Professional Elective	L	T	P	C
							3	0	0	3

Pre-requisite Courses	Nil	Co-requisite Courses	Nil	Progressive Courses	Nil
Course Offering Department	Electrical and Electronics Engineering	Data Book / Codes/Standards			

Course Learning Rationale (CLR):	*The purpose of learning this course is to:*
CLR-1 :	*Understand the wiring system for residential ,commercial and industrial consumers*
CLR-2 :	*Acquire knowledge on standard methodologies for measuring energy in the workplace and energy audit instruments.*
CLR-3 :	*Acquire knowledge about Electrical distribution system design aspects of industrial and commercial buildings*
CLR-4 :	*Comprehend power quality issues and power factor correction*
CLR-5 :	*Describe the various techniques in industrial automation*
CLR-6 :	*Acquire knowledge on the methodologies and technologies of industrial automation*

Course Learning Outcomes (CLO):	*At the end of this course, learners will be able to:*	Learning 1: Level of Thinking (Bloom)	2: Expected Proficiency (%)	3: Expected Attainment (%)	PLO 1: Engineering Knowledge	2: Problem Analysis	3: Design & Development	4: Analysis, Design, Research	5: Modern Tool Usage	6: Society & Culture	7: Environment & Sustainability	8: Ethics	9: Individual & Team Work	10: Communication	11: Project Mgt. & Finance	12: Life Long Learning	13: PSO - 1	14: PSO - 2	15: PSO - 3
CLO-1 :	*Design the different components of wiring system*	2	80	75	H	M	M	M	-	-	-	L	-	-	-	-	M	L	L
CLO-2 :	*Analyze the concept of energy audit and different loads*	3	80	75	H	M	M	L	-	-	-	-	-	-	-	-	M	M	L
CLO-3 :	*Evaluate and design of distribution system and address different Communication systems in industries*	3	80	75	H	M	L	L	-	-	-	M	-	-	-	-	M	M	-
CLO-4 :	*Address the different power quality problem and various methods of power factor correction*	3	80	75	H	-	-	-	-	-	-	-	-	-	-	-	M	M	-
CLO-5 :	*Identify, monitor and control using PLC and SCADA*	2	80	75	H	M	M	L	M	-	-	-	-	-	-	-	M	M	-
CLO-6 :	*Analyze the problem pertaining to power management and automation in industries*	3	80	75	H	M	M	L	M	-	-	-M	-	-	-	-	M	M	L

Duration (hour)		9	9	9	9	9
S-1	SLO-1	*LT system wiring components*	*System approach and End use approach to efficient use of Electricity*	*Electrical System Design*	*Overview of power quality*	*Computer controlled systems Insulation coordination and Automation*
	SLO-2	*Selection of cables,wires,switches*	*Energy auditing: Types and objectives*	*Distribution System Design*	*Various issues in power quality*	*Modeling of system*
S-2	SLO-1	*Selection of distribution box.*	*audit instruments- ECO assessment*	*Electrical Design Aspects of Industrial Buildings*	*Various standards of voltages*	*simulation of switching surges*
	SLO-2	*Metering system*	*Economic methods*	*Commercials Buildings – Design aspects*	*Voltage sag-Definition and types*	*capabilities; voltage acceptance criteria*
S-3	SLO-1	*Tariff structure*	*specific energy analysis*	*Electrical Safety*	*System Data for power quality*	*insulation coordination case study*
	SLO-2	*Protection components*	*Minimum energy paths*	*Earthing Practices at various voltage levels*	*Voltage Drop Calculations*	*methods of minimizing switching transients*
S-4	SLO-1	*Fuse ,MCB inverse current characteristics*	*Electric motors*	*IS Code for earthing*	*Computer- Aided Analysis*	*Study role of Basic PLC*
	SLO-2	*Isolator ,Relay,MPCB*	*Energy efficient controls and starting efficiency*	*Distribution Automation System : Necessity, System Control Hierarchy*	*Power factor correction studies*	*Role of an automation*
S-5	SLO-1	*Electric shock and safety practices*	*Motor Efficiency*	*Basic Distribution Management System Functions*	*Introduction to over voltages*	*Advantages of process automation*
	SLO-2	*Types of Residential system*	*Load Analysis*	*Integration of Distributed Generation*	*Description and Modeling*	*PLC based control system design , Panel metering*
S-6	SLO-1	*Types of commercial wiring system*	*Variable speed drives*	*Custom Power components in distribution systems-*	*Acceptance Criteria-Frequency Scan Analysis*	*Introduction to SCADA*
	SLO-2	*Genaral rules for wiring system*	*Pumps and Fans-Efficient Control strategies*	*Distribution system Performance*	*Voltage Magnification Analysis*	*Common System Components*
S-7	SLO-1	*Guide lines for installation*	*Optimal selection and sizing*	*reliability calculations*	*Sustained Over voltages*	*Various functions of SCADA System for distribution automation*
	SLO-2	*Load calculation*	*Optimal operation and Storage*	*Communication Systems for Control and Automation*	*Switching Surge Analysis*	*SCADA Architecture*

S-8	SLO-1	*sizing of wire*	*Electric Energy Scenario*	*Wireless Communications*	*Back-to-Back Switching*	*Various control of SCADA System*
	SLO-2	*Rating of main switch and distribution board*	*Demand Side Management-Industrial Load Management*	*Wired Communications*	*KVAR calculation*	*Supervision and Control in SCADA*
S-9	SLO-1	*Earthing system calculation*	*Load Curves-Load Shaping Objectives-Methodologies-Barriers*	*DA Communication Protocols*	*Types of compensation*	*HMI, RTU and Supervisory Stations*
	SLO-2	*Requirements of commercial installation*	*Classification of Industrial Loads- -Load Modelling; Electricity pricing*	*Architectures and user interface*	*Over view of compensation*	*Trends in SCADA, Security Issues*

Learning Resources	*1.. H. Joshi, Residential Commercial and Industrial Systems, McGraw Hill Education, 2008.* *2. DONALD BEEMAN, Industrial Power Systems Handbook, McGRAW-HILL BOOK COMPANY, INC* *3. Rasamy Natarajan, Computer-Aided Power System Analysis, Marcel Dekker Inc., 2002* *4. S.L. Uppal and G.C. Garg, Electrical Wiring, Estimating & Costing, Khanna publishers, 2008*	*5.James Northcote – Green, Robert Wilson, Control and Automation of Electrical Power Distribution Systems, CRC Press, New York, 2007.* *6. Turan Gonen: .Electric Power Distribution System Engineering. McGraw Hill Company. 1986* *7. James Northcote – Green, Robert Wilson, Control and Automation of Electrical Power Distribution Systems, CRC Press, New York, 2007.*

Learning Assessment

	Bloom's Level of Thinking	Continuous Learning Assessment (50% weightage)								Final Examination (50% weightage)	
		CLA – 1 (10%)		CLA – 2 (15%)		CLA – 3 (15%)		CLA – 4 (10%)#			
		Theory	Practice	Theory	Practice	Theory	Practice	Theory	Practice	Theory	Practice
Level 1	Remember Understand	40 %	-	30 %	-	30 %	-	30 %	-	30%	-
Level 2	Apply Analyze	40 %	-	40 %	-	40 %	-	40 %	-	40%	-
Level 3	Evaluate Create	20 %	-	30 %	-	30 %	-	30 %	-	30%	-
	Total	100 %		100 %		100 %		100 %		100 %	

CLA – 4 can be from any combination of these: Assignments, Seminars, Tech Talks, Mini-Projects, Case-Studies, Self-Study, MOOCs, Certifications, Conf. Paper etc.,

Course Designers

Experts from Industry	Experts from Higher Technical Institutions	Internal Experts
1.Mr.Srinath rao, Alstrom,sreenathr.rao@alstrom.com	*1.Dr. P. Somasundaram, CEG, Anna University, mpsomasundaram@annauniv.edu*	*1.Dr.V.Kalyanasundaram,SRMIST*
2.Mr.Manjunath rao, Alstrom,manjunath.rao1103@gmail.com	*2.Dr. B. K. Panigrahi, IIT Delhi, bkpanigrahi@ee.iitd.ac.in*	*2.Dr.S.Vidyasagar, SRMIST*

Course Code	18EEE312T	Course Name	FACTS	Course Category	E	Professional Elective	L	T	P	C
							3	0	0	3

Pre-requisite Courses	Nil	Co-requisite Courses	Nil	Progressive Courses	Nil
Course Offering Department	Electrical and Electronics Engineering	Data Book / Codes/Standards	Nil		

Course Learning Rationale (CLR):	*The purpose of learning this course is to:*
CLR-1 :	*Outline the fundamentals of FACTS controllers*
CLR-2 :	*Discuss shunt and series compensation techniques and its objectives*
CLR-3 :	*Understand the concept of TCSC controllers*
CLR-4 :	*Learn basic idea of voltage and phase angle regulator in power system*
CLR-5 :	*Familiarize the concept of versatile FACTS controllers*
CLR-6 :	*Create overall structure of facts controllers and application of FACTS controller*

Course Learning Outcomes (CLO):	*At the end of this course, learners will be able to:*	Learning 1: Level of Thinking (Bloom)	Learning 2: Expected Proficiency (%)	Learning 3: Expected Attainment (%)	PLO 1: Engineering Knowledge	PLO 2: Problem Analysis	PLO 3: Design & Development	PLO 4: Analysis, Design, Research	PLO 5: Modern Tool Usage	PLO 6: Society & Culture	PLO 7: Environment & Sustainability	PLO 8: Ethics	PLO 9: Individual & Team Work	PLO 10: Communication	PLO 11: Project Mgt. & Finance	PLO 12: Life Long Learning	PLO 13: PSO - 1	PLO 14: PSO - 2	PLO 15: PSO - 3
CLO-1 :	*Summarize the concepts of FACTS controllers*	1	80	75	H	-	-	-	-	-	-	-	-	-	-	-	H	M	-
CLO-2 :	*categorize the shunt and series compensation techniques used in facts controllers and its objectives*	2	80	75	H	-	-	-	-	-	-	-	-	-	-	-	M	M	-
CLO-3 :	*Examine the operation of TCSC and application of TCSC*	2	80	75	H	-	-	-	-	-	-	-	-	-	-	-	H	M	-
CLO-4 :	*Relate the various application of phase shift transformer and phase angle regulator*	2	80	75	H	-	-	-	-	-	-	-	M	M	-	-	H	H	-
CLO-5 :	*Gain knowledge the basic concept of STATCOM, UPSC and its application*	2	80	75	H	-	-	-	M	-	-	-	-	-	-	-	H	M	-
CLO-6 :	*Design a suitable FACTS controller to compensating of real and reactive power using FACTS devices*	2	80	75	H	-	-	-	M	-	-	-	M	M	-	-	H	M	-

Duration (hour)		9	9	9	9	9
S-1	SLO-1	*Electrical Transmission Network*	*Introduction to passive compensation*	*Need for variable series compensation*	*Phase shifting transformer*	*voltage source converters*
	SLO-2	*HVDC Vs HVAC*	*Objectives of shunt and series compensation*	*TCSC: Basic and practical module*	*Configurations of SPST*	*current source converter*
S-2	SLO-1	*Conventional Control Mechanisms-Automatic Generation Control (AGC)*	*Introduction to Single-phase and three phase-Thyristor controlled Reactor (TCR)*	*Net reactance offered by TCSC,*	*Objectives of voltage and phase angle regulators*	*Static synchronous series compensator :*
	SLO-2	*Excitation Control-Transformer Tap-Changer Control-Phase-Shifting Transformers*	*The 12-Pulse TCR*	*Operation of TCSC: Basic principle*	*Real and reactive power of voltage and phase angle regulators*	*principle of operation*
S-3	SLO-1	*System compensation*	*Analysis of single phase TCR*	*X-I and V-I characteristics of TCSC*	*Applications of Phase Angle Regulator*	*VI characteristics*
	SLO-2	*Analysis of Uncompensated Transmission system*	*SVC configurations- Fixed Capacitor*	*Different modes of Operation Explain TCSC*	*Approaches to Thyristor controlled voltage regulators*	*Applications*
S-4	SLO-1	*Necessity of FACTS controller*	*Thyristor-Controlled Reactor and its operating characteristics*	*Different modes of operation Explain MSC*	*Approaches to phase angle regulators*	*Introduction to Static synchronous compensator (STATCOM)*
	SLO-2	*Load and system Compensation*	*Operating Characteristics without Voltage Control*	*Analysis of TCSC*	*Continuously Controllable Thyristor Tap changers*	*STATCOM Principle of operation*
S-5	SLO-1	*Comparison between Series-Connected and Shunt-Connected Compensating Voltages*	*Operating Characteric With Voltage Control*	*Analysis of TSSC*	*Thyristor Tap Changer with Discrete Level Control*	*VI characteristics*
	SLO-2	*Modeling long transmission line*	*SVC voltage control operation*	*Capability Characteristics (single and multi-module TCSC) TCSC losses*	*Improvement of Transient Stability*	*Applications*
S-6	SLO-1	*Real and reactive power flows in AC system*	*Q-V characteristics*	*TCSC applications*	*Power Oscillation Damping*	*UPFC: basic module -capabilities*

	SLO-2	*Symmetrical lossless line Midpoint compensation*	*Thyristor Switched Capacitor (TSC)-operation-.*	*Modelling of TCSC for Stability Studies*	*Basic Issues in the Damping of Low Frequency Oscillations in Large Power Systems*	*UPFC Modes of operation*
S-7	SLO-1	*Surge Impedance Loading*	*Practical switching strategy V-I characteristics of TSC*	*power flow enhancement*	*System Modelling for Small Signal Stability*	*Applications*
	SLO-2	*Classification of FACTS controllers controllable parameters*	*(TSC)-operation -VI characteristics*	*Variable reactance model for transient stability study*	*Damping of Power Oscillations Using Series FACTS Controllers*	*Introduction to Generalized unified power flow controller (GUPFC)*
S-8	SLO-1	*Applications of FACTS*	*(TCR)-operation -VI characteristics*	*TCSC: Open loop current control*	*Damping of Power Oscillations Using Shunt FACTS Controllers*	*Inter line power flow controller (IPFC)*
	SLO-2	*Relative Power Carrying Capability of AC and DC Transmission Lines*	*Advantages of slope in SVC dynamic characteristics*	*TCSC: closed loop current control*	*Switching Converter-Based Voltage and Phase Angle Regulators*	*Configuration of IPFC*
S-9	SLO-1	*The Impact of Distributed Generation*	*SVC Applications*	*Power flow incorporating with SVC and TCSC*	*Hybrid Phase Angle Regulators*	*Application*
	SLO-2	*The Effect of Electricity Deregulation*	*Enhancement of steady state and transient stability*	*Mitigation of Subsynchronous Resonance with TCSC*	*A Case Study of Damping Controllers in UPFC*	*Simulation of SVC and TCSC with SMIB system*

Learning Resources	*1. Mohan Mathur, R. & Rajiv K. Varma, Thyristor Based FACTS Controller for Electrical Transmission Systems, Wiley Interscience Publications, 2011.* *2. Narain G. Hingorani& Laszlo Gyugyi, Understanding FACTS – Concepts & Technology of Flexible AC Transmission Systems, Standard Publishers, New Delhi, 2011.*	*3. Yong Hua Song and Allan T. Johns Flexible Ac Transmission Systems (FACTS), The Institution of Engineering and Technology 2008* *4. https://nptel.ac.in/courses/108107114/* *5. https://npti.gov.in/flexible-ac-transmission-system*

Learning Assessment											
	Bloom's Level of Thinking	Continuous Learning Assessment (50% weightage)								Final Examination (50% weightage)	
		CLA – 1 (10%)		CLA – 2 (15%)		CLA – 3 (15%)		CLA – 4 (10%)#			
		Theory	Practice	Theory	Practice	Theory	Practice	Theory	Practice	Theory	Practice
Level 1	Remember Understand	40 %	-	30 %	-	30 %	-	30 %	-	30%	-
Level 2	Apply Analyze	40 %	-	40 %	-	40 %	-	40 %	-	40%	-
Level 3	Evaluate Create	20 %	-	30 %	-	30 %	-	30 %	-	30%	-
	Total	100 %		100 %		100 %		100 %		100 %	

CLA – 4 can be from any combination of these: Assignments, Seminars, Tech Talks, Mini-Projects, Case-Studies, Self-Study, MOOCs, Certifications, Conf. Paper etc.,

Course Designers		
Experts from Industry	Experts from Higher Technical Institutions	Internal Experts
1.Mr.Manjunath rao, Alstrom,manjunath.rao1103@gmail.com	*1.Dr.D.Devaraj, Dean-Academic,Kalasalingam Academy of Research and Education, d.devaraj@klu.ac.in*	*1. Mr.D.Maharajan, SRMIST*
2.Dr. T. Prakash, TNEB, Mt. Road, prakash.thyagarajan@tnebnet.org	*2. Dr. S. Ramareddy, Jerusalem College of Engineering,srr.victory@gmail.com*	*2. Mr.V.Kubendran, SRMIST*

Course Code	18EEE313T	Course Name	HIGH VOLTAGE ENGINEERING	Course Category	E	Professional Elective	L	T	P	C
							3	0	0	3

Pre-requisite Courses	Nil	Co-requisite Courses	Nil	Progressive Courses	Nil
Course Offering Department	Electrical and Electronics Engineering	Data Book / Codes/Standards	Nil		

Course Learning Rationale (CLR):	*The purpose of learning this course is to:*
CLR-1 :	*Outline the concepts of over voltages and Insulation Co-ordination on power system*
CLR-2 :	*Discuss the solid, liquid and gaseous dielectrics with its relevance to application of high voltages.*
CLR-3 :	*Understand the concept of generation of high voltages*
CLR-4 :	*Familiarize the concept on the measurement of high voltages and currents*
CLR-5 :	*Describe the testing of high voltage equipments and its application.*
CLR-6 :	*Create overall understanding of various types of overvoltages, high voltage generation, measurement and testing*

Course Learning Outcomes (CLO):	*At the end of this course, learners will be able to:*	Learning 1 Level of Thinking (Bloom)	2 Expected Proficiency (%)	3 Expected Attainment (%)	1 Engineering Knowledge	2 Problem Analysis	3 Design & Development	4 Analysis, Design, Research	5 Modern Tool Usage	6 Society & Culture	7 Environment & Sustainability	8 Ethics	9 Individual & Team Work	10 Communication	11 Project Mgt. & Finance	12 Life Long Learning	13 PSO - 1	14 PSO - 2	15 PSO - 3
CLO-1 :	*Gain knowledge on overvoltage protection and the importance on insulation co-ordination levels.*	2	80	75	H	-	-	-	-	-	M	-	-	-	-	-	-	M	-
CLO-2 :	*Understand the basics of dielectrics and its breakdown process on high voltage application*	2	80	75	H	M	L	L	-	-	M	-	-	-	-	-	M	M	-
CLO-3 :	*Acquire knowledge on high voltage generation*	2	80	75	H	M	L	L	-	-	-	-	M	M	-	-	M	M	-
CLO-4 :	*Gain knowledge on measurement of high voltage generation*	2	80	75	H	M	L	L	L	-	-	H	-	-	-	-	M	M	M
CLO-5 :	*Demonstrate the testing procedures of high voltage equipment and its application*	3	80	75	H	M	-	-	-	-	-	H	-	-	-	-	M	M	H
CLO-6 :	*Summarize the scenarios of over voltages and applications of high voltage equipments for generation ,measurement and testing*	3	75	75	H	M	L	L	L	-	M	H	M	M	-	-	M	M	M

Duration (hour)		9	9	9	9	9
S-1	SLO-1	*Causes of over voltages*	*Gaseous breakdown in uniform and non-uniform fields*	*Generation of high DC voltages – Half-wave and full-wave rectifier circuits*	*HVDC measurement techniques Series Resistance microammeter*	*Testing of High voltage electrical apparatus*
	SLO-2	*Effects of overvoltages on power system*	*Conduction and breakdown in gases-Ionization process*	*Voltage doubler circuits*	*Resistance potential divider*	*Technical terms definition for high voltage testing*
S-2	SLO-1	*Parameters of lightning strokes*	*Townsend's current growth equation in the presence of secondary processes*	*voltage multiplier circuits*	*Generating voltmeter*	*Testing procedures on insulators-Power frequency tests*
	SLO-2	*Characteristics of lightning strokes-Direct ,indirect strokes and backflashover*	*Townsend's Criterion for breakdown*	*Van de Graff generator*	*Measurement of high A.C and impulse voltages-*	*Impulse tests*
S-3	SLO-1	*Origin of Switching overvoltages*	*Experimental determination of Townsend's coefficients*	*Generation of high alternating voltages*	*Series Impedance voltmeters*	*Testing procedures on bushings-Power frequency tests*
	SLO-2	*Characteristics of Switching overvoltages*	*Breakdown in electronegative gases*	*Cascaded transformer*	*Series capacitance voltmeter*	*Thermal test*
S-4	SLO-1	*Impact of switching surges in EHV and UHV systems*	*Time lags for breakdown*	*Resonant transformer-Series connection*	*Capacitance potential dividers and capacitance voltage transformers*	*Testing procedures on isolators*
	SLO-2	*Control of overvoltages due to switching overvoltages*	*Streamer Breakdown mechanism in gases*	*Resonant transformer-Parallel connection*	*Potential Transformer, Electrostatic voltmeter,*	*Short-circuit test*
S-5	SLO-1	*Causes of power frequency overvoltages in EHV and UHV systems*	*Paschen's law-Derivation*	*Generation of high frequency alternating voltages- Advantages*	*Peak reading ac voltmeter-Series capacitor, peak voltmeter*	*Testing procedures of cables-Preparation of cables-Dielectric power test*
	SLO-2	*Remedial measures adopted in EHV and UHV systems*	*Practical Considerations in using gases for insulation purposes*	*Tesla coil equivalent circuit*	*Digital peak voltmeter*	*High voltage test and Partial discharge test*
S-6	SLO-1	*Protection against Lightning overvoltages and switching surges of short duration-Ground wires*	*vacuum breakdown*	*Generation of impulse voltages-Standard impulse waveshapes*	*Measurement of high dc, ac and impulse voltages -Sphere gap measurement*	*Testing procedures of transformers-e overvoltage test, Partial discharge test*
	SLO-2	*Protection of transmission lines against over voltages-Ground rods and counter-poise wires*	*Liquid as insulators-Electrical properties*	*waveshape control parameters*	*Factors influencing the spark over voltage of sphere gaps*	*Impulse testing of transformers-Procedures-Detection and location of fault*

S-7	SLO-1	*Protective devices-Rod gap, Expulsion gap*	*Conduction and breakdown in pure and commercial liquids*	*Multistage impulse generator-Marx circuit*	*Resistance Potential divider for impulse voltage measurements*	*Testing procedures of surge diverters*
	SLO-2	*Protector tubes, Surge arrester*	*Breakdown mechanisms in solid dielectrics-Intrinsic and Electromechanical breakdown*	*Marx circuit -simulation*	*Capacitance potential dividers for impulse voltage measurements*	*Radio Interference Measurements – Measurement of Radio Interference voltage*
S-8	SLO-1	*Principles of Insulation Coordination-Ideal requirements of a protective device*	*Breakdown mechanisms in solid dielectrics-Intrinsic and Electromechanical breakdown*	*Generation of impulse current-Definition-Circuits for producing impulse current waves*	*Measurement of high DC, AC and impulse measurements-High DC currents-DC current transformer-Hall generators*	*RIV measurement circuit*
	SLO-2	*Surge diverters,Equipment insulation level and insulation co-ordination of substation*	*Thermal breakdown, solid breakdown used in practice*	*Generation of rectangular current pulses*	*Measurement of high frequency and impulse currents- Resistive shunts*	*Non-destructive testing of materials and measurement of direct current resistivity*
S-9	SLO-1	*insulation level at substation with protective zones*	*Breakdown in composite dielectrics-properties*	*Circuits for producing switching surge voltages*	*Rogowski coils,Magnetic links,Faraday Generator*	*Measurement of dielectric constant and loss factor. Partial discharge measurements*
	SLO-2	*Insulation Coordination in EHV and UHV systems*	*Mechanism of breakdown in composite dielectrics*	*Tripping and control of impulse generators-Trigatron gap*	*Cathode Ray Oscillographs for Impulse voltage and current measurements*	*Application of high voltage engineering in food processing and bio-medical industry*

Learning Resources	*1. Naidu.M.S, and Kamaraju, High Voltage Engineering, Tata McGraw Hill,2014.* *2. Wadhwa.C.L, High Voltage Engineering New age international publishers Ltd.-New Delhi 2010.* *3. Ravindra Arora, Wolfgang Mosh, High Voltage and Electrical InsulationEngineering, Wiley-IEEE Press 2011.*	*4. G.V. Barbosa –Canovas, Pulsed electric fields in food processing: FundamentalAspects and applications, CRC Publisher Edition March 2001.* *5.H. L. M. Lelieveld and Notermans.S,et.al., Food preservation by pulsed electricFields: From research to application, Woodhead Publishing Ltd. October 2007.*

Learning Assessment

	Bloom's Level of Thinking	Continuous Learning Assessment (50% weightage)								Final Examination (50% weightage)	
		CLA – 1 (10%)		CLA – 2 (15%)		CLA – 3 (15%)		CLA – 4 (10%)#			
		Theory	Practice	Theory	Practice	Theory	Practice	Theory	Practice	Theory	Practice
Level 1	Remember Understand	40 %	-	30 %	-	30 %	-	30 %	-	30%	-
Level 2	Apply Analyze	40 %	-	40 %	-	40 %	-	40 %	-	40%	-
Level 3	Evaluate Create	20 %	-	30 %	-	30 %	-	30 %	-	30%	-
	Total	100 %		100 %		100 %		100 %		100 %	

CLA – 4 can be from any combination of these: Assignments, Seminars, Tech Talks, Mini-Projects, Case-Studies, Self-Study, MOOCs, Certifications, Conf. Paper etc.,

Course Designers		
Experts from Industry	Experts from Higher Technical Institutions	Internal Experts
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Course Code	18EEE314T	Course Name	POWER QUALITY	Course Category	E	Professional Elective	L	T	P	C
							3	0	0	3

Pre-requisite Courses	Nil	Co-requisite Courses	Nil	Progressive Courses	Nil
Course Offering Department	Electrical and Electronics Engineering	Data Book / Codes/Standards	Nil		

Course Learning Rationale (CLR):	*The purpose of learning this course is to:*
CLR-1 :	*Understand the characterization of electric power quality*
CLR-2 :	*Study the sources of power quality events such as voltage sag, short and long duration variations*
CLR-3 :	*Explain the reduction of PQ problems using custom power devices and harmonic filters*
CLR-4 :	*Impart knowledge on various methods of power quality monitoring*
CLR-5 :	*Illustrate the power quality issues in distributed generation*
CLR-6 :	*Understand Power Quality events, Measuring equipments and their impact on Distributed Generation*

Course Learning Outcomes (CLO):	*At the end of this course, learners will be able to:*	Learning 1: Level of Thinking (Bloom)	Learning 2: Expected Proficiency (%)	Learning 3: Expected Attainment (%)
CLO-1 :	*Describe the causes and effects of power quality problems and categorize the various electrical power quality issues in power systems*	1	75	75
CLO-2 :	*Identify the power quality major events like voltage sag, interruptions and harmonics*	2	75	75
CLO-3 :	*Design and simulate the custom power devices and harmonic filters*	3	75	75
CLO-4 :	*Interpret in usage of various PQ measuring instruments*	2	75	75
CLO-5 :	*Identify the various power quality issues in solar system and wind energy conversion system*	2	75	75
CLO-6 :	*Analyze PQ issues in wind and solar energy system and utilize the monitoring equipments for PQ events*	3	75	75

Program Learning Outcomes (PLO)

	1 Engineering Knowledge	2 Problem Analysis	3 Design & Development	4 Analysis, Design, Research	5 Modern Tool Usage	6 Society & Culture	7 Environment & Sustainability	8 Ethics	9 Individual & Team Work	10 Communication	11 Project Mgt. & Finance	12 Life Long Learning	13 PSO - 1	14 PSO - 2	15 PSO - 3
CLO-1	H	-	-	-	-	-	-	M	-	-	-	-	-	-	M
CLO-2	H	L	L	-	-	-	-	-	-	-	-	-	M	M	-
CLO-3	H	M	M	L	M	-	L	M					M	M	M
CLO-4	H	-	-	-	L	-	M	M	-	-	-	-	L	M	M
CLO-5	H	L	L	-	-	-	M	-	-	-	-	-	M	M	-
CLO-6	H	L	L	L	M	-	M	M	-	-	-	-	M	M	M

Duration (hour)		9	9	9	9	9
S-1	SLO-1	*Introduction to power distribution system*	*Sources of Sag and Interruptions*	*Fundamentals of harmonics*	*Introduction to Power Quality monitoring*	*Introduction to Distributed Generation Technologies*
	SLO-2	*Power quality: concepts and definition*	*Classification of Voltage sag*	*Sources of harmonics*	*Power Quality Monitoring considerations*	*Resurgence of DG*
S-2	SLO-1	*Characterization of Transients*	*Estimating Voltage Sag performance – Area of Vulnerability, Equipment sensitivity to voltage sags*	*Definitions: Average value - RMS value - True power factor - phase sequence - Fourier series*	*Perspective of Power Quality Measuring equipments*	*Perspectives on DG benefits*
	SLO-2	*Causes and effects of Transients*	*Transmission system sag performance evaluation, Utility distribution system sag performance evaluation*	*Numerical example for harmonic analysis*	*Overview of Power Quality measurement equipments*	*Perspectives on Interconnection*
S-3	SLO-1	*Characterization, causes and effects of Short duration variations – interruptions*	*Fundamental principles of protection*	*Voltage and current distortions, Harmonics indices - (THD and TDD)*	*Power Quality Measurement Equipment: Power line disturbance analyzer*	*Interface to the Utility System*
	SLO-2	*Characterization, causes and effects of Short duration variations – Sags and Swells*	*Solutions of voltage sag at the end user level*	*Harmonics standards (IEEE, IEC)*	*Spectrum analyzer and Harmonic analyzer,*	*Various types of electrical system interfaces*
S-4	SLO-1	*Characterization of Long duration variations*	*Voltage sag and interruption indices*	*Harmonics sources from commercial load*	*Flicker meters*	*Power Quality issues of DG*
	SLO-2	*Causes and effects of Long duration variations*	*Basic Reliability evaluation techniques*	*Harmonics sources from industrial nonlinear load*	*Disturbance analyzer*	*Various types of Power Quality issues affected by DG*
S-5	SLO-1	*Characterization of Voltage imbalance and Waveform distortion*	*Motor-Starting sags*	*Effect of harmonics distortion*	*Transducer requirements*	*Operating conflicts*
	SLO-2	*Causes and effects of Voltage imbalance and Waveform distortion*	*Motor-starting methods*	*Impact on capacitors, transformers, motors, teleCommunications, energy and demand metering*	*Demonstration of harmonic analyzer*	*Description of Operating conflicts results in Power Quality problems*

S-6	SLO-1	*Characterization of Voltage fluctuation and Power Frequency variations*	*Utility System Fault-Clearing Issues*	*Devices for controlling Harmonics - Inline choke*	*Assessment of Power Quality Measurement Data*	*DG on Low-Voltage Distribution networks*
	SLO-2	*Causes and effects of Voltage fluctuation and Power Frequency variations*	*Overview of Transient Faults*	*Zig Zag transformer*	*Off-line and On-line Power quality data assessment*	*Integration techniques for DG on networks*
S-7	SLO-1	*CBEMA*	*Overview of Permanent Faults*	*Harmonic filters: Passive, Active and Hybrid filters*	*Application of Intelligent Systems to power quality monitoring*	*Siting DG*
	SLO-2	*ITI curves*	*Voltage sag Mitigation methods*	*Design of filters - simulation*	*Design of expert systems for monitoring applications*	*Discussion on optimal DG siting problem*
S-8	SLO-1	*Introduction to Power Quality standards*	*Mitigation of sag - Dynamic Voltage Restorer (DVR)*	*Harmonic analysis*	*Requirements on industry Power Quality monitoring applications*	*DG Interconnection standards*
	SLO-2	*International Standards of Power Quality*	*Principle and configuration of DVR*	*Illustration of Harmonic analysis with an Industry case study*	*Web based Power Quality monitoring system*	*Interconnection requirements*
S-9	SLO-1	*Introduction to Power Quality events*	*Mitigation of sag - Distribution static synchronous compensator (DSTATCOM)*	*Seminar on Harmonic analysis*	*Power Quality monitoring standards*	*Power Quality issues in grid integrated Solar system*
	SLO-2	*Computer simulation of Power Quality events*	*Principle and configuration of DSTATCOM*	*Recent advancement in Harmonic distortion analysis*	*IEEE 1159 and IEC 61000-4-30*	*Power Quality issues in grid connected wind energy conversion system*

Learning Resources	1. *Roger C. Dugan, Mark Mc Granaghan, Surya Santoso, H.Wayne, H. Wayne Beaty, Electrical Power Systems Quality, Tata McGraw Hill, Third edition, 2012.* 2. *Math H J Bollen, Understanding Power Quality Problems: Voltage Sags and Interruptions, IEEE Press, New York, 2000.*	3. *Arindam Ghosh ,Power Quality Enhancement Using Custom Power Devices, Kluwer Academic Publishers, 2002.* 4. *G.T.Heydt, Electric Power Quality, Stars in a Circle Publications, second edition, 1994.* 5. *https://nptel.ac.in/courses/108106025/Power%20quality_in_power_distribution_systems.pdf.*

Learning Assessment

	Bloom's Level of Thinking	Continuous Learning Assessment (50% weightage)								Final Examination (50% weightage)	
		CLA – 1 (10%)		CLA – 2 (15%)		CLA – 3 (15%)		CLA – 4 (10%)#			
		Theory	Practice	Theory	Practice	Theory	Practice	Theory	Practice	Theory	Practice
Level 1	Remember Understand	40 %	-	30 %	-	30 %	-	30 %	-	30%	-
Level 2	Apply Analyze	40 %	-	40 %	-	40 %	-	40 %	-	40%	-
Level 3	Evaluate Create	20 %	-	30 %	-	30 %	-	30 %	-	30%	-
	Total	100 %		100 %		100 %		100 %		100 %	

CLA – 4 can be from any combination of these: Assignments, Seminars, Tech Talks, Mini-Projects, Case-Studies, Self-Study, MOOCs, Certifications, Conf. Paper etc.

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Course Designers

Experts from Industry	Experts from Higher Technical Institutions	Internal Experts
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2. Mr.Manjunath rao, Alstrom,manjunath.rao1103@gmail.com	*2. Dr.K.Selvi, Thiagarajar College of Engineering, Madurai, kseee@tce.edu*	*2. Mr.D.Ravichandran, SRMIST*

Course Code	18EEE315T	Course Name	SMART GRID	Course Category	E	Professional Elective	L	T	P	C
							3	0	0	3

Pre-requisite Courses	Nil	Co-requisite Courses	Nil	Progressive Courses	Nil
Course Offering Department	Electrical and Electronics Engineering	Data Book / Codes/Standards	Nil		

Course Learning Rationale (CLR):	*The purpose of learning this course is to:*
CLR-1 :	*Describe the architecture of smart grid, standards and policies*
CLR-2 :	*Examine the issues with renewable energy integration and energy management system*
CLR-3 :	*Enrich the students with knowledge on measurement techniques in smart grid*
CLR-4 :	*Understand power system studies in smart grid*
CLR-5 :	*Acquire knowledge on Communication networks and security challenges*
CLR-6:	*Understand the management and control of smart grid*

Course Learning Outcomes (CLO):	*At the end of this course, learners will be able to:*	Learning 1: Level of Thinking (Bloom)	2: Expected Proficiency (%)	3: Expected Attainment (%)	PLO 1: Engineering Knowledge	2: Problem Analysis	3: Design & Development	4: Analysis, Design, Research	5: Modern Tool Usage	6: Society & Culture	7: Environment & Sustainability	8: Ethics	9: Individual & Team Work	10: Communication	11: Project Mgt. & Finance	12: Life Long Learning	13: PSO - 1	14: PSO - 2	15: PSO - 3
CLO-1 :	*Understand the smart grid architecture and standards*	1	80	75	H	-	-	-	-	-	-	H	-	-	-	-	M	H	M
CLO-2 :	*Analyze the issues with renewable energy integration*	2	80	75	H	L	-	-	-	-	M	H	-	-	-	-	M	H	M
CLO-3 :	*Apply measurement techniques in smart grid*	2	80	75	H	L	-	-	-	-	-	-	-	-	-	-	M	H	-
CLO-4 :	*Explain the power system studies in smart grid*	2	80	75	H	M	-	-	M	-	-	-	-	-	-	-	M	H	-
CLO-5 :	*Summarize Communication networks and security issues*	1	80	75	H	-	-	-	-	-	-	-	-	-	-	-	M	H	M
CLO:6:	*Apply management and control strategies in smart grid*	1	80	75	H	L	-	-	M	-	M	H	-	-	-	-	M	H	M

Duration (hour)		9	9	9	9	9
S-1	SLO-1	*Evolution of Electric Grid*	*Necessity of renewable power generation*	*Importance of measurement in smart grid*	*Basics of load flow studies*	*Role of Communication infrastructures in smart grid*
	SLO-2	*Definitions and Need for Smart Grid*	*Benefits of renewable generation in smart grid*	*Measurement parameters in smart grid*	*Extended load flow studies in smart grid*	*Types of Communication infrastructures*
S-2	SLO-1	*Basics of smart grid*	*Importance of PV system*	*Introduction to Smart Meters*	*Necessity of voltage stability analysis*	*Elements of data Communication networks*
	SLO-2	*Comparison of Power grid with Smart grid power system*	*Grid integration issues of PV system*	*Block diagram of smart meters*	*Voltage stability analysis in smart grid*	*Standards of data Communication networks*
S-3	SLO-1	*Smart grid components*	*Importance of wind system*	*Communication infrastructure for smart metering*	*Importance of state estimation*	*Wired networks in smart grid*
	SLO-2	*Smart grid driversfunctions*	*Grid integration issues of wind system*	*Communication protocols for smart metering*	*Approach of smart grid to state estimation*	*Wireless networks in smart grid*
S-4	SLO-1	*Opportunities, challenges and benefits*	*Basics of energy storage system*	*Basics of AMI drivers*	*Necessity of optimization techniques*	*Functional groups of smart grid Communications*
	SLO-2	*Functions of Smart Grid Components*	*Operation of independent Large-Scale Battery Storage system*	*Benefits of AMI drivers*	*Optimization techniques in smart grid-case study*	*Types of Communications in smart grid*
S-5	SLO-1	*Wholesale energy market in smart grid*	*Necessity of Battery management system*	*Necessity of WAMS network*	*Different intelligent techniques*	*Characterization of smart grid data*
	SLO-2	*Advantages of building integrated and distributed power systems*	*Types of Battery management system in smart grid*	*Wide area measurement system in smart grid*	*Applications of computational intelligence in smart grid*	*Secure data management in smart grid*
S-6	SLO-1	*Approach to smart grid interoperability standards*	*Necessity of energy management system*	*Introduction to Phasor measurement units*	*Transmission system automation*	*Applications of smart grid data*
	SLO-2	*IEEE standards for Smart Grid*	*Energy management system in smart grid*	*Architecture of Phasor measurement units*	*Components of transmission system automation*	*Impact of bad data in smart grid data*
S-7	SLO-1	*International policies in Smart Grid*	*Basics of demand side management*	*Communications in PMUs*	*Distribution system automation*	*Data cleaning in smart grid data*
	SLO-2	*National and International Initiatives in Smart Grid*	*Demand side management in smart grid*	*Implementation of dynamic visualization system for real time power system data*	*Components of Distribution system automation*	*Smart grid network interoperability*

S-8	SLO-1	*Operation of smart grid*	*Basics of demand response*	*Smart buildings in smart grid*	*PHEV in distribution network*	*Basics of cyber security*
	SLO-2	*Control strategies of smart grid*	*Demand response issues in smart grid*	*Components in smart buildings*	*Charging strategies in PHEV*	*Cyber security issues in smart grid*
S-9	SLO-1	*Basics of microgrid*	*Study of power quality parameters*	*ASHRAE standard for smart buildings*	*Discharging strategies in PHEV*	*Types of cyber attacks*
	SLO-2	*Micro grid importance in smart grid*	*Power quality issues associated with renewable energy in smart grid*	*Multi agent systems in smart grid*	*Impact of PHEV on the grid*	*Mitigation approach to cyber security attacks*

Learning Resources	*1.James Momoh, Smart Grid: Fundamentals of design and analysis, John Wiley & sons Inc, IEEE press 2012.* *2. Janaka Ekanayake, Nick Jenkins, Kithsiri Liyanage, Jianzhong Wu, Akihiko Yokoyama, Smart Grid: Technology and Applications, John Wiley & sons inc, 2012.* *3. Fereidoon P. Sioshansi, Smart Grid: Integrating Renewable, Distributed & Efficient Energy, Academic Press, 2012.*	*4. Clark W.Gellings, The smart grid: Enabling energy efficiency and demand response, Fairmont Press Inc,2009.* *5. Kenneth C.Budka, Jayant G.Deshpande, Marina Thottan, and* Communication networks for smart grids, *Springer, 2014.* 6.https://onlinecourses.nptel.ac.in/noc18_ee42/course

Learning Assessment

	Bloom's Level of Thinking	Continuous Learning Assessment (50% weightage)								Final Examination (50% weightage)	
		CLA – 1 (10%)		CLA – 2 (15%)		CLA – 3 (15%)		CLA – 4 (10%)#			
		Theory	Practice	Theory	Practice	Theory	Practice	Theory	Practice	Theory	Practice
Level 1	Remember Understand	40 %	-	30 %	-	30 %	-	30 %	-	30%	-
Level 2	Apply Analyze	40 %	-	40 %	-	40 %	-	40 %	-	40%	-
Level 3	Evaluate Create	20 %	-	30 %	-	30 %	-	30 %	-	30%	-
	Total	100 %		100 %		100 %		100 %		100 %	

CLA – 4 can be from any combination of these: Assignments, Seminars, Tech Talks, Mini-Projects, Case-Studies, Self-Study, MOOCs, Certifications, Conf. Paper etc.,

Course Designers

Experts from Industry	Experts from Higher Technical Institutions	Internal Experts
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Course Code	18EEE316T	Course Name	VEHICULAR POWER SYSTEM	Course Category	E	Professional Elective	L	T	P	C
							3	0	0	3

Pre-requisite Courses	Nil	Co-requisite Courses	Nil	Progressive Courses	Nil
Course Offering Department	Electrical and Electronics Engineering	Data Book / Codes/Standards	Nil		

Course Learning Rationale (CLR):	*The purpose of learning this course is to:*
CLR-1 :	*Understand the importance of electric transportation system and the basics of electric vehicle components and design*
CLR-2 :	*Acquire knowledge on battery technologies in transportation*
CLR-3 :	*Gain knowledge on charging and starting systems in vehicular application*
CLR-4 :	*Explain the importance of fuel cell and application*
CLR-5 :	*Examine the working and control of electric propulsion systems*
CLR-6 :	*Create overall structure of vehicular power system*

Course Learning Outcomes (CLO):	*At the end of this course, learners will be able to:*	Learning 1: Level of Thinking (Bloom)	Learning 2: Expected Proficiency (%)	Learning 3: Expected Attainment (%)	PLO 1: Engineering Knowledge	PLO 2: Problem Analysis	PLO 3: Design & Development	PLO 4: Analysis, Design, Research	PLO 5: Modern Tool Usage	PLO 6: Society & Culture	PLO 7: Environment & Sustainability	PLO 8: Ethics	PLO 9: Individual & Team Work	PLO 10: Communication	PLO 11: Project Mgt. & Finance	PLO 12: Life Long Learning	PLO 13: PSO - 1	PLO 14: PSO - 2	PLO 15: PSO - 3
CLO-1 :	*Examine on different transportation development strategies and architecture of hybrid drive train*	2	80	75	H	L	L	-	-	-	-	-	-	-	-	-	L	L	-
CLO-2 :	*Understand the construction, working and maintenance of battery*	2	80	75	H	M	H	-	-	-	-	-	L	-	-	-	H	M	-
CLO-3 :	*Summarize the charging and starting systems principle, diagnosing and advancements in automotive*	2	80	75	H	-	M	-	-	-	-	-	L	-	-	-	H	M	-
CLO-4 :	*Interpret the fuel cell structure, operation, types and characteristics of fuel cell technology*	2	80	75	H	L	M	-	-	-	-	-	L	-	-	-	H	M	-
CLO-5 :	*Outline different electric drives and its control techniques*	2	80	75	H	-	M	-	-	-	-	-	-	-	-	-	H	M	-
CLO-6 :	*Understand a vehicle's power system using components like energy storage system and power converters*	2	80	75	H	L	M	-	-	-	-	-	L	-	-	-	M	M	-

Duration (hour)		9	9	9	9	9
S-1	SLO-1	*History of modern transportation*	*Introduction to energy storage systems*	*Requirements of charging system*	*Structure and operation of fuel cell*	*DC motor drives principle of operation*
	SLO-2	*Importance of different transportation development strategies to future oil supply*	*Battery requirements for HEVs, PHEVs and EVs*	*Charging system principles*	*Types of fuel cell (PAFC and PEM)*	*Analysis of DC motor drives performance*
S-2	SLO-1	*History of hybrid electric vehicles*	*Working principle and construction of lead-acid, nickel cadmium*	*Alternators basics and working*	*Types of fuel cell (MCFC and SOFC)*	*Chopper control techniques for DC motor drives*
	SLO-2	*History of electric vehicles*	*Working principle and construction of nickel cadmium*	*Charging circuits basics and working*	*Types of fuel cell (DMFC, AFC and ZAFC)*	*Rectifier control techniques for DC motor drives*
S-3	SLO-1	*Social and environmental importance of hybrid and electric vehicles*	*Working principle and construction of nickel metal hydride*	*Charging system testing instruments*	*Fuel cell based power processing systems introduction*	*Induction motor drives principle of operation*
	SLO-2	*Key challenges of hybrid and electric vehicles*	*Working principle and construction of lithium ion batteries*	*Diagnosing charging system faults*	*Benefits of power processing systems*	*Analysis of Induction motor drives performance*
S-4	SLO-1	*Specifications of PHEVs, BEVs, EVs and HEVs*	*Properties of battery*	*New developments in charging systems*	*Important properties of fuel cells for vehicles*	*Inverter control techniques for induction motor drives*
	SLO-2	*The future of electric vehicles*	*Characteristics of battery*	*Advanced charging systems*	*Alternate fuels for fuel cell vehicles*	*Cycloconverter control techniques for induction motor drives*
S-5	SLO-1	*Requirement of drive train*	*Maintenance of battery*	*Requirements of starting systems*	*Fuel cost and fuel economies comparison*	*Permanent magnetic brush-less DC motor drive operation*
	SLO-2	*Sizing of components in drive train*	*Visual inspection of battery*	*Starter motors and its circuits*	*Comparison of characteristics of fuel cells*	*Analysis of brush-less DC motor drives performance*
S-6	SLO-1	*Series configuration of HEVs*	*Battery testing instruments*	*Inertia starter and pre-engaged starter*	*Fuel cell based drive trains*	*Control techniques of BLDC motor drive*
	SLO-2	*Parallel configuration of HEVs*	*Diagnosing battery faults*	*Permanent magnet starter, integrated starter generator and electronic starter*	*Comparison of BEV, DHFC/EV and DMFC/EV*	*Implementing control techniques for BLDC motor drive*
S-7	SLO-1	*Power split configuration of HEVs*	*Introduction to supercapacitor*	*Starting system testing instrument*	*Transition from diesel to fuel cell engines*	*Sensorless control for BLDC drive introduction*

	SLO-2	*Merits and Demerits of different HEV configurations*	*Introduction to flywheel*	*Diagnosing in starting system faults*	*Fuel cell/battery hybrid power system*	*Different control techniques for BLDC drive introduction*
S-8	SLO-1	*Vehicle dynamics*	*Advanced battery technology*	*Advanced starting system technology*	*Fuel cell in domestic application*	*Switched reluctance motor drives principle of operation*
	SLO-2	*Problems using vehicle dynamics*	*Developments in electrical storage*	*New developments in starting systems*	*Fuel cell in industrial application*	*Analysis of switched reluctance motor drives performance*
S-9	SLO-1	*Modelling electric vehicle range*	*Case studies on battery technologies*	*Case studies in charging and starting systems*	*Case studies on fuel cell technologies*	*Control techniques of switched reluctance motor drive*
	SLO-2	*Problems under vehicle travel range*	*Software implementation of battery and its applications*	*Software implementation of charging and starting systems*	*Software implementation of fuel cell and its applications*	*Implementing control techniques for switched reluctance motor drive*

Learning Resources	1. *A. Emadi, M. Ehsani and John M. Miller, Vehicular Power Systems, Marcel Dekker, New York, 2004.* 2. *Ion Boldea and S.A Nasar, Electric drives, CRC Press, 2005.* 3. *Sandeep Dhameja, Electric Vehicle Battery Systems, Newnes, 2002.*	4. *Chris Mi, M. Abul Masrur, David Wenzhong Gao, Hybrid Electric Vehicles: Principles and Applications with Practical Perspectives, Wiley, 2011.* 5. *Iqbal Husain, Electric and Hybrid Vehicles: Design Fundamentals, CRC Press, 2nd Edition, 2010.* 6. *https://www.diyguru.org/course/electric-vehicle/*

Learning Assessment

	Bloom's Level of Thinking	Continuous Learning Assessment (50% weightage)								Final Examination (50% weightage)	
		CLA – 1 (10%)		CLA – 2 (15%)		CLA – 3 (15%)		CLA – 4 (10%)#			
		Theory	Practice	Theory	Practice	Theory	Practice	Theory	Practice	Theory	Practice
Level 1	Remember Understand	40 %	-	30 %	-	30 %	-	30 %	-	30%	-
Level 2	Apply Analyze	40 %	-	40 %	-	40 %	-	40 %	-	40%	-
Level 3	Evaluate Create	20 %	-	30 %	-	30 %	-	30 %	-	30%	-
	Total	100 %		100 %		100 %		100 %		100 %	

CLA – 4 can be from any combination of these: Assignments, Seminars, Tech Talks, Mini-Projects, Case-Studies, Self-Study, MOOCs, Certifications, Conf. Paper etc.,

Course Designers

Experts from Industry	Experts from Higher Technical Institutions	Internal Experts
1.Dr.S.Sambath, TANGEDCO,Tamilnadu, eses.eng@gmail.com	*1. Dr.Chandramohan, CEG, Anna University, c_dramo@annauniv.edu*	*1. Mrs. A. Geetha, SRMIST*
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Course Code	18EEE407T	Course Name	POWER SYSTEM HARMONICS	Course Category	E	Professional Elective	L	T	P	C
							3	0	0	3

Pre-requisite Courses	Nil	Co-requisite Courses	Nil	Progressive Courses	Nil
Course Offering Department	Electrical and Electronics Engineering	Data Book / Codes/Standards	Nil		

Course Learning Rationale (CLR):	*The purpose of learning this course is to:*
CLR-1 :	*Understand the fundamentals and standards of harmonics*
CLR-2 :	*Study the various sources of harmonics*
CLR-3 :	*Enumerate the effects of harmonics in various equipments*
CLR-4 :	*Classify the methods of power system harmonics mitigation*
CLR-5 :	*Explore the approach of harmonics system study*
CLR-6 :	*Develop an overall knowledge about harmonics in power system*

Course Learning Outcomes (CLO):	*At the end of this course, learners will be able to:*	Learning 1: Level of Thinking (Bloom)	Learning 2: Expected Proficiency (%)	Learning 3: Expected Attainment (%)	PLO 1: Engineering Knowledge	2: Problem Analysis	3: Design & Development	4: Analysis, Design, Research	5: Modern Tool Usage	6: Society & Culture	7: Environment & Sustainability	8: Ethics	9: Individual & Team Work	10: Communication	11: Project Mgt. & Finance	12: Life Long Learning	13: PSO - 1	14: PSO - 2	15: PSO - 3
CLO-1 :	*Identify the harmonic indices and study the characteristics of harmonics*	2	80	75	H	-	-	-	-	-	-	H	-	-	-	-	-	-	H
CLO-2 :	*Understand the level of harmonics in equipments and devices*	3	80	75	H	-	-	-	-	-	-	-	-	-	-	-	-	-	-
CLO-3 :	*Familiarize the harmonics effects in critical loads and equipments*	3	80	75	H	-	-	-	-	-	-	-	-	-	-	-	M	M	-
CLO-4 :	*Study and compare the various filters used for harmonics mitigation*	3	80	75	H	H	M	-	-	-	-	-	-	-	-	-	M	M	-
CLO-5 :	*Simulate the harmonics analysis in a low/medium voltage system*	3	80	75	H	H	M	M	-	-	-	-	-	-	-	-	M	M	-
CLO-6 :	*Design a harmonic mitigation for the industrial and commercial applications*	3	80	75	H	H	M	M	-	-	-	M	-	-	-	-	M	M	M

Duration (hour)		9	9	9	9	9
S-1	SLO-1	*Introduction*	*Traditional sources*	*Harmonics effects – Thermal losses*	*Harmonics Filters*	*Harmonics modeling of system components - Generator,*
	SLO-2	*Basics of harmonic theory*	*Transformers*	*Copper, core and dielectric losses*	*Passive filters*	*Harmonics modeling of Shunt capacitors*
S-2	SLO-1	*Representation of Harmonics*	*Rotating machines*	*Harmonics effects on power system equipment*	*Single tuned filters*	*Harmonics modeling of Loads*
	SLO-2	*Fourier series – coefficients*	*Arc furnaces*	*Capacitor bank*	*Double tuned filters*	*Harmonics modeling of Induction motor*
S-3	SLO-1	*Fourier transform*	*Modern sources*	*Transformers*	*Damped filters*	*Harmonics modeling of Transformer with network*
	SLO-2	*Discrete Fourier transform (DFT)*	*Power electronics devices*	*Neutral grounding overloading*	*Detuned filters*	*Harmonics modeling of Transformer with different configuration*
S-4	SLO-1	*Fast Fourier transform (FFT)*	*Rectifiers*	*Rotating machines*	*Series tuned filter design*	*Harmonics modeling of Transmission line model*
	SLO-2	*Examples of harmonic estimation using FFT*	*A.C. Regulators*	*Pulsating torque*	*Impedance plot of series tuned filter design*	*Harmonics modeling of Transmission line with network*
S-5	SLO-1	*Characteristics of harmonics in power system – Symmetry*	*Power converters – Six pulse converters*	*Power electronics devices*	*Second order damped filters*	*Examples – transmission line*
	SLO-2	*Phase sequence*	*Six pulse converters - Analysis*	*Power converters*	*Impedance plot of second order damped filter design*	*Examples – Problems on load*
S-6	SLO-1	*Voltage and current distortion factors - Total harmonic distortion (THD)*	*Twelve pulse converters*	*Harmonics on power system protection*	*Active filters*	*Harmonics analysis using spread sheet*
	SLO-2	*Real, Reactive and Apparent power*	*Twelve pulse converters - Analysis*	*Unexpected relay operation*	*Characteristics of active filters*	*Analysis of harmonics analysis using spread sheet*
S-7	SLO-1	*Distortion power; Power factor*	*Inverters*	*Harmonics effects on consumer equipment*	*Other methods of mitigation*	*Simulation of harmonics analysis*
	SLO-2	*Total influence factor (TIF) and I*T Product*	*Cycloconverters*	*UPS*	*Transformer connection*	*harmonics resonance*

S-8	SLO-1	*Voltage THD limits – IEEE standards*	*Thyristor controlled reactors*	*Lighting loads*	*Network topology reconfiguration*	*Simulation of harmonics filters*
	SLO-2	*Voltage THD limits – IEC standards*	*Static VAR compensator*	*Electronics devices*	*Increase of supply mode stiffness*	*Analysis of simulation output of harmonics filters*
S-9	SLO-1	*Current THD limits – IEEE standards*	*Effect of transformer connection on harmonics*	*Harmonic interference with Communication*	*Harmonic cancellation through use of multi pulse converters*	*Case study*
	SLO-2	*Current THD limits – IEC standards*	*Star-Delta and Delta-Star*	*Microwave links, telephone interference*	*Series reactor as harmonic attenuator elements*	*Analysis of Case study*

Learning Resources	*1. Power system harmonics ,Fundamentals, Analysis and filter design – George J. Wakileh – Reprinted 2010* *2.Power system harmonics, J. Arrillaga and N.R.Watson 1998 – Reprinted 2000* *3. Power system harmonics, Francisco_De_La_Rosa – 2006*	*4. Elecrical power system quality, R C Dugan, Mark F.Mcgranaghan, Surya Santoso, H.Wayne Beaty -* *5. Harmonics analysis software user manual* *6. https://web.ecs.baylor.edu/faculty/grady/Understanding_Power_System_Harmonics_Grady_April_2012*

Learning Assessment

	Bloom's Level of Thinking	Continuous Learning Assessment (50% weightage)								Final Examination (50% weightage)	
		CLA – 1 (10%)		CLA – 2 (15%)		CLA – 3 (15%)		CLA – 4 (10%)#			
		Theory	Practice	Theory	Practice	Theory	Practice	Theory	Practice	Theory	Practice
Level 1	Remember Understand	40 %	-	30 %	-	30 %	-	30 %	-	30%	-
Level 2	Apply Analyze	40 %	-	40 %	-	40 %	-	40 %	-	40%	-
Level 3	Evaluate Create	20 %	-	30 %	-	30 %	-	30 %	-	30%	-
	Total	100 %		100 %		100 %		100 %		100 %	

CLA – 4 can be from any combination of these: Assignments, Seminars, Tech Talks, Mini-Projects, Case-Studies, Self-Study, MOOCs, Certifications, Conf. Paper etc.,

Course Designers

Experts from Industry	Experts from Higher Technical Institutions	Internal Experts
Dr. K. Karthikeyan, ABB Ltd., k.karthikeyan@in.abb.com	*Dr.B.Chitti Babu, IIIT, bcbabu@iiitdm.ac.in*	*Mr. D.Ravichandran, SRMIST, ravichandran.d@ktr.srmuniv.ac.in*
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Course Code	18EEE408T	Course Name	HVDC AND EHVAC SYSTEMS	Course Category	E	Professional Elective	L	T	P	C
							3	0	0	3

Pre-requisite Courses	Nil	Co-requisite Courses	i	Progressive Courses	Nil
Course Offering Department	Electrical and Electronics Engineering	Data Book / Codes/Standards	Nil		

Course Learning Rationale (CLR):	*The purpose of learning this course is to:*
CLR-1 :	*Outline the concepts of Extra High Voltage transmission systems*
CLR-2 :	*Explain the general background and operational concepts in EHVAC Transmission Systems*
CLR-3 :	*Give idea about the factors affecting EHV transmission and the protection of EHV lines*
CLR-4 :	*Impart knowledge about HVDC Transmission systems*
CLR-5 :	*Expose to the concept of harmonics and basis of protection for HVDC Systems.*
CLR-6 :	*Know the detailed background of extra high voltage AC transmission and high voltage DC transmission*

Course Learning Outcomes (CLO):	*At the end of this course, learners will be able to:*	Learning			Program Learning Outcomes (PLO)														
		1	2	3	1	2	3	4	5	6	7	8	9	10	11	12	13	14	15
		Level of Thinking (Bloom)	Expected Proficiency (%)	Expected Attainment (%)	Engineering Knowledge	Problem Analysis	Design & Development	Analysis, Design, Research	Modern Tool Usage	Society & Culture	Environment & Sustainability	Ethics	Individual & Team Work	Communication	Project Mgt. & Finance	Life Long Learning	PSO - 1	PSO - 2	PSO - 3
CLO-1 :	*Understand the basic concepts of Extra High Voltage Transmission.*	2	80	75	H	-	-	-	-	-	M	L	-	-	-	-	M	M	L
CLO-2 :	*Analyze the general background of EHVAC Transmission Systems*	3	80	75	H	M	M	-	-	-	-	-	-	-	-	-	M	M	-
CLO-3 :	*Acquire knowledge in operational concepts and protection in EHVAC Transmission Systems*	3	80	75	H	M	M	-	-	-	M	L	-	-	-	-	M	M	L
CLO-4 :	*Infer the significance of HVDC Transmission and its modern trends and applications.*	3	80	75	H	-	-	-	-	-	-	-	M	M	-	-	M	M	-
CLO-5 :	*Gain idea in the general principle of HVDC control and harmonic elimination in HVDC Systems*	3	80	75	H	M	M	-	M	-	-	-	-	-	-	-	M	H	-
CLO-6 :	*Interprete the operational concepts of high voltage AC and DC transmission*	3	80	75	H	M	M	-	M	-	M	L	M	M	-	-	H	M	L

Duration (hour)		9	9	9	9	9
S-1	SLO-1	*Brief Description of Energy Sources*	*Power handling capacity of AC transmission line*	*Effects of corona*	*Choice of HVDC Transmission*	*Pulse number*
	SLO-2	*Development of Energy sources*	*Line losses of AC transmission line*	*Attenuation of travelling waves due to corona loss*	*Basic outline of HVDC Transmission*	*Choice of Converter Configuration*
S-2	SLO-1	*Introduction to EHV transmission*	*Introduction to mechanical considerations in transmission line performance*	*Generation of audible noise*	*Comparison of Economics, Technical Performance of DC power Transmission*	*Introduction to Graetz circuit*
	SLO-2	*Standard Voltage levels of Transmission systems*	*Types of vibrations and oscillations*	*Characteristics and its limitations of audible noise*	*Comparison of Reliability of DC power Transmission*	*Simplified analysis of Graetz circuit*
S-3	SLO-1	*Hierarchical levels for Transmission systems*	*Concept of bundled conductors*	*Generation of corona pulses*	*Description of HVDC transmission system*	*Concept of HVDC link Control*
	SLO-2	*Costs of Transmission Lines And Equipment*	*Properties of Bundled conductors*	*Properties of corona pulses*	*Types of HVDC links*	*Principles of HVDC link control*
S-4	SLO-1	*Necessity for EHV transmission*	*Surface voltage gradient on single conductor bundles*	*Limits for radio interference fields*	*Components of a Converter station*	*DC Breaker – Basic concepts of DC circuit interruption*
	SLO-2	*Challenges involved in EHV transmission*	*Derivation of Surface voltage gradient on single conductor bundles*	*Evaluation of radio interference using Cigre Formula*	*Description of a Converter station*	*DC Breaker –Characteristics and Applicatiobns*
S-5	SLO-1	*Operational Aspects of EHV AC transmission*	*Surface voltage gradient on double conductor bundles*	*Concept of RL filter to block corona enery*	*Basic concepts of multi-terminal HVDC system.*	*AC Filter –Criteria of design*
	SLO-2	*Electrical characteristics of EHV cables*	*Derivation of Surface voltage gradient on double conductor bundles*	*Design of RL filter*	*Types and potential applications of multi-terminal HVDC system.*	*AC Filter –Ratings of filter components and protection of filters*
S-6	SLO-1	*Gas insulated EHV transmission lines*	*Basic concepts of reactive power compensation*	*Intereference to TV reception from EHV lines*	*Effects of proximity of ac and dc transmission lines*	*DC Filter –Criteria of design*
	SLO-2	*Properties of SF_6 gas*	*Principles of shunt compensation*	*Discharges from an EHV line causing television interference*	*HVDC transmission based on Voltage Source Converters*	*DC Filter –Hybrid active filter for DC filtering*
S-7	SLO-1	*Effect of Power-Frequency Magnetic Fields on Human Health*	*Principles of series compensation*	*Concept of lightning strokes*	*Merits of HVDC System*	*Protection Against Over Currents, Over Voltages*

	SLO-2	*Effect of High Electro Static Field on Humans, Animals, and Plants*	*Sub-synchronous resonance in compensated lines*	*General principles of the lighting protection problem*	*Limitations of HVDC System*	*Protection Systems in HVDC Substation*
S-8	SLO-1	*Introduction to line parameters*	*Counter measures for Sub-synchronous resonance problem*	*Arresters used for EHV systems*	*Applications of HVDC transmission*	*Necessity of simulation of a dynamic system*
	SLO-2	*Determination of resistance of EHV lines*	*Improvement of system performance due to reactive power compensation.*	*Protective characteristics of lightning arresters*	*Modern Trends in HVDC transmission*	*Tools for simulation of a dynamic system*
S-9	SLO-1	*Determination of inductance of EHV lines*	*Comparison of Overhead and Underground lines*	*Operating characteristics of lightning arresters*	*Seminar on case Studies of HVDC links in the world- I*	*Digital Dynamic Simulation of Converters*
	SLO-2	*Determination of capacitance of EHV lines*	*Examples of Giant power pools in the world*	*Insulation Coordination based on lightning*	*Seminar on case Studies of HVDC links in the world- II*	*Digital Dynamic Simulation of DC Systems*

Learning Resources	1. *Rakosh Das Begamudre, Extra High Voltage AC Transmission Engineering, Fourth Edition , New Age International(P) Limited,Publishers.,2011* 2. *Padiyar K.R., HVDC Power Transmission Systems, Third Edition,New Age International (P) Limited Publishers.,2015.*	3. *Chakrabarti.A , M.L.Soni,P.V.Gupta,U.S.Bhatnagar, PowerSystem Engineering, DhanpatRai& Co., 2010.* 4. *Sunil S.Rao, Switchgear Protection and Power Systems,13th edition,Khanna Publishers,2008.* 5. *http://www.nptelvideos.com/course.php?id=480*

Learning Assessment

	Bloom's Level of Thinking	Continuous Learning Assessment (50% weightage)								Final Examination (50% weightage)	
		CLA – 1 (10%)		CLA – 2 (15%)		CLA – 3 (15%)		CLA – 4 (10%)#			
		Theory	Practice	Theory	Practice	Theory	Practice	Theory	Practice	Theory	Practice
Level 1	Remember Understand	40 %	-	30 %	-	30 %	-	30 %	-	30%	-
Level 2	Apply Analyze	40 %	-	40 %	-	40 %	-	40 %	-	40%	-
Level 3	Evaluate Create	20 %	-	30 %	-	30 %	-	30 %	-	30%	-
	Total	100 %		100 %		100 %		100 %		100 %	

CLA – 4 can be from any combination of these: Assignments, Seminars, Tech Talks, Mini-Projects, Case-Studies, Self-Study, MOOCs, Certifications, Conf. Paper etc.,

Course Designers

Experts from Industry	Experts from Higher Technical Institutions	Internal Experts
1.Dr.K.Karthikeyan, ABB India Ltd., k.karthikeyan@in.abb.com	*1. Dr Subhransu Sekhar Dash, Government College of Engineering, Keonjhar, Subhransudash_fee@gcekjr.ac.in*	*1. Ms. E. Annie Grace, SRMIST*
2. Mr.Senthilkumar,ATI,rskrd1962@gmail.com	*2.Dr. A. Venkadesan, NIT Puducherry, venkadesan@nitpy.ac.in*	*2. Dr. S. Padmini, SRMIST*

Course Code	18EEE409T	Course Name	POWER SYSTEM DYNAMICS	Course Category	E	Professional Elective	L	T	P	C
							3	0	0	3

Pre-requisite Courses	Nil	Co-requisite Courses	Nil	Progressive Courses	Nil
Course Offering Department	Electrical & Electronics Engineering	Data Book / Codes/Standards	NIL		

Course Learning Rationale (CLR):	*The purpose of learning this course is to:*
CLR-1 :	*Enumerate the significance of stability study and its classification*
CLR-2 :	*Explain the concept of detailed modelling of synchronous machine for stability studies*
CLR-3 :	*Understand and model the various excitation system*
CLR-4 :	*Examine the small-signal stability study of single-machine infinite bus (SMIB) system*
CLR-5 :	*Discuss the Sub-synchronous oscillations and countermeasures for small-signal stability*
CLR-6 :	*Develop the mathematical model of synchronous machine and assessment of small-signal stability*

Course Learning Outcomes (CLO):	*At the end of this course, learners will be able to:*	Learning 1: Level of Thinking (Bloom)	Learning 2: Expected Proficiency (%)	Learning 3: Expected Attainment (%)	PLO 1: Engineering Knowledge	PLO 2: Problem Analysis	PLO 3: Design & Development	PLO 4: Analysis, Design, Research	PLO 5: Modern Tool Usage	PLO 6: Society & Culture	PLO 7: Environment & Sustainability	PLO 8: Ethics	PLO 9: Individual & Team Work	PLO 10: Communication	PLO 11: Project Mgt. & Finance	PLO 12: Life Long Learning	PLO 13: PSO - 1	PLO 14: PSO - 2	PLO 15: PSO - 3
CLO-1 :	*Explain the basics of stability analysis and its types*	1	75	75	H	H	-	-	-	-	-	-	-	-	-	-	M	M	-
CLO-2 :	*Apply the idea of Park's transformation and express the voltage and flux linkage equation, torque and power equation of synchronous machine in rotor reference frame.*	3	75	75	H	H	L	H	H	-	-	-	-	-	-	-	M	M	-
CLO-3 :	*Describe the excitation system, types and its modelling for stability studies*	3	75	75	H	H	L	H	H	-	-	-	-	-	-	-	M	M	-
CLO-4 :	*Analyze the small-signal stability for the SMIB system with classical model of synchronous machine*	3	75	75	H	H	H	H	H	-	-	-	-	H	-	-	M	M	-
CLO-5 :	*Infer Sub-synchronous oscillations and the enhancement methods of small-signal stability*	3	75	75	H	H	H	H	-	-	-	-	-	-	-	-	M	M	-
CLO-6 :	*Design the mathematical model of synchronous machine and evaluate the small-signal stability*	3	75	75	H	H	H	H	H	-	-	-	-	H	-	-	M	M	-

Duration (hour)		9	9	9	9	9
S-1	SLO-1	*Introduction –Basic elements of power system*	*Introduction to Three phase synchronous machine*	*Excitation system requirements*	*Small-signal stability of dynamic Systems*	*Introduction to Sub-synchronous oscillations*
	SLO-2	*Structure of power system-power system control*	*RMF, MMF waveform*	*Basic functions of Excitation system*	*Local, finite and global stability*	*Turbine-generator torsional characteristics*
S-2	SLO-1	*Operating states of power system and control strategies*	*Winding model*	*Elements of an excitation system*	*Linearization*	*Structure of typical lumped mass shaft system model*
	SLO-2	*Normal design contingencies*	*Modelling assumptions,*	*Control functions of an excitation system*	*State-space representation*	*Shaft model representation*
S-3	SLO-1	*System design for stability*	*Sign convention*	*Protective functions of an excitation system*	*Mathematical analysis of stability*	*Equations of inertia constant-Torsional stiffness-Damping coefficient*
	SLO-2	*Classifications of stability*	*Stator voltage equations in abc coordinates*	*Types of Excitation System (ES)*	*Eigen properties of the state matrix*	*Derive the Shaft system equations between turbine and generators*
S-4	SLO-1	*The stability phenomena: small-signal and transient stability*	*Rotor voltage equations in abc coordinates*	*DC excitation system-(DC1A)*	*Eigenvalues of the state matrix*	*Computation of damping and stiffness coefficient for a five mass model system*
	SLO-2	*Basic assumptions made in stability studies*	*Stator flux linkage equations in abc coordinates*	*DC excitation system with amplidyne*	*Eigenvectors, participation factor, modal matrices*	*Computation of each shaft section torque for a five mass model system*
S-5	SLO-1	*Rotor dynamics and the swing equation*	*Rotor flux linkage equations in abc coordinates*	*AC Excitation system*	*Eigenvalues and stability-trajectory behaviour*	*Torsional natural frequencies*
	SLO-2	*Transient stability- Illustrate with Single machine connected to infinite bus (SMIB) system*	*Stator self-inductance calculation*	*Field-Controlled Alternator Rectifier ES*	*Mode shape and participation factor.*	*Example of torsional characteristics of coal-fired unit with static exciter*
S-6	SLO-1	*Numerical problem on transient stability analysis of SMIB system*	*Stator to rotor Mutual-inductance calculation*	*Stationary rectifier based AC Exciter*	*Controllability and observability-concept of complex frequency*	*Small-signal stability enhancement-methods*

	SLO-2	*Power versus rotor angle curve,Power-rotor angle equations-(during a fault, after fault clearing and removal of the faulted circuit)- Numerical problem*	*Rotor to Stator Mutual-inductance, Rotor self –inductance calculation*	*Alternator-supplied controlled-rectifier ES*	*State-space form of Synchronous machine's swing equation*	*Different types of Power system stabilizers (PSS)- Need of PSS*
S-7	SLO-1	*Transient stability assessment of SMIB system by Equal-Area Criterion*	*Park's transformation*	*Rotating type- Brush less Excitation system*	*Case study on small signal stability analysis of Single-Machine Infinite Bus (SMIB) with classical machine model*	*Stabilizers based on shaft speed signal*
	SLO-2	*Computation of Critical clearing angle-critical clearing time- Numerical problem*	*Voltage and flux linkage equations in dqo reference frame (Park's equations)*	*Static Excitation system*	*Block diagram representation of SMIB system*	*Delta-P-Omega stabilizer*
S-8	SLO-1	*Introduction to Voltage stability*	*Steady state analysis-voltage, Current, and flux linkage relationships.*	*Potential-source controlled rectifier-static type excitation system*	*Calculation of synchronizing torque coefficient, system matrix, eigenvalues and participation factor*	*Frequency based stabilizer, Digital stabilizer*
	SLO-2	*Voltage collapse- Illustrate with two bus radial system*	*Phasor representation-Steady state equivalent circuit.*	*Modelling and computer simulation of excitation system*	*The effect of damping torque in the stability of SMIB system with classical machine model*	*Enhancement of stability by Excitation control design*
S-9	SLO-1	*Large disturbance and small disturbance*	*Simplified model (constant flux linkage)-Classical machine model.*	*Detailed excitation system model- DCIA*	*Speed and rotor angle time response of SMIB system with classical machine model*	*Exciter gain, Phase-lead compensation, stabilizing signal washout, Stabilizer gain-Stabilizer limits*
	SLO-2	*Voltage stability- Mid-term and Long-term stability*	*Steady State analysis of Synchronous machine using simulation software*	*AC1A and AC4A model of excitation system*	*Synchronous machine model using suitable simulation software*	*General observation on excitation control design*

Learning Resources	1. *P.Kundur, Power System Stability and Control, McGraw Hill Inc, New York, 1995.* 2. *R.Ramanujam, Power System Dynamics: Analysis and Simulation, PHI Publishers, Delhi, 2nd edition 2013.* 3. *M.A.Pai and W.Sauer, Power System Dynamics and Stability, Pearson Education Asia, India, 2002.*	4. *K.R.Padiyar, Power System Dynamics, Stability & Control, 2nd Edition, B.S. Publications, Hyderabad, 2002.* 5. *P.M Anderson and A.A Fouad, Power System Control and Stability, Iowa State University Press, Ames, Iowa, 1978.* 6. *https://nptel.ac.in/courses/108102080/*

Learning Assessment

	Bloom's Level of Thinking	Continuous Learning Assessment (50% weightage)								Final Examination (50% weightage)	
		CLA – 1 (10%)		CLA – 2 (15%)		CLA – 3 (15%)		CLA – 4 (10%)#			
		Theory	Practice	Theory	Practice	Theory	Practice	Theory	Practice	Theory	Practice
Level 1	Remember Understand	40 %	-	30 %	-	30 %	-	30 %	-	30%	-
Level 2	Apply Analyze	40 %	-	40 %	-	40 %	-	40 %	-	40%	-
Level 3	Evaluate Create	20 %	-	30 %	-	30 %	-	30 %	-	30%	-
	Total	100 %		100 %		100 %		100 %		100 %	

CLA – 4 can be from any combination of these: Assignments, Seminars, Tech Talks, Mini-Projects, Case-Studies, Self-Study, MOOCs, Certifications, Conf. Paper etc.,

Course Designers

Experts from Industry	Experts from Higher Technical Institutions	Internal Experts
1.Dr. Sharon Ravichandran, ABB Ltd., Chennai,sharonravi87@gmail.com	*1. Prof. K.Shanthi Swarup, IITM, Chennai, ksswarup@iitm.ac.in*	*1.Mr. D. Maharajan, SRMIST*
2.Dr.V.P.Boopathi, Powersys., Chennai,Boopathivp@gmail.com	*2.Prof. R.P.Kumudini Devi, Anna University, kumudini@annauniv.ac.in*	*2.Dr. D. Sattianandan, SRMIST*

Course Code	18EEE410T	Course Name	MODERN POWER SYSTEM ANALYSIS	Course Category	E	Professional Elective	L	T	P	C
							3	0	0	3

Pre-requisite Courses	18EEC303T	Co-requisite Courses	NIL	Progressive Courses	Nil
Course Offering Department	Electrical and Electronics Engineering	Data Book / Codes/Standards	Nil		

Course Learning Rationale (CLR):	*The purpose of learning this course is to:*
CLR-1 :	*Explain the numerical method involved in for optimal power flow analysis*
CLR-2 :	*Analyse the significance of contingency analysis and power system security states*
CLR-3 :	*Outline the concepts of distribution system*
CLR-4 :	*Understand and analyze the different concepts of stability*
CLR-5 :	*Demonstrate the concepts of state estimation of power systems*
CLR-6 :	*Evaluate the overall analysis of power system problems starting from transmission to distribution*

Course Learning Outcomes (CLO):	*At the end of this course, learners will be able to:*	Learning 1: Level of Thinking (Bloom)	2: Expected Proficiency (%)	3: Expected Attainment (%)	PLO 1: Engineering Knowledge	2: Problem Analysis	3: Design & Development	4: Analysis, Design, Research	5: Modern Tool Usage	6: Society & Culture	7: Environment & Sustainability	8: Ethics	9: Individual & Team Work	10: Communication	11: Project Mgt. & Finance	12: Life Long Learning	13: PSO - 1	14: PSO - 2	15: PSO - 3
CLO-1 :	*Acquire the knowledge on the numerical methods of optimal power flow analysis*	3	75	75	H	M	M	M	M	-	-	-	-	-	-	-	M	M	-
CLO-2 :	*Analyse the concepts of power system security*	3	75	75	H	M	M	M	M	-	-	-	-	-	-	-	M	M	-
CLO-3 :	*Familiarize the knowledge on distribution system and its application*	3	75	75	H	M	M	M	M	-	-	-	-	-	-	-	M	M	-
CLO-4 :	*Categorize the study of stability analysis*	3	75	75	H	M	M	M	-	-	-	-	-	-	-	-	M	M	-
CLO-5 :	*Gain knowledge on the concept of state estimation in power systems*	3	75	75	H	L	L	-	-	-	-	-	-	-	-	-	M	M	-
CLO-6 :	*Create ,design and analyze the power system issues starting from transmission to distribution*	3	75	75	H	M	M	M	M	-	-	-	-	-	-	-	M	M	-

Duration (hour)		9	9	9	9	9
S-1	SLO-1	*Formulation of power flow problem*	*Overview of security analysis*	*Basic concepts of stability*	*Introduction - Primary distribution systems*	*Need for state estimation*
	SLO-2	*Solution through Newton-Raphson method*	*Need for Power system Security*	*Classifications of stability*	*Types of primary distribution systems*	*Basic methods of state estimation*
S-2	SLO-1	*Problems solving- Newton-Raphson method*	*Factors affecting power system security*	*Small signal stability of a single machine infinite bus system*	*Secondary distribution systems*	*Comparison of power flow and state estimation problems*
	SLO-2	*Fast decoupled power flow solutions*	*Introduction to Contingency analysis*	*Small signal stability-solving numerical*	*Types of Secondary distribution systems*	*Least Square State Estimation*
S-3	SLO-1	*Problems solving-Fast Decoupled method*	*Contingency analysis-Addition and removal of one line*	*Transient stability-Runge kutta method*	*Ring main distribution systems*	*Weighted Least Square State Estimation*
	SLO-2	*Comparison of Load flow methods*	*Computation of bus impedance matrix from bus admittance matrix*	*Runge kutta method - Solving numericals*	*Ring main distribution systems-solving numerical*	*State estimation from Non-linear measurements*
S-4	SLO-1	*Power flow studies-simulation*	*Problem solving-contingency analysis*	*Runge kutta method - Solving numericals*	*Load flow of radial distribution networks-solving numerical*	*Static state estimation for power systems*
	SLO-2	*Power flow studies-simulation*	*Problem solving-contingency analysis*	*Runge kutta method - Solving numericals*	*Load flow of radial distribution networks - solving numerical*	*Weighted Least Square State Estimation – solving numericals*
S-5	SLO-1	*DC power flow solutions*	*Calculation of new bus voltage due to addition and removal of one line-simulation*	*Transient stability- Simulation*	*General design characteristics of distribution system*	*Detection of bad measurements*
	SLO-2	*AC-DC power flow model*	*Solving numericals*	*Voltage stability*	*Primary distribution system - design*	*Identification of bad measurements*
S-6	SLO-1	*Optimal Power Flow-Introduction*	*Linear sensitivity factors*	*Transmission characteristics*	*Primary distribution system - design*	*Detection and identification of bad measurements*
	SLO-2	*Gradient method*	*Problem solving-Linear sensitivity factors*	*Transmission characteristics*	*Voltage,scheme and feeder size selection*	*solving numerical*
S-7	SLO-1	*Problem solving-Gradient method*	*Problem solving-Linear sensitivity factors*	*Generator characteristics*	*Secondary distribution system - design*	*Network observability*
	SLO-2	*Newton's method*	*AC power flow method*	*Generator characteristics*	*Lamp flicker-Origin*	*Problem solving Network observability*

S-8	SLO-1	*Security constrained optimal power flow*	*Problem solving-AC power flow method*	*Load characteristics*	*Types of flicker and remedial measures*	*Pseudo measurements*
	SLO-2	*Optimal generation scheduling*	*Contingency selection*	*Load characteristics*	*Design of capacitors to distribution systems*	*State estimation including Phasor measurement units*
S-9	SLO-1	*Problem solving-optimal generation scheduling*	*Contingency ranking*	*Characteristics of reactive compensating devices.*	*Design of capacitors to distribution systems-solving numerical*	*State estimation including Phasor measurement units*
	SLO-2	*Optimal unit committment*	*Security analysis and contingency evaluation*	*Typical scenario of voltage collapse*	*Design of capacitors to distribution systems-solving numerical*	*Application of state estimation in power system in load forecasting*

Learning Resources	1. *Pai M.A. and Dheeman Chatterjee, Computer Techniques in Power System Analysis, Mc Graw Hill Education (India) Private Limited, New Delhi, 2016.* 2. *John.J.Grainger, William D. Stevenson, Jr, Power System Analysis, Mc Graw Hill Education (India) Private Limited, New Delhi, 2015.* 3. *Allen Wood J.and Bruce.F. Wollenberg, Power Generation Operation and Control, 2nd Edition, John Wiley & Sons, New York, 1996.*	4. *Prabha Kundur, Power system stability and control, Electrical power research institute-power system engineering series.* 5. *Mukhtar Ahmad, Power System State Estimation, Lap Lambert Acad Publishers, 2013.*

Learning Assessment											
	Bloom's Level of Thinking	Continuous Learning Assessment (50% weightage)								Final Examination (50% weightage)	
		CLA – 1 (10%)		CLA – 2 (15%)		CLA – 3 (15%)		CLA – 4 (10%)#			
		Theory	Practice	Theory	Practice	Theory	Practice	Theory	Practice	Theory	Practice
Level 1	Remember Understand	40 %	-	30 %	-	30 %	-	30 %	-	30%	-
Level 2	Apply Analyze	40 %	-	40 %	-	40 %	-	40 %	-	40%	-
Level 3	Evaluate Create	20 %	-	30 %	-	30 %	-	30 %	-	30%	-
	Total	100 %		100 %		100 %		100 %		100 %	

CLA – 4 can be from any combination of these: Assignments, Seminars, Tech Talks, Mini-Projects, Case-Studies, Self-Study, MOOCs, Certifications, Conf. Paper etc.,

Course Designers		
Experts from Industry	Experts from Higher Technical Institutions	Internal Experts
1.Dr.V.P.Boopathi, Powersys., Chennai,Boopathivp@gmail.com	*1.Dr. K. S. Swarup, IITM, Chennai, ksswarup@iitm.ac.in*	*1.Dr. S. Padmini, SRMIST*
2.Dr. T. Prakash, TNEB, Mt. Road, prakash.thyagarajan@tnebnet.org	*2.Dr. P. Somasundaram, Anna University, mpsomasundram@annauniv.edu*	*2.Dr. K. Vijayakumar, SRMIST*

Course Code	18EEE411T	Course Name	POWER SYSTEM DEREGULATION	Course Category	E	Professional Elective	L	T	P	C
							3	0	0	3

Pre-requisite Courses	NIL	Co-requisite Courses	NIL	Progressive Courses	NIL
Course Offering Department	Electrical & Electronics Engineering	Data Book / Codes/Standards	NIL		

Course Learning Rationale (CLR):	The purpose of learning this course is to:
CLR-1 :	*Understand the basics of deregulation and economics of power system*
CLR-2 :	*Learn Unit commitment, optimal power flow and its constraints*
CLR-3 :	*Understand the activity of GENCO and independent system operator*
CLR-4 :	*Get familiarized with the various transmission services*
CLR-5 :	*Gain knowledge on the role of security and congestion management in deregulated power system.*
CLR-6 :	*Create overall restructuring of power system starting from generation to power transmission and distribution*

Course Learning Outcomes (CLO):	At the end of this course, learners will be able to:	Learning 1 Level of Thinking (Bloom)	2 Expected Proficiency (%)	3 Expected Attainment (%)	PLO 1 Engineering Knowledge	2 Problem Analysis	3 Design & Development	4 Analysis, Design, Research	5 Modern Tool Usage	6 Society & Culture	7 Environment & Sustainability	8 Ethics	9 Individual & Team Work	10 Communication	11 Project Mgt. & Finance	12 Life Long Learning	13 PSO - 1	14 PSO - 2	15 PSO - 3
CLO-1 :	*Illustrate the basics of deregulation in conventional power system*	2	75	75	H	H	-	-	-	-	-		-	-	-	-	H	H	-
CLO-2 :	*Use the concept of Unit commitment, optimal power flow in electric power system*	2	75	75	H	H	-	-	-	-	-	M	-	-	-	-	H	H	M
CLO-3 :	*Apply the knowledge on the various role of ISO in deregulated environment*	2	75	75	H	M	-	-	-	-	-	-	-	-	-	-	H	H	-
CLO-4 :	*Analyze various transmission system problems*	2	75	75	H	M	--	-	-	-	-	-	-	-	-	-	H	H	-
CLO-5 :	*Utilize the basic role of security and congestion management and its solutions*	3	75	75	H	M	M	M	-	-	-	M	-	-	-	-	H	H	M
CLO-6 :	*Analyze the power system generation and transmission losses with various components in deregulated system*	3	75	75	H	M	M	M	-	-	-	M	-	-	-	-	H	H	M

Duration (hour)		9	9	9	9	9
S-1	SLO-1	*Introduction- Deregulation*	*Optimal Power Flow problem model*	*Operational planning activities of ISO*	*embedded cost based transmission pricing*	*Introduction to Congestion,*
	SLO-2	*Structure of a deregulated electricity system*	*Limits on Real and Reactive power flow*	*Single Auction Market*	*Postage stamp method*	*reasons for transfer capability limitation*
S-2	SLO-1	*Different entities in deregulated electricity markets*	*OPF Examples (quantitative analysis)*	*Double Auction Market*	*MW mile method(quantitative analysis)*	*Importance of congestion management*
	SLO-2	*Power system Deregulation in different countries*	*Characteristic features of OPF & its applications*	*ISO in Pool markets*	*Incremental cost based transmission pricing*	*Features of congestion management*
S-3	SLO-1	*competitive electricity markets*	*Unit commitment in conventional electricity market*	*ISO in Bilateral markets*	*Short run marginal cost based method*	*Classification of congestion management methods*
	SLO-2	*Benefits from a competitive electricity market*	*UC Constraints*	*Operational planning activities of GENCO*	*Long run marginal cost based method*	*Calculation of ATC*
S-4	SLO-1	*Classification of electricity markets*	*price based Unit commitment Design in deregulated electricity market*	*GENCO in pool and bilateral markets*	*Revenue Reconciliation*	*Economic instruments for Handling congestion*
	SLO-2	*Pool co and Bilateral Markets*	*Constraints in price based Unit commitment*	*Market participation issues*	*Transmission open access and pricing mechanisms in various countries*	*Congestion pricing methods*
S-5	SLO-1	*effects of deregulation*	*Competitive bidding., strategic bidding*	*Power exchange*	*Cost components of Transmission System Operator (TSO)*	*Market splitting*
	SLO-2	*Pre dispatch and instantaneous dispatch*	*parameters affecting bidding strategies*	*market operations*	*Transfer capability on open access transmission system*	*counter trade*

S-6	SLO-1	*Review of Economic Load Dispatch problem (ELD)*	*Formation of power pools*	*Market power- standard cost*	*Developments in international transmission pricing*	*Transmission rights*
	SLO-2	*Constraints in ELD problem*	*Economic Exchange of Energy*	*Price forecasting*	*Transmission Security management in deregulated environment*	*Inter zonal congestion management*
S-7	SLO-1	*Economic Load Dispatch problem In Deregulation*	*Multi area Joint Dispatch (quantitative analysis)*	*Power wheeling*	*Scheduling of spinning reserves in deregulated electric market*	*Intra zonal congestion management*
	SLO-2	*Economic Load Dispatch problem (quantitative analysis)*	*Energy Brokerage system*	*Types of wheeling transactions*	*Introduction of ancillary services*	*Price area congestion management*
S-8	SLO-1	*Conditions for optimum*	*Role of Independent system operator (ISO),*	*Transmission open access and types*	*Types of Ancillary services*	*Capacity alleviation method*
	SLO-2	*Significance of Lagrange Multipliers*	*Types of electricity market*	*Cost components in transmission*	*Classification of ancillary services*	*Contingency reserve services*
S-9	SLO-1	*Security constrained Economic dispatch*	*Structure of UK Electricity deregulated market*	*pricing of power transactions*	*Ancillary services management in various countries*	*Indian electricity act*
	SLO-2	*Preventive and corrective rescheduling*	*Structure of Nordic Electricity deregulated market*	*Ideal Wheeling Rate*	*Interruptible load options for security management*	*Indian power exchange*

Learning Resources	1. *KankarBhattacharya, Operation of Restructured Power Systems, Kluwer academic publishers, 2001.* 2. *Mohammad Shahidehpoura and Muwaffaq A lomoush, Restructured Electric Power System operation trading and volatility, Macsel Dekker Inc,2001* 3. *Zaccour.G. Deregulation of Electric Utilities, Kluwer academic publishers, 1998 .*	4. *Xiao ping Zhang, Restructured Electric Power Systems: Analysis of Electricity Markets with Equilibrium Models, IEEE press, 2010* 5. *THE ELECTRICITY ACT, 2003, http://www.cercind.gov.in/Act-with-amendment.pdf* 6. *https://nptel.ac.in/courses/108101005/.*

Learning Assessment

	Bloom's Level of Thinking	Continuous Learning Assessment (50% weightage)								Final Examination (50% weightage)	
		CLA – 1 (10%)		CLA – 2 (15%)		CLA – 3 (15%)		CLA – 4 (10%)#			
		Theory	Practice	Theory	Practice	Theory	Practice	Theory	Practice	Theory	Practice
Level 1	Remember Understand	40%	-	30%	-	30%	-	30%	-	30%	-
Level 2	Apply Analyze	40%	-	40%	-	40%	-	40%	-	40%	-
Level 3	Evaluate Create	20%	-	30%	-	30%	-	30%	-	30%	-
	Total	100 %		100 %		100 %		100 %		100 %	

CLA – 4 can be from any combination of these: Assignments, Seminars, Tech Talks, Mini-Projects, Case-Studies, Self-Study, MOOCs, Certifications, Conf. Paper etc.,

Course Designers		
Experts from Industry	Experts from Higher Technical Institutions	Internal Experts
1.Dr.S.Sambath, TANGEDCO,Tamilnadu, eses.eng@gmail.com	*1.Dr. M.P.Selvan, NIT Trichy, selvanmp@nitt.edu*	*Mr. K.Selvakumar, SRMIST*
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Course Code	18EEE317T	Course Name	SYSTEM THEORY	Course Category	E	Professional Elective	L	T	P	C
							3	0	0	3

Pre-requisite Courses	18EEC301J	Co-requisite Courses	Nil	Progressive Courses	Nil
Course Offering Department	Electrical & Electronics Engineering	Data Book / Codes/Standards	Nil		

Course Learning Rationale (CLR):	The purpose of learning this course is to:
CLR-1 :	*Model and represent the systems in state variable form*
CLR-2 :	*Understand the need of controllability and observability*
CLR-3 :	*Provide adequate knowledge in the phase plane analysis*
CLR-4 :	*Give a basic knowledge in describing function analysis*
CLR-5 :	*Educate on stability analysis of systems using Lyapunov's theory*
CLR-6 :	*Create a mindset to model and analyze the system stability using system theory concepts*

Course Learning Outcomes (CLO):	At the end of this course, learners will be able to:	Learning 1: Level of Thinking (Bloom)	2: Expected Proficiency (%)	3: Expected Attainment (%)	PLO 1: Engineering Knowledge	2: Problem Analysis	3: Design & Development	4: Analysis, Design, Research	5: Modern Tool Usage	6: Society & Culture	7: Environment & Sustainability	8: Ethics	9: Individual & Team Work	10: Communication	11: Project Mgt. & Finance	12: Life Long Learning	13: PSO - 1	14: PSO - 2	15: PSO - 3
CLO-1 :	*Apply the state space method to model Linear and Nonlinear system*	3	75	75	H	H	M	M	-	-	-	-	-	-	-	-	M	M	-
CLO-2 :	*Test the controllability and observability of the system*	3	75	75	H	H	M	M	-	-	-	-	-	-	-	-	M	M	-
CLO-3 :	*Apply the concepts of phase plane analysis to linear and Nonlinear system*	3	75	75	H	H	M	M	-	-	-	-	-	-	-	-	M	M	-
CLO-4 :	*Formulate the Describing function for Nonlinear system*	3	75	75	H	H	M	M	-	-	-	-	-	-	-	-	M	M	-
CLO-5 :	*Determine the stability of Nonlinear system using Lyapunov and Variable- Gradiant Method*	3	75	75	H	H	H	H	-	-	-	-	-	-	-	-	M	M	-
CLO-6 :	*Apply system theory concepts to model and analyze real time system*	3	75	75	H	H	H	H	-	-	-	-	-	-	-	-	M	M	-

Duration (hour)		9	9	9	9	9
S-1	SLO-1	*Concept of State-tate equation for Dynamic Systems*	*Concept of Controllability & Observability*	*Features of linear and non-linear systems*	*Basic concepts of describing functions*	*Introduction to Stability Analysis of Nonlinear System*
	SLO-2	*Time invariance and linearity- Non uniqueness of state model*	*Controllability Test for Time Varying and Time In varying Case: Minimum Energy Control*	*Common physical non-linearity's*	*Describing Function and Harmonic Balance*	*Equilibrium Points*
S-2	SLO-1	*State Diagram*	*Observability test for Time Varying and Time In- varying system*	*Methods of linearizing non-linear systems*	*Describing function analysis of nonlinear systems*	*Stability in the sense of Lyapunov*
	SLO-2	*Physical System: Linear Continuous Time model*	*Principle of Duality*	*Introduction to phase portraits*	*Importance of Describing Function*	*BIBO Stability*
S-3	SLO-1	*Physical System: Nonlinear system Model*	*Controllability of State model in Jordan Canonical Form*	*Concept of phase portraits*	*Derivation of describing functions for Hysteresis non-linearity*	*Stability of Linear Time Invariant Systems*
	SLO-2	*Local Linearization of Nonlinear Model*	*Observability of State model in Jordan Canonical Form*	*Singular points*	*Derivation of describing functions for Dead zone non-linearity*	*Problem Solving to find stability of Linear Time Invariant System*
S-4	SLO-1	*Solution of Nonlinear Continuous Time State Equation*	*Controllability and Observability Canonical Forms of State mode*	*Existence of Limit cycles*	*Basics of Backlash non-linearity*	*Introduction to Nonlinear Continuous Time Autonomous Systems*
	SLO-2	*Runge Kutta Method*	*Controllable Subspace, Unobservable Subspace*	*Use of Limit cycle in control system*	*Derivation of describing functions for Backlash non-linearity*	*Equilibrium Stability of Nonlinear Continuous Time Autonomous Systems*
S-5	SLO-1	*Solution of Linear Time Varying Continuous Time State Equation*	*Canonical Decomposition Theorem*	*Construction of phase portraits*	*Derivation of describing functions for Ideal Relay non-linearity*	*Basics of the Direct Method of Lyapunov*

	SLO-2	*The Homogeneous Solution*	*Input- Output Maps from State Model for Linear and Nonlinear System*	*Problem solving in phase portraits*	*Derivation of describing functions for Hysteretic Relay non-linearity*	*Direct Method of Lyapunov for Linear Continuous-Time Autonomous Systems*
S-6	SLO-1	*Evaluation of State Transition Matrix*	*Output Controllability*	*Phase plane analysis of linear System*	*Basics of Saturation non-linearity*	*Finding Lyapunov Functions for Nonlinear Continuous Time Autonomous Systems*
	SLO-2	*Non Homogeneous Solution*	*Dead-beat Controller*	*Problem solving in Phase plane for linear system*	*Derivation of describing functions for Saturation non-linearity*	*Krasovskii Method of Stability Analysis*
S-7	SLO-1	*Solution of Linear Time In-varying Continuous Time State Equation*	*Reducibility of Linear System*	*Phase plane analysis of Nonlinear System*	*General Conditions for stability of Nonlinear system*	*Finding Lyapunov Functions for Nonlinear Continuous Time Autonomous Systems*
	SLO-2	*Evaluation using Similarity Transform*	*Reducibility of Nonlinear System*	*Problem solving in Phase plane for Non-linear system*	*Describing function Conditions for stability of Nonlinear system*	*Variable- Gradient Method*
S-8	SLO-1	*Solution of Linear Time In-varying Continuous Time State Equation*	*Linear System Realizations: Phase Variable Canonical Form*	*Isocline method*	*Possibilities of Oscillations occurrence in Non Linear System*	*Transients in Non Linear System*
	SLO-2	*Evaluation using Cayley Hamilton Technique*	*Nonlinear System Realizations: Phase Variable Canonical Form*	*Importance of Isocline Method in Non Linear control system*	*Stability analyses of oscillations in Nonlinear system*	*Use of Lyapunov to Estimate Transients*
S-9	SLO-1	*Solution of Linear Time In-varying Continuous Time State Equation*	*Linear System Realizations: Jordan Canonical Form*	*Basics of Inverted Pendulum*	*Introduction to DC Motor Model*	*Stability Analysis Case Study related with Power Engineering Application*
	SLO-2	*Evaluation using Inverse Laplace Transform*	*Nonlinear System Realizations: Jordan Canonical Form*	*Example of Nonlinear System: Inverted Pendulum on a Cart*	*Describing function analysis of DC Motor with Permanent Magnet*	*Stability Analysis Case Study related with Power Engineering Application*

Learning Resources	1. *Katsuhiko Ogata, Modern Control Engineering,5th ed., Prentice Hall, 2017.* 2. *M. Gopal, Modern Control System Theory, 3rd ed., New Age International, 2014.* 3. *Marquez Horacio J Marquez, Nonlinear Control Systems: Analysis and Design, 2nd ed., Wiely Publications, 2012.*	4. *Zoran Vukic, Ljubomir Kuljaca, Dali Donlagic and Sejid Tesnjak, Nonlinear Control Systems, Marcel Dekker Inc, 2007.* 5. *Richard C.Dorf, Robert H.Bishop, Modern control system theory, 13th ed., Pearson Education Ltd, 2016.* 6. *https://www.edx.org/course/introduction-state-space-control-mitx-6-302-1x*

Learning Assessment

	Bloom's Level of Thinking	Continuous Learning Assessment (50% weightage)								Final Examination (50% weightage)	
		CLA – 1 (10%)		CLA – 2 (15%)		CLA – 3 (15%)		CLA – 4 (10%)#			
		Theory	Practice	Theory	Practice	Theory	Practice	Theory	Practice	Theory	Practice
Level 1	Remember Understand	40 %	-	30 %	-	30 %	-	30 %	-	30 %	-
Level 2	Apply Analyze	40 %	-	40 %	-	40 %	-	40 %	-	40 %	-
Level 3	Evaluate Create	20 %	-	30 %	-	30 %	-	30 %	-	30 %	-
	Total	100 %		100 %		100 %		100 %		100 %	

CLA – 4 can be from any combination of these: Assignments, Seminars, Tech Talks, Mini-Projects, Case-Studies, Self-Study, MOOCs, Certifications, Conf. Paper etc.,

Course Designers

Experts from Industry	Experts from Higher Technical Institutions	Internal Experts
1. Ms.R.Vijayalakshmi, C2C Engineering, vijayalakshmi@c2cengineering.co.in	*Dr.S.K.Patnaik, CEG, Anna University, skpatnaik@annauniv.edu*	*Dr.R. Narayanamoorthi, SRMIST*
2. Dr. S. Paramasivam, Danfoss, Industries Pvt Ltd, paramsathya@yahoo.com	*Dr. A. Venkadesan, NIT, Pondicherry, venkadesan@nitpy.ac.in*	*Dr.N. Chellammal, SRMIST*

Course Code	18EEE318T	Course Name	ROBUST CONTROL SYSTEM	Course Category	E	Professional Elective	L	T	P	C
							3	0	0	3

Pre-requisite Courses	18EEC301J	Co-requisite Courses	Nil	Progressive Courses	Nil
Course Offering Department	Electrical and Electronics Engineering	Data Book / Codes/Standards	Nil		

Course Learning Rationale (CLR):	*The purpose of learning this course is to:*
CLR-1 :	*Introduce the basics of Robust control principles*
CLR-2 :	*Solve the various problems in linear systems different stabilization methods*
CLR-3 :	*Compute the performance of linear systems by the measured parameters*
CLR-4 :	*Understand the performance and limitations of Feedback control*
CLR-5 :	*Identify the solutions for H∞ control and µSynthesis*
CLR-6 :	*Create a overall structure for Robust control system*

Course Learning Outcomes (CLO):	*At the end of this course, learners will be able to:*	Learning 1 Level of Thinking (Bloom)	2 Expected Proficiency (%)	3 Expected Attainment (%)	1 Engineering Knowledge	2 Problem Analysis	3 Design & Development	4 Analysis, Design, Research	5 Modern Tool Usage	6 Society & Culture	7 Environment & Sustainability	8 Ethics	9 Individual & Team Work	10 Communication	11 Project Mgt. & Finance	12 Life Long Learning	13 PSO - 1	14 PSO - 2	15 PSO - 3
CLO-1 :	*Understand the basics of Robust control principles*	2	80	75	H	M	M	-	-	-	-	-	-	-	-	-	H	M	-
CLO-2 :	*Calculate the parameters of Linear systems by using different stabilization methods*	3	80	75	H	H	M	M	M	-	-	-	-	-	-	-	M	M	-
CLO-3 :	*Analyze the performance of linear systems by the measured parameters*	3	80	75	H	H	H	M	-	-	-	-	M	-	-	-	H	M	-
CLO-4 :	*Acquire knowledge on Observer, Feedback control systems*	3	80	75	H	M	H	M	-	-	-	-	M	M	-	-	H	H	-
CLO-5 :	*Analyze the basics of H∞ control and µSynthesis and its solution*	3	80	75	H	H	M	M	-	-	-	-	M	M	-	-	H	M	-
CLO-6 :	*Design a Robust control system for Real time Control Applications*	3	80	75	H	H	M	M	M	-	-	-	M	M	-	-	H	M	-

Duration (hour)		9	9	9	9	9
S-1	SLO-1	*Introduction Engineering Background of RobustControl*	*Introduction Fundamentals ofLinearSystem*	*Introduction to Stabilization ofLinearSystems*	*Introduction to Performance Limitation ofFeedbackControl*	*Introduction to H ∞ Control &µSynthesis*
	SLO-2	*A Brief History of RobustControl*	*Structural Properties ofDynamicSystem*	*StateFeedback*	*PoissonIntegralFormula*	*ControlProblemand H ∞ Control Norm*
S-2	SLO-1	*Methodologies of RobustControl*	*Stability - Bounded-InputBounded-OutputStability*	*Observer - Full-OrderObserver*	*All-Pass and Minimum-PhaseTransferFunctions*	*Input–OutputRelationofTransferMatrix's H ∞ Norm*
	SLO-2	*Small-GainApproach*	*InternalStability*	*MinimalOrderObserver*	*Limitation on Achievable Closed-loopTransferFunction*	*Disturbance Control andWeightingFunction*
S-3	SLO-1	*Positive Real Method*	*Pole–Zero Cancellation*	*Parametrization ofStabilizingControllers*	*InterpolationCondition*	*LMI Solution 1:VariableElimination*
	SLO-2	*LyapunovMethod*	*StabilizabilityandDetectability*	*Generalized FeedbackControl System*	*Analysis ofSensitivityFunction*	*LMI Solution 2: VariableChange*
S-4	SLO-1	*Robust Regional PolePlacement*	*Problem solving session*	*Problem solving session*	*IntegralRelation*	*Problem solving session*
	SLO-2	*GainScheduling*	*LinearFractionalTransformation*	*ParametrizationofControllers*	*Problem solving session*	*Design of Generalized Plant andWeighting Function*
S-5	SLO-1	*Problem solving session*	*SystemPerformance*	*YoulaParametrization*	*Bode Integral RelationonSensitivity*	*µSynthesis*
	SLO-2	*Basics of Linear Algebra and Function Analysis*	*TestSignals*	*Structure ofClosed-LoopSystem*	*BodePhase Formula*	*Definition of µ andItsImplication*
S-6	SLO-1	*Trace, Determinant, Matrix Inverse, and BlockMatrix*	*Steady-StateResponse & TransientResponse*	*Structure of2-Degree-of-Freedom Systems*	*Limitation ofReference Tracking*	*Propertiesofµ*
	SLO-2	*Problem solving session*	*Comparison of Open-Loop andClosed-LoopControls*	*Implementation of 2-Degree-of-Freedom*	*1-Degree-& 2 Degree of-FreedomSystem*	*D–K IterationDesign*

S-7	SLO-1	*Linear VectorSpace*	*Problem solving session*	*SystemPerformance*	*Relation between Time Domain and FrequencyDomainProperties*	*RegionalPolePlacement*
	SLO-2	*Norm and Inner Product of Vector*	*Basics of Convex Analysis and LMI*	*Problem solving session*	*Parseval'sTheorem*	*Convex Region and ItsCharacterization*
S-8	SLO-1	*LinearSubspace*	*Convex Set and Convex Function*	*TestSignals*	*Fourier Transform and InverseFourierTransform*	*Condition for RegionalPolePlacement*
	SLO-2	*Matrix and Linear Mapping*	*Control Problem andLMI*	*Steady-StateResponse*	*KYPLemma*	*CompositeLMIRegion*
S-9	SLO-1	*Eigenvalue and Eigenvector*	*Interior Point Method*	*TransientResponse*	*Problem solving session*	*Problem solving session*
	SLO-2	*Problem solving session*	*Problem solving session*	*Problem solving session*	*Case Study: Stabilization of aUnicycleRobot*	*Case Study: Transient Stabilization of aPowerSystem*

Learning Resources	*1. Kang zhi liu, Yu Yao, Robust Control – Theory and Applications, Wiley Publications, 2016.* *2. T. Glad and L. Ljung, Control Theory: Multivariable and Non-linear methods, Taylor and Francis, London, 2009.* *3. S. Skogstad and I. Postlethwaite, Multivariable Feedback Control, John Wiley and Sons,2005.*	*4. B. Burl, Linear Optimal Control H2 and H∞ Methods, Addison Wesley, California, US.1999.* *5. K. Zhou, J. C. Doyle and K. Glover, Robust and Optimal Control, Prentice-Hall, 1999* *6. Online Course: https://swayam.gov.in/* *7. NPTEL: Control Engineering, Robust Control Systems. https://nptel.ac.in/courses/108103007/8*

Learning Assessment

	Bloom's Level of Thinking	Continuous Learning Assessment (50% weightage)								Final Examination (50% weightage)	
		CLA – 1 (10%)		CLA – 2 (15%)		CLA – 3 (15%)		CLA – 4 (10%)#			
		Theory	Practice	Theory	Practice	Theory	Practice	Theory	Practice	Theory	Practice
Level 1	Remember Understand	40 %	-	30 %	-	30 %	-	30 %	-	30%	-
Level 2	Apply Analyze	40 %	-	40 %	-	40 %	-	40 %	-	40%	-
Level 3	Evaluate Create	20 %	-	30 %	-	30 %	-	30 %	-	30%	-
	Total	100 %		100 %		100 %		100 %		100 %	

CLA – 4 can be from any combination of these: Assignments, Seminars, Tech Talks, Mini-Projects, Case-Studies, Self-Study, MOOCs, Certifications, Conf. Paper etc.,

Course Designers

Experts from Industry	Experts from Higher Technical Institutions	Internal Experts
1. Dr. Venkatarao Ryali, Electromechanical Control Systems Lab at GE Global Research, Bengaluru.	*1. Dr.S.K.Patnaik, CEG, Anna University, skpatnaik@annauniv.edu*	*1. Mr.S.Senthilmurugan, SRMIST*
2. Mr. Pugazhendhi K, Control & Instrumentation at ENMAS GB POWER SYSTEMS PROJECTS LTD.Chennai,	*2. r. B. K. Panigrahi, IIT Delhi, bkpanigrahi@ee.iitd.ac.in*	*2. Ms R.Rajarajeswari, SRMIST*

Course Code	18EEE319T	Course Name	FUNDAMENTALS OF ROBOTICS	Course Category	E	Professional Elective	L	T	P	C
							3	0	0	3

Pre-requisite Courses	NIL	Co-requisite Courses	Nil	Progressive Courses	Nil
Course Offering Department	Electrical & Electronics Engineering	Data Book / Codes/Standards	Nil		

Course Learning Rationale (CLR):	*The purpose of learning this course is to:*
CLR-1	*Understand the concepts and basic structure of Robots*
CLR-2	*Recognize the basics of end effectors and drive systems*
CLR-3	*Enrich the students on the basics of Robotic manipulator and understand the kinematics of serial manipulators*
CLR-4	*Analyze the basics of Sensors and its various applications in Robots.*
CLR-5	*Design the Algorithms for mobile Robot navigation.*
CLR-6	*Utilize the concepts in robotics for the understanding of automation technology*

Course Learning Outcomes (CLO):	*At the end of this course, learners will be able to:*	Learning 1: Level of Thinking (Bloom)	Learning 2: Expected Proficiency (%)	Learning 3: Expected Attainment (%)	PLO 1: Engineering Knowledge	PLO 2: Problem Analysis	PLO 3: Design & Development	PLO 4: Analysis, Design, Research	PLO 5: Modern Tool Usage	PLO 6: Society & Culture	PLO 7: Environment & Sustainability	PLO 8: Ethics	PLO 9: Individual & Team Work	PLO 10: Communication	PLO 11: Project Mgt. & Finance	PLO 12: Life Long Learning	PLO 13: PSO - 1	PLO 14: PSO - 2	PLO 15: PSO - 3
CLO-1	*Interpret the basic structure of Robots and apply it to design the Robots.*	2	75	75	H	H	M	L	-	-	-	-	-	-	-	-	M	M	-
CLO-2	*Acquire knowledge about end effectors and actuators systems*	3	75	75	H	H	H	M	-	-	-	-	-	-	-	-	H	M	-
CLO-3	*Select robotic manipulator and understand the kinematics of serial manipulators*	2	75	75	H	H	H	M	-	-	-	-	-	-	-	-	H	H	-
CLO-4	*Select and implement the sensors for various applications in Robots.*	3	75	75	H	H	H	M	-	-	-	-	-	-	-	-	M	M	-
CLO-5	*Develop the algorithms for mobile Robot navigation.*	3	75	75	H	H	H	H	-	-	-	-	-	-	-	-	H	M	-
CLO-6	*Apply the concepts of robotics in real time applications*	3	75	75	H	H	H	H	-	-	-	-	-	-	-	-	H	M	-

Duration (hour)		9	9	9	9	9
S-1	SLO-1	*Robotics: Definition Advantage and disadvantage of robots*	*Robot Drives- Actuators*	*Matrix representation*	*Robot Sensors*	*Localization*
	SLO-2	*History of robotics*	*Actuators selection.*	*Fixed – reference frame*	*Selection of sensor*	*Path Planning*
S-2	SLO-1	*Classification of robots*	*Characteristics of actuating system*	*Representation of frame at the origin of a fixed-reference frame*	*Contact and touch sensor*	*Examples oflocalization system*
	SLO-2	*Robot components,*	*Comparisons of actuating system*	*Representation of frame in a fixed reference frame*	*Tactile sensor*	*Brief representations*
S-3	SLO-1	*Robot characteristics*	*Electric Actuators: DC motor*	*Representation of rigid body*	*Gripping force sensing*	*Brief considerations*
	SLO-2	*Co-ordinate systems*	*Brushless DC motor*	*Robot Kinematics - Position analysis*	*Slip sensing*	*Mobile robot localization using practical filters*
S-4	SLO-1	*Robot reference frame*	*Hydraulic actuators*	*Representation of a pure transformation*	*Proximity sensor*	*Map representations*
	SLO-2	*Degrees of freedom*	*Pneumatic actuators*	*Representation of combined transformation*	*range sensor*	*Map considerations*
S-5	SLO-1	*Configuration space*	*Robot end effectors*	*Calculation of transformations*	*Light sensors*	*Simultaneous planning localization and mapping (SLAM)*
	SLO-2	*Operational space*	*Classification of end-effectors*	*Transformations relative to the rotating frame*	*Pressure sensors*	*Path planning*
S-6	SLO-1	*Robots as mechanisms*	*Drive system for grippers*	*Inverse transformation matrix*	*strain gauge based force-torque sensors*	*Path planning challenges*
	SLO-2	*Robot configurations-cartesian*	*Mechanical grippers*	*Inverse transformation matrix of the universe, robot, hand and end effectors frame*	*Position sensor*	*Types of Path planning algorithms*
S-7	SLO-1	*Robot configurations- cylinder*	*Magnetic grippers*	*Forward kinematics-2 DOF of kinematics analysis*	*Displacement sensor*	*Robotics applications with examples*
	SLO-2	*Robot\ configurations- polar*	*Vacuum grippers*	*Forward kinematics-3 DOF of kinematics analysis*	*Sensors-Vision systems*	*Material handling:Pick and place operation*
S-8	SLO-1	*Robot configurations- articulate*	*Adhesive grippers*	*Inverse kinematics- 2 DOF of kinematics analysis*	*Low level vision sensing and digitizing*	*Palletizing and depalletizing*
	SLO-2	*Robot wrist mechanism*	*Selection criteria for grippers*	*Inverse kinematics- 3 DOF of kinematics analysis*	*Vision cameras*	*Machine loading and unloading*
S-9	SLO-1	*Precision and accuracy of robot*	*Gripper force analysis and design*	*Euler angles*	*Charge coupled device line scan sensor*	*Welding, A sensor based joystick controlled teleoperated manipulator*
	SLO-2	*simple problems in precision and accuracy of robot*	*simple problems in Gripper*	*Issues in inverse kinematics*	*Applications of robotics vision system*	*A sensor based joystick controlled teleoperated manipulator*

Learning Resources	1. S. R. Deb & Sankha Deb, Robotics Technology and Flexible Automation, 2nd ed., Tata Mcgraw Hill, 2010. 2. Niku, Saeed,Introduction to robotics", 2nd ed., John Wiley & Sons, 2010. 3. John J. Craig, Introduction to Robotics: Mechanics and Control, 4th., Addison Wesley,2018.	4. Mikell. P. Groover, Industrial Robotics Technology, Programming and Applications", 3rded .,McGraw Hill Co, 2008. 5. https://www.edx.org/learn/robotics

Learning Assessment											
	Bloom's Level of Thinking	Continuous Learning Assessment (50% weightage)								Final Examination (50% weightage)	
		CLA – 1 (10%)		CLA – 2 (15%)		CLA – 3 (15%)		CLA – 4 (10%)#			
		Theory	Practice	Theory	Practice	Theory	Practice	Theory	Practice	Theory	Practice
Level 1	Remember Understand	40 %	-	30 %	-	30 %	-	30 %	-	30%	-
Level 2	Apply Analyze	40 %	-	40 %	-	40 %	-	40 %	-	40%	-
Level 3	Evaluate Create	20 %	-	30 %	-	30 %	-	30 %	-	30%	-
	Total	100 %		100 %		100 %		100 %		100 %	

CLA – 4 can be from any combination of these: Assignments, Seminars, Tech Talks, Mini-Projects, Case-Studies, Self-Study, MOOCs, Certifications, Conf. Paper etc.,

Course Designers		
Experts from Industry	Experts from Higher Technical Institutions	Internal Experts
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2.Mr.Uday kumar,KPIT,udaykumar2495@gmail.com	2.Dr.S.K.Patnaik, CEG, Anna University, skpatnaik@annauniv.edu	2.Dr.K.Mohanraj, SRMIST

Course Code	18EEE320T	Course Name	SIGNALS AND SYSTEMS	Course Category	E	Professional Elective	L	T	P	C
							3	0	0	3

Pre-requisite Courses	Nil	Co-requisite Courses	Nil	Progressive Courses	Nil
Course Offering Department	Electrical & Electronics Engineering	Data Book / Codes/Standards	Nil		

Course Learning Rationale (CLR):	*The purpose of learning this course is to:*
CLR-1 :	*Categorize the different types of continuous and discrete time signals*
CLR-2 :	*Classify the various types of continuous and discrete systems*
CLR-3 :	*Perform the discrete Fourier transform on signals*
CLR-4 :	*Perceive the digital IIR filters*
CLR-5 :	*Realize the digital FIR filters*
CLR-6 :	*Acquire knowledge on identification and creation of signals and systems*

Course Learning Outcomes (CLO):	*At the end of this course, learners will be able to:*	Learning 1: Level of Thinking (Bloom)	Learning 2: Expected Proficiency (%)	Learning 3: Expected Attainment (%)	PLO 1: Engineering Knowledge	PLO 2: Problem Analysis	PLO 3: Design & Development	PLO 4: Analysis, Design, Research	PLO 5: Modern Tool Usage	PLO 6: Society & Culture	PLO 7: Environment & Sustainability	PLO 8: Ethics	PLO 9: Individual & Team Work	PLO 10: Communication	PLO 11: Project Mgt. & Finance	PLO 12: Life Long Learning	PLO 13: PSO - 1	PLO 14: PSO - 2	PLO 15: PSO - 3
CLO-1 :	*Identify the continuous and discrete time signals*	2	80	75	H	H	L	L	L	-	-	-	-	-	-	-	H	M	-
CLO-2 :	*Distinguish the various types of continuous and discrete systems*	2	80	75	H	H	L	L	L	-	-	-	-	-	-	-	H	M	-
CLO-3 :	*Assess the Discrete Fourier transform on signals*	2	80	75	H	H	M	M	-	-	-	-	-	-	-	-	H	M	-
CLO-4 :	*Develop the digital IIR filters*	3	80	75	H	H	H	H	L	-	-	-	-	-	-	-	H	M	-
CLO-5 :	*Design the digital FIR filters*	3	80	75	H	H	H	H	L	-	-	-	-	-	-	-	H	M	-
CLO-6 :	*Evaluate the various types of signals and systems*	3	80	75	H	H	H	H	L	-	-	-	-	-	-	-	H	M	-

Duration (hour)		9	9	9	9	9
S-1	SLO-1	*Analog signals, discrete time signals and digital signals*	*Continuous time systems*	*System representation through differential equations*	*Design procedure of Analog Butterworth Filter*	*Design procedure of FIR filter by window technique*
	SLO-2	*Deterministic and random signals*	*Discrete time systems*	*System representation through difference equations*	*Design of Analog Butterworth Filter*	*Rectangular and Hamming windows*
S-2	SLO-1	*Periodic and aperiodic signals*	*Memory less and memory systems*	*Realization of discrete time systems: Direct form - I*	*Design procedure of Analog Chebyshev Filter*	*Hanning and Blackmann Windows*
	SLO-2	*Energy and power signals*	*Causal and non-causal systems*	*Realization of discrete time systems: Direct form - II*	*Design of Analog Chebyshev Filter*	*Kaiser window*
S-3	SLO-1	*Even-odd signals*	*Linear and non-linear systems*	*Realization of discrete time systems: Cascade form*	*Bilinear transform technique*	*Design of low pass FIR filter: Calculation of window coefficients*
	SLO-2	*Causal and non-causal signals*	*Time variant and time invariant systems*	*Realization of discrete time systems: Parallel form*	*Quantitative treatment of Bilinear transform technique*	*Design of low pass FIR filter: Calculation of filter coefficients*
S-4	SLO-1	*Standard continuous time signals: Unit step and Impulse signals*	*Stable and unstable systems*	*Discrete Fourier Transform (DFT)*	*Impulse invariance technique*	*Design of high pass FIR filter: Determination of window coefficients*
	SLO-2	*Standard continuous time signals: Sinusoidal and Exponential signals*	*FIR and IIR systems*	*Calculation of DFT*	*Quantitative treatment of Impulse invariance technique*	*Design of high pass FIR filter: Determination of filter coefficients*
S-5	SLO-1	*Standard discrete time signals: Unit step and Impulse signals*	*Recursive and non-recursive systems*	*DFT properties: Linearity, Periodicity, Circular convolution*	*Design of IIR Butterworth digital filters using bilinear transform technique*	*Design of band pass FIR filter: Calculation of window coefficients -*
	SLO-2	*Standard discrete time ignals:Sinusoidal and Exponential signals*	*System properties via the impulse response: Causality*	*DFT properties: Time reversal, Circular time shift, Parseval's theorem*	*Design of IIR Chebyshev digital filters using bilinear transform technique*	*Design of band pass FIR filter: Calculation of filter coefficients*
S-6	SLO-1	*Transformations of the independent variable: Addition, Multiplication and Shifting*	*System properties via the impulse response: Memory*	*DFT using DIT-FFT algorithm*	*Design of IIR Butterworth digital filters using impulse invariance technique – Self study*	*Design of band stop FIR filter: Determination of window coefficients – Seminar*

	SLO-2	*Transformations of the independent variable: Scaling and Reversal*	*Relation between continuous and discrete time systems*	*Calculation of DFT using DIT-FFT*	*Design of IIR Chebyshev digital filters using impulse invariance technique – Self study*	*Design of band stop FIR filter: Determination of filter coefficients – Seminar*
S-7	SLO-1	*Sampling and Sampling Theorem*	*Continuous time convolution*	*DFT using DIF-FFT algorithm*	*Realization of IIR Butterworth digital filters*	*Realization of FIR filters: Transversal realization structure*
	SLO-2	*Quantization and Coding*	*Quantitative treatment of Continuous time convolution*	*Calculation of DFT using DIF-FFT algorithm -Assignment*	*Realization of IIR Butterworth digital filters*	*Realization of FIR filters: Linear phase realization structure*
S-8	SLO-1	*Aliasing*	*Discrete time convolution*	*Inverse DFT*	*Need of Pre-warping*	*Realization of FIR filters: Polyphase realization structure*
	SLO-2	*Effects of Aliasing*	*Quantitative treatment of Discrete time convolution*	*Calculation of IDFT*	*Pre warping – Frequency transformation in digital domain*	*Realization of FIR filters: Cascade structure*
S-9	SLO-1	*Simulation on continuous time signals*	*Simulation on Continuous time systems*	*Circular convolution*	*Simulation on digital IIR Butterworth filters*	*Simulation on digital FIR low and high pass filters*
	SLO-2	*Simulation on discrete time signals*	*Simulation on discrete time systems*	*Quantitative treatment of Circular convolution -Assignment*	*Simulation on digital IIR Chebyshev filters*	*Simulation on digital FIR band pass and band stop filters*

Learning Resources	*1. H. P. Hsu, Signals and systems, Schaum's series, McGraw Hill Education, 2010.* *2. S. Haykin and B. V. Veen, Signals and Systems, John Wiley and Sons, 2007.* *3. A. V. Oppenheim and R. W. Schafer, Discrete-Time Signal Processing, Prentice Hall, 2009.* *4. M. J. Robert, Fundamentals of Signals and Systems, McGraw Hill Education, 2007.*	*5. B. P. Lathi, Linear Systems and Signals, Oxford University Press, 2009.* *6. A. V. Oppenheim, A. S. Willsky and S. H. Nawab, Signals and systems, Prentice HallIndia, 1997.* *7. J. G. Proakis and D. G. Manolakis, Digital Signal Processing: Principles, Algorithms,and Applications, Pearson, 2006.* *8. https://extension.ucsd.edu/courses-and-programs/signals-and-systems*

Learning Assessment

	Bloom's Level of Thinking	Continuous Learning Assessment (50% weightage)								Final Examination (50% weightage)	
		CLA – 1 (10%)		CLA – 2 (15%)		CLA – 3 (15%)		CLA – 4 (10%)#			
		Theory	Practice	Theory	Practice	Theory	Practice	Theory	Practice	Theory	Practice
Level 1	Remember Understand	40 %	-	30 %	-	30 %	-	30 %	-	30%	-
Level 2	Apply Analyze	40 %	-	40 %	-	40 %	-	40 %	-	40%	-
Level 3	Evaluate Create	20 %	-	30 %	-	30 %	-	30 %	-	30%	-
	Total	100 %		100 %		100 %		100 %		100 %	

CLA – 4 can be from any combination of these: Assignments, Seminars, Tech Talks, Mini-Projects, Case-Studies, Self-Study, MOOCs, Certifications, Conf. Paper etc.,

Course Designers

Experts from Industry	Experts from Higher Technical Institutions	Internal Experts
1. Dr. Sharon Ravichandran, ABB Ltd., Chennai, sharonravi87@gmail.com	*1. Dr. M.Jaya Bharata Reddy, NIT, Trichy, jbreddy@nitt.edu*	*1. Dr.K.Mohanraj, SRMIST*
2. Mr.Sabari Ramanan, Manager, Siemens, Chennai, sabari.pm@siemens.com	*2. Dr. B. K. Panigrahi, IIT Delhi, bkpanigrahi@ee.iitd.ac.in*	*2. Dr.A.Rathinam, SRMIST*

Course Code	18EEE412T	Course Name	ADVANCED CONTROL THEORY	Course Category	E	Professional Elective	L	T	P	C
							3	0	0	3

Pre-requisite Courses	18EEC301J	Co-requisite Courses	Nil	Progressive Courses	Nil
Course Offering Department	Electrical & Electronics Engineering	Data Book / Codes/Standards	Nil		

Course Learning Rationale (CLR):	*The purpose of learning this course is to:*
CLR-1 :	*Educate on the basic concepts of multivariable control system*
CLR-2 :	*Understand the design concepts in model predictive control techniques*
CLR-3 :	*Provide adequate knowledge on preliminary concepts in Adaptive control schemes*
CLR-4 :	*Provide knowledge on Variable Structure control techniques*
CLR-5 :	*Educate on different optimal control practices*
CLR- 6:	*Create a mindset to use the advanced control techniques in complex system*

Course Learning Outcomes (CLO):	*At the end of this course, learners will be able to:*	Learning 1: Level of Thinking (Bloom)	Learning 2: Expected Proficiency (%)	Learning 3: Expected Attainment (%)	PLO 1: Engineering Knowledge	PLO 2: Problem Analysis	PLO 3: Design & Development	PLO 4: Analysis, Design, Research	PLO 5: Modern Tool Usage	PLO 6: Society & Culture	PLO 7: Environment & Sustainability	PLO 8: Ethics	PLO 9: Individual & Team Work	PLO 10: Communication	PLO 11: Project Mgt. & Finance	PLO 12: Life Long Learning	PLO 13: PSO-1	PLO 14: PSO-2	PLO 15: PSO-3
CLO-1 :	*Formulate the Multivariable control techniques to Multiple parameter system*	3	75	75	H	H	M	M	-	-	-	-	-	-	-	-	M	M	-
CLO-2 :	*Apply the model predictive control strategy to linear and Nonlinear systems*	3	75	75	H	H	H	H	-	-	-	-	-	-	-	-	M	M	-
CLO-3 :	*Articulate the basic adaptive control technique to a system*	3	75	75	H	H	M	M	-	-	-	-	-	-	-	-	M	M	-
CLO-4 :	*Design the sliding mode control to a dynamic system*	3	75	75	H	H	M	M	-	-	-	-	-	-	-	-	M	M	-
CLO-5 :	*Analyze and design the optimal control techniques for linear and Nonlinear systems*	3	75	75	H	H	H	H	-	-	-	-	-	-	-	-	M	M	-
CLO-6 :	*Apply the advanced control techniques in real time problems*	3	75	75	H	H	H	H	-	-	-	-	-	-	-	-	M	M	-

Duration (hour)		9	9	9	9	9
S-1	SLO-1	*Basics of Classical Feedback Control*	*Introduction to Model Predictive control*	*Introduction to adaptive control*	*Introduction to Sliding Mode Control*	*Introduction to Optimal Control*
	SLO-2	*Introduction to multivariable control systems*	*MPC Strategy, Historical perspectives.*	*Effects of process variations*	*Properties of Sliding Motion*	*Importance of Optimal Control*
S-2	SLO-1	*Transfer functions for MIMO systems*	*MPC Elements: Prediction Model*	*Introduction to Adaptive control schemes*	*Pseudo Sliding With a Smooth Control*	*Basics of Parameter Optimization*
	SLO-2	*Negative Feedback Control system in MIMO system*	*MPC Elements: Objective Function*	*Types of Adaptive Control Schemes*	*State Space Approach in Sliding Mode*	*Parameter Optimization in Optimal Control*
S-3	SLO-1	*Multivariable frequency response analysis*	*Model forms for model predictive control Forms*	*Adaptive control problem*	*Sliding Mode Control: Problem Statement*	*Performance Index in Optimal Control*
	SLO-2	*Directions in Multivariable Systems*	*Dynamic Matrix Control*	*Non-parametric identification*	*Existence Solution and Equivalent Control*	*Constraints in Optimal Control*
S-4	SLO-1	*Introduction to multivariable system mapping-poles & zeros*	*Model predictive control Forms*	*Deterministic Self Tuning Regulators*	*Properties of Sliding Motion*	*Calculus of variance in Optimal Control*
	SLO-2	*Singular value decomposition*	*Model Algorithmic Control*	*Pole Placement in Adaptive Control*	*Properties of Sliding Motion*	*Basic Concepts, Functions in optimal Control*
S-5	SLO-1	*Limitations On Performance In MIMO Systems:: Functional controllability*	*Model predictive control Forms*	*Indirect Self Tuning Regulators*	*The reachability Problem in Sliding Mode Control*	*Optimum of a Function*
	SLO-2	*Limitations imposed by time delays*	*Predictive Functional Control*	*Continuous Time Self tuners*	*Single input Control Structure*	*Optimum of a Functional*
S-6	SLO-1	*Limitations On Performance In MIMO Systems*	*Generalized Predictive Control*	*Introduction to Stochastic Tuning Regulators*	*Unit Vector Approach: Existence in Ideal Sliding Mode*	*The basic variational Problem*
	SLO-2	*Limitations imposed by RHP zeros*	*Introduction and Formulation of Predictive Control*	*Predictive Self Tuning Regulators*	*Description of the sliding Motion by Unit Vector Approach*	*Second Variation Problem*

S-7	SLO-1	*Trade-offs in MIMO feedback design*	*Introduction to Multivariable Model Predictive Control*	*Stochastic Adaptive Problem*	*Introduction to types of Sliding Mode Design Approach (Qualitative)*	*Introduction to linear quadratic optimal control system*
	SLO-2	*Traditional LQG and LQR problems*	*Generalized Model of Multivariable Predictive Control*	*Dual Control in stochastic Predictive Control*	*Introduction to types of Sliding Mode Design Approach (Quantitative)*	*linear quadratic optimal control system Model*
S-8	SLO-1	*Introduction to linear quadratic regulation (LQR) control*	*Constrained Model Predictive Control*	*Introduction to Auto Tuning of Controller*	*Direct Eigen Structure Assignment Approach (Qualitative)*	*Finite Time Linear Quadratic Regulator*
	SLO-2	*Robustness properties of LQR control*	*Constraint General Form, Example*	*PID Controller Auto Tuning*	*Direct Eigen Structure Assignment Approach (Quantitative)*	*Problem Formulation in Finite Time Linear Quadratic Regulator*
S-9	SLO-1	*Introduction to H_2 control*	*Introduction to Robust Model Predictive Control - Application*	*Introduction to Gain Scheduling - Application*	*Introduction to higher order sliding mode control*	*Introduction to LQR system for general performance Index*
	SLO-2	*Introduction to $H\infty$ control*	*Introduction to Robust Model Predictive Control - Application*	*Introduction to Gain Scheduling - Application*	*Problems in Higher order sliding mode control*	*Introduction to LQR system for general performance Index*

Learning Resources	1. *Sigurd Skogestad and Ian Postlethwaite, Multivariable Feedback Control: Analysis and Design, 2ed (WILEY-Interscience), 2014.* 2. *Eduardo F. Camacho, Carlos Bordons Alba, Model Predictive Control, Springer, 2013.* 3. *Karl J.Astrom and Bjorn Wittenmark, Adaptive Conrol, Pearson Education, 2nd Editon, 2013.*	*4. C Edwards, S Spurgeon Sliding Mode Control: Theory And Applications, CRC Press, 1998.* *5. Donald E. Kirk, Optimal Control Theory: An Introduction, Prentice – Hall networks series, New Jersey, 2012.* *6. https://www.cranfield.ac.uk/courses/short/energy-and-power/advanced-control-systems*

Learning Assessment

	Bloom's Level of Thinking	Continuous Learning Assessment (50% weightage)								Final Examination (50% weightage)	
		CLA – 1 (10%)		CLA – 2 (15%)		CLA – 3 (15%)		CLA – 4 (10%)#			
		Theory	Practice	Theory	Practice	Theory	Practice	Theory	Practice	Theory	Practice
Level 1	Remember Understand	40 %	-	30 %	-	30 %	-	30 %	-	30 %	-
Level 2	Apply Analyze	40 %	-	40 %	-	40 %	-	40 %	-	40 %	-
Level 3	Evaluate Create	20 %	-	30 %	-	30 %	-	30 %	-	30 %	-
	Total	100 %		100 %		100 %		100 %		100 %	

CLA – 4 can be from any combination of these: Assignments, Seminars, Tech Talks, Mini-Projects, Case-Studies, Self-Study, MOOCs, Certifications, Conf. Paper etc.,

Course Designers		
Experts from Industry	Experts from Higher Technical Institutions	Internal Experts
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Course Code	18EEE413T	Course Name	DISTRIBUTED CONTROL SYSTEMS	Course Category	E	Professional Elective	L	T	P	C
							3	0	0	3

Pre-requisite Courses	Nil	Co-requisite Courses	Nil	Progressive Courses	Nil
Course Offering Department	Electrical and Electronics Engineering	Data Book / Codes/Standards	Nil		

Course Learning Rationale (CLR):	*The purpose of learning this course is to:*
CLR-1 :	*Learn the architecture, Organization and operation of PLC, SCADA and Distributed Control System (DCS)*
CLR-2 :	*Impart knowledge about basic controllers and DCS controller Configuration*
CLR-3 :	*Know the importance of Alarm features in DCSs*
CLR-4 :	*Impart adequate knowledge onMaintenance and Troubleshooting procedures of DCS*
CLR-5 :	*Learn the basics of Advanced Process Controllers in DCSs and Latest trends related to DCS*
CLR-6 :	*Gain Knowledge about basic DCS controllers Alarm system management and advanced process controllers*

		Learning			Program Learning Outcomes (PLO)														
		1	2	3	1	2	3	4	5	6	7	8	9	10	11	12	13	14	15
Course Learning Outcomes (CLO):	*At the end of this course, learners will be able to:*	Level of Thinking (Bloom)	Expected Proficiency (%)	Expected Attainment (%)	Engineering Knowledge	Problem Analysis	Design & Development	Analysis, Design, Research	Modern Tool Usage	Society & Culture	Environment & Sustainability	Ethics	Individual & Team Work	Communication	Project Mgt. & Finance	Life Long Learning	PSO - 1	PSO - 2	PSO - 3
CLO-1 :	*Familiarize the concepts and abstractions of distributed systems and their limitations*	2	80	75	H	L	L	L	-	-	-	-	-	-	-	-	M	M	-
CLO-2 :	*Obtain the knowledge of basic controllers and DCS controller Configuration*	2	80	75	H	L	L	-	-	-	-	-	-	-	-	-	M	M	-
CLO-3 :	*Enrich the knowledge of Alarm features of DCS*	2	80	75	H	L	M	L	-	-	-	-	-	-	-	-	M	L	-
CLO-4 :	*Analyse the system for the awareness of the issues and procedures to perform DCS Maintenance and Troubleshooting*	3	80	75	H	H	M	M	-	-	-	-	-	-	-	-	M	M	-
CLO-5 :	*Acquire the basics of Advanced Process Controllers in DCSs and Latest trends related to DCS*	3	80	75	H	H	H	H	-	-	-	-	-	-	-	-	M	M	-
CLO-6 :	*Evaluate and specify DCSs to ensure efficient and optimum operation of Plant*	3	80	75	H	H	H	H	-	-	-	-	-	-	-	-	M	M	-

Duration (hour)		9	9	9	9	9
S-1	SLO-1	*Programmable Logic Controller (PLC) – brief overview*	*Introduction to basic controller, Identification of the controller boards*	*Alarm system management: An alarm system, Functions of the plant or process operator*	*Introduction to Distributed control system reporting, Operation of advanced DCS using multi-screen display*	*Advanced Process Controllers:Feed forward Control*
	SLO-2	*Block Diagram of PLC*	*Discrete and logic control, Sequential and batch control*	*Functions of an alarm system, An effective alarm system*	*Cross screen invocation and linking*	*Cascade Control*
S-2	SLO-1	*An overview of SCADA systems: Introduction and Basics of SCADA system*	*Basic DCS controller configuration: Introduction and Control modes*	*Design overview*	*Alarm reporting, generation and acceptance*	*Statistical Process Control*
	SLO-2	*SCADA key features*	*Tracking and initialization in control slots used for cascade control*	*Human and ergonomic factors*	*Different types of logs and reports configurable on a DCS*	*Basics of advanced process control and optimization*
S-3	SLO-1	*Remote terminal units (RTUs)*	*Control functions*	*Structure of a good alarm system*	*Introduction to Distributed control system (DCS) configuration*	*Latest DCS Trends:Monitoring and control in the Field*
	SLO-2	*Typical requirements for an RTU system*	*Control algorithms*	*Safety integrity level (SIL)*	*System/project tree structure, DCS system database*	*Industrial Internet*
S-4	SLO-1	*PLCs used as RTUs and Consideration and benefits of SCADA system*	*Sequential Controllers for Batch Processing*	*Definition of strategy, Strategy for alarm system design*	*Configuration of control functions*	*Internet of Things*
	SLO-2	*DCS versus SCADA terminology*	*Defining equipment procedures*	*Strategy for alarm system maintenance and management at the site/plant, Generation of minimum design documentation for each alarm*	*Configuration of operator/monitoring functions*	*Mobile and remote devices*
S-5	SLO-1	*SCADA software package*	*Phase logic programming*	*Measurement of the alarms, Field measurements for deriving alarms*	*Configuration of system hardware structure*	*Cloud ProcessingMonitoring and control in the Cloud*
	SLO-2	*Hardware, software, system interfacing*	*Phase logic interface*	*Hardware for alarm processing, Alarm displays*	*Configuration of system software*	*Typical DCS and SCADA systems: Honeywell Plant Scape system*
S-6	SLO-1	*Overview of Distributed Control Systems: Introduction and Basic concepts of Distributed Computing*	*Logic block functions in advanced controller*	*Testing of alarms, Generation of various types of alarms*	*Documentation and Commissioning*	*Foxboro I/A series DCS*

	SLO-2	*Evolution of Distributed Computing System*	*DCS controller configuration*	*Selection of alarm settings*	*Introduction to Maintenance & Troubleshooting*	*Delta system*
S-7	SLO-1	*Present market trends in DCS*	*Introduction to Communications for DCS & SCADA systems: Purpose and Basic Communications principles*	*Setting alarm priority*	*Maintenance requirements of system and system elements*	*Citect*
	SLO-2	*Basic DCS specification*	*Balanced and unbalanced transmission lines*	*Design of field sensors for generating alarms*	*Requirements for in-built diagnostic and maintenance routines*	*Wonderware*
S-8	SLO-1	*General description of a commercial DCS*	*4 EIA-232 interface standards (CCITT V.24 interface standard)*	*Logical processing of alarms*	*Requirement for installation of UPS system*	*Distributed control system applications: Use of DCS in oil and gas processing environment*
	SLO-2	*Advantage of DCS systems*	*The EIA-485 interface standard*	*Design of alarm list displays*	*Recovery of a DCS following power outage*	*Use of DCS in pulp and paper environment*
S-9	SLO-1	*DCS selection criteria*	*Interoperability, ModBus protocol*	*Measurement of performance*	*Proper troubleshooting methods, identify typical Communication malfunctions and faults, Identifying failures, malfunctions, and faults*	*Use of DCS in petroleum-refining environment*
	SLO-2	*DCS architecture*	*HART protocol, The promise of FieldBus and DeviceNet and Benefits*	*Usefulness of alarms*	*Diagnostics of Communication faults*	*Distributed control systems project implementation*

Learning Resources	1. *Michael P. Lukas, Distributed Control Systems: Their Evaluation and Design, Van Nostrand Reinhold Co., 1986.* 2. *Boyer, S.A. SCADA: Supervisory Control and Data Acquisition. 4th Edition. International Society for Automation, Raleigh, USA, 2010.* 3. *Gene F. Franklin, J.David Powell, Abbas Emami, Feedback Control of Dynamic Systems, Naeini, Pearson* 4. *Srinivas Medida, Pocket Guide on Industrial Automation, For Engineers and Technicians, IDC Technologies.*	5. *Bela G. Liptak, Process Measurement and Analysis, Instrument Engineers' Handbook Fourth Edition, CRC Press.* 6. *Richard L. Shell, Ernest L. Hall, Handbook of Industrial Automation, University of Cincinnati Cincinnati, Ohio, 2000.* 7. *Practical Distributed Control Systems (DCS) for Engineers and Technicians, Revision 6.1, IDC Technologies.* 8. *www.isa.org*

Learning Assessment

	Bloom's Level of Thinking	Continuous Learning Assessment (50% weightage)								Final Examination (50% weightage)	
		CLA – 1 (10%)		CLA – 2 (15%)		CLA – 3 (15%)		CLA – 4 (10%)#			
		Theory	Practice	Theory	Practice	Theory	Practice	Theory	Practice	Theory	Practice
Level 1	Remember Understand	40 %	-	30 %	-	30 %	-	30 %	-	30%	-
Level 2	Apply Analyze	40 %	-	40 %	-	40 %	-	40 %	-	40%	-
Level 3	Evaluate Create	20 %	-	30 %	-	30 %	-	30 %	-	30%	-
	Total	100 %		100 %		100 %		100 %		100 %	

CLA – 4 can be from any combination of these: Assignments, Seminars, Tech Talks, Mini-Projects, Case-Studies, Self-Study, MOOCs, Certifications, Conf. Paper etc.,

Course Designers

Experts from Industry	Experts from Higher Technical Institutions	Internal Experts
Kranti kumar Chittiprolu, krantikumar.ch@cleanmaxsolar.com, Reginal Design Head, Solar Sector, CleanMax Solar.	*Dr. P. Lakshmi, Anna University, Madras,p_lakshmi@annauniv.edu*	*Ms. T.M. Thamizh Thentral, SRMIST*
Ms. Vijayalakshmi Ramani, Head-Engineering at C2C Engineering, Chennai, vijayalakshmi@c2cengineering.co.in	*Dr.S.K.Patnaik, CEG, Anna University, skpatnaik@annauniv.edu*	*Ms. R. Rajarajeswari, SRMIST*

Course Code	18EEE414T	Course Name	CONTROL SYSTEM DESIGN	Course Category	E	Professional Elective	L	T	P	C
							3	0	0	3

Pre-requisite Courses	18EEC301J	Co-requisite Courses	Nil	Progressive Courses	Nil
Course Offering Department	Electrical and Electronics Engineering	Data Book / Codes/Standards	Nil		

Course Learning Rationale (CLR):	*The purpose of learning this course is to:*	Learning			Program Learning Outcomes (PLO)														
		1	2	3	1	2	3	4	5	6	7	8	9	10	11	12	13	14	15
CLR-1 :	*Gain knowledge on stability using frequency domain methods*																		
CLR-2 :	*Analyze state space analysis of mechanical systems*																		
CLR-3 :	*Impart knowledge on controllability/observability of control systems*																		
CLR-4 :	*Outline the concept and design of robust control systems*																		
CLR-5 :	*Examine stability of nonlinear autonomous systems by state space methods*																		
CLR 6 :	*Gain knowledge on the design, control and analysis of Linear and non-linear system.*																		
Course Learning Outcomes (CLO):	*At the end of this course, learners will be able to:*	Level of Thinking (Bloom)	Expected Proficiency (%)	Expected Attainment (%)	Engineering Knowledge	Problem Analysis	Design & Development	Analysis, Design, Research	Modern Tool Usage	Society & Culture	Environment & Sustainability	Ethics	Individual & Team Work	Communication	Project Mgt. & Finance	Life Long Learning	PSO - 1	PSO - 2	PSO - 3
CLO-1 :	*Apply frequency domain methods for stability analysis*	2	80	75	H	H	L	L	-	-	-	-	-	-	-	-	M	M	-
CLO-2 :	*Evaluate linear dynamical systems by state space methods*	3	80	75	H	H	M	M	-	-	-	-	-	-	-	-	H	M	-
CLO-3 :	*Determine controllability/observability by rank test*	3	80	75	H	H	L	L	-	-	-	-	-	-	-	-	L	L	-
CLO-4 :	*Design robust control system for real time system*	3	80	75	H	H	L	L	-	-	-	-	-	-	-	-	M	M	-
CLO-5 :	*Analyse stability of nonlinear autonomous systems by state space methods*	2	80	75	H	M	L	l	-	-	-	-	-	-	-	-	L	L	-
CLO 6 :	*Design of compensators to analyse the system stability and performance of Control system.*	3	80	75	H	H	H	H	-	-	-	-	-	-	-	-	M	M	-

Duration (hour)		9	9	9	9	9
S-1	SLO-1	*Introduction to Design of Feedback Control Systems*	*Introduction to Design of State Variable Feedback Systems*	*Introduction to Controllability and Observability*	*Introduction to Robust control system*	*Lyapunov's stability*
	SLO-2	*Approaches to System Design*	*Advantages of State Space Representation*	*Conditions for Controllability and Observability*	*Review of norms for signals and systems*	*Stability of Autonomous Systems*
S-2	SLO-1	*Cascade Compensation Networks*	*State-space Equations*	*Algebraic definitions for Controllability and Observability*	*Review of Nyquist Criterion and Classical Stability Margin*	*Stability of linear and non-linear autonomous systems*
	SLO-2	*System Design Using Integration Networks*	*State model of LTI and SISO linear systems*	*Full-state feedback control design*	*The small Gain Theorem and Applications of Small Gain Theorem to the Robust Control*	*Lyapunov's indirect method*
S-3	SLO-1	*Design procedure for Phase-Lead network Using the Bode Diagram*	*State space representation using physical variables*	*Need for Observer*	*Robust control systems and system sensitivity*	*Lyapunov's direct method*
	SLO-2	*Design example: Phase-Lead design for different types system*	*State space representation using phase variables*	*Structure and properties of observer*	*System sensitivities to parameter perturbations*	*optimal control positive definite function*
S-4	SLO-1	*Design procedure for Phase-Lead network Using the root locus*	*State space models of DC motor*	*Integrated full-state feedback and observer*	*Analysis of robustness*	*optimal control negative definite function*
	SLO-2	*Design example: Phase-Lead design for different types system*	*State space models of inverted pendulum*	*Pole placement for single-output systems*	*System with uncertain parameters of robust control system*	*Positive semi-definite functions*
S-5	SLO-1	*Design procedure for Phase-Lag network Using the Bode Diagram*	*Decomposition of Transfer Functions- Direct Decomposition*	*Compensator design by separation principle*	*Considerations in design of robust control system Design*	*Negative semi-definite functions*
	SLO-2	*Design example: Phase-Lag design for different types of system*	*Cascade and parallel Decomposition*	*Reference inputs*	*Design of robust PID controlled systems*	*Lyapunov stability criteria*
S-6	SLO-1	*Design procedure for Phase-Lag network Using the root locus*	*Similarity Transformation*	*Types of observer*	*Robust internal mode control systems*	*Introduction to optimal control*
	SLO-2	*Design example: Phase-Lag design for different types system*	*Solution of state equations*	*Compensator design using full order observer*	*Design of internal mode control systems*	*Riccatti Equation*

S-7	SLO-1	*Design on the Bode Diagram Using Analytical Methods*	*Computation of the State Transition Matrix by infinite series method*	*Optimal control systems*	*Loop shaping necessary and sufficient conditions.*	*Linear Quadratic Regulator*
	SLO-2	*System design using analytical technique*	*Computation of the State Transition Matrix by Laplace transformation*	*Determination of optimal control systems*	*Robust stability test.*	*Lasalle's invariance principle*
S-8	SLO-1	*Systems with a Pre-filter*	*Computation of the State Transition Matrix by Cayley-Hamilton Theorem*	*Optimal system with control energy consideration*	*Robust performance test.*	*Instability Theorem*
	SLO-2	*Design for Deadbeat Response*	*Computation of the State Transition Matrix by Canonical Transformation*	*Disturbances and tracking systems*	*Design Examples: the pseudo quantitative feedback system*	*Design Examples-Linear Harmonic Oscillator*
S-9	SLO-1	*System design using control design software*	*Computation of the State Transition Matrix by Sylvester's method*	*Design Examples-Automatic test system*	*Robust Control Systems using Control design software*	*Design Examples-Non-Linear Spring mass system with Damper*
	SLO-2	*Sequential design of disk drive read system*	*Transfer Function from the State-Model*	*Diesel Electric Locomotive control system*	*Sequential design of disk drive read system*	*Design Example-Pendulum with and without friction*

Learning Resources	1. *Richard C. Dorf and Robert H. Bishop, Modern Control Systems, Prentice Hall, Upper Saddle River, NJ, 2001* 2. *Katsuhiko Ogata, Discrete Time Control Systems, Pearson* 3. *Gene F.Franklin, J.David Powell, Abbas Emami, Feedback Control of Dynamic Systems, Naeini, Pearson*	4. *Bernard Friedland, Control System Design: An Introduction to State-Space Methods (Dover Books on Electrical Engineering), Dover Publications Inc., 2005.* 5. *Steen Toffner-Clausen, System Identification and Robust Control, Springer Verlag London Limited 1996.* 6. *R.M.Murray, Z.Li, S.S.Sastry, A Mathematical Introduction to Robotic Manipulations, CRC Press, 1993.* 7. *http://nptel.ac.in/courses/108103007/16*

Learning Assessment											
	Bloom's Level of Thinking	Continuous Learning Assessment (50% weightage)								Final Examination (50% weightage)	
		CLA – 1 (10%)		CLA – 2 (15%)		CLA – 3 (15%)		CLA – 4 (10%)#			
		Theory	Practice	Theory	Practice	Theory	Practice	Theory	Practice	Theory	Practice
Level 1	Remember Understand	40 %	-	30 %	-	30 %	-	30 %	-	30%	-
Level 2	Apply Analyze	40 %	-	40 %	-	40 %	-	40 %	-	40%	-
Level 3	Evaluate Create	20 %	-	30 %	-	30 %	-	30 %	-	30%	-
	Total	100 %		100 %		100 %		100 %		100 %	

CLA – 4 can be from any combination of these: Assignments, Seminars, Tech Talks, Mini-Projects, Case-Studies, Self-Study, MOOCs, Certifications, Conf. Paper etc.,

Course Designers		
Experts from Industry	Experts from Higher Technical Institutions	Internal Experts
1. Dr. Sharon Ravichandran, ABB Ltd., Chennai,sharonravi87@gmail.com	*1.Dr. P. Lakshmi, Anna University, Madras,p_lakshmi@annauniv.edu*	*1.Ms. T.M. Thamizh Thentral, SRMIST*
2.Ms. Vijayalakshmi Ramani, Head-Engineering at C2C Engineering, Chennai, vijayalakshmi@c2cengineering.co.in	*2.Dr.S.K.Patnaik, CEG, Anna University, skpatnaik@annauniv.edu*	*2. Ms. R. Rajarajeswari, SRMIST*

Course Code	18EEE415T	Course Name	DIGITAL CONTROL SYSTEM	Course Category	E	Professional Elective	L	T	P	C
							3	0	0	3

Pre-requisite Courses	18EEC301J	Co-requisite Courses	Nil	Progressive Courses	Nil
Course Offering Department	Electrical and Electronics Engineering	Data Book / Codes/Standards	Nil		

Course Learning Rationale (CLR):	*The purpose of learning this course is to:*
CLR-1 :	*Enrich the students on the basics of time domain analysis*
CLR-2 :	*Explain the procedure for stability analysis*
CLR-3 :	*Outline the concepts of state space model, controllability and observability*
CLR-4 :	*Gain knowledge on the design of classical compensators*
CLR-5 :	*Understand the concepts of formulation and evaluation of regulators and filters*
CLR-6 :	*Create overall control system structure for industrial applications*

Course Learning Outcomes (CLO):	*At the end of this course, learners will be able to:*	Learning 1: Level of Thinking (Bloom)	Learning 2: Expected Proficiency (%)	Learning 3: Expected Attainment (%)	PLO 1: Engineering Knowledge	PLO 2: Problem Analysis	PLO 3: Design & Development	PLO 4: Analysis, Design, Research	PLO 5: Modern Tool Usage	PLO 6: Society & Culture	PLO 7: Environment & Sustainability	PLO 8: Ethics	PLO 9: Individual & Team Work	PLO 10: Communication	PLO 11: Project Mgt. & Finance	PLO 12: Life Long Learning	PLO 13: PSO - 1	PLO 14: PSO - 2	PLO 15: PSO - 3
CLO-1 :	*Gain knowledge on Z transform techniques*	*2*	*80*	*75*	*H*	*M*	*M*	-	-	-	-	-	-	-	-	-	*H*	*M*	-
CLO-2 :	*Interpret the knowledge of sampling and design of controllers*	*3*	*80*	*75*	*H*	*M*	*M*	*M*	*M*	-	-	-	-	-	-	-	*M*	*M*	-
CLO-3 :	*Illustrate modelling and state variable analysis*	*3*	*80*	*75*	*H*	*M*	*M*	*M*	-	-	-	-	-	-	-	-	*H*	*M*	-
CLO-4 :	*Analyze the effects of compensators*	*3*	*80*	*75*	*H*	*M*	*M*	*M*	*M*	-	-	-	-	-	-	-	*H*	*H*	-
CLO-5 :	*Design of regulators and filters for practical system*	*3*	*80*	*75*	*H*	*M*	*M*	*M*	-	-	-	-	-	-	-	-	*H*	*M*	-
CLO-6 :	*Design a control system and analyze the stability of the real time system*	*3*	*80*	*75*	*H*	*M*	*M*	*M*	*M*	-	-	-	-	-	-	-	*H*	*M*	-

Duration (hour)		9	9	9	9	9
S-1	SLO-1	*Basic components of a control system*	*Introduction to sampling*	*Introduction to state variable model*	*Compensator design*	*Introduction- Pole placement*
	SLO-2	*Classification of control systems*	*Sampled data control systems*	*State variable concepts, First , second companion forms*	*Compensating networks types: Cascade and feedback*	*State observers*
S-2	SLO-1	*Elements of an automatic control system*	*Sampled signal flow graph*	*Various canonical forms*	*Cascade Lead compensator design using Bode plot*	*Controller Design by State Feedback*
	SLO-2	*Applications of control system*	*Sampling time and frequency domain description aliasing, hold operation,*	*Jordan canonical models*	*Problems related to lead compensators*	*Stability improvement by state feedback*
S-3	SLO-1	*Introduction to Z-transform*	*Mathematical modeling of sampling process and analysis*	*Analysis-state space models*	*Cascade Lag compensator design using Bode plot*	*Necessary and sufficient condition for arbitrary pole placement*
	SLO-2	*Z-transform Concept*	*First order hold, factors limiting the choice of sampling rate,reconstruction.*	*Problems related to state space model*	*Problems related to lag compensators*	*State regulator design*
S-4	SLO-1	*Properties of Z-transform*	*Sampling and reconstruction of continuous time signals*	*Discrete state variable models*	*Problems related to lead- lag compensators*	*Design of state observers*
	SLO-2	*Z-transform relation with Laplace transform*	*Stability analysis of discrete system*	*Elementary principles.*	*Digital implementation of lead and lag controllers*	*Full Order Observer Design*
S-5	SLO-1	*Inverse z-Transforms and Problems*	*Jury stability test*	*Characteristic equation, state transition matrix*	*Design of digital control systems with deadbeat response*	*Reduced Order Observer Design*
	SLO-2	*Mapping of s-plane to z-plane*	*Bi-linear transformation*	*Solution to discrete state equation*	*Practical issues with deadbeat response design*	*Evaluation of State Feedback Gain Matrix*
S-6	SLO-1	*Pulse transfer function*	*Problems related to stability analysis*	*Stability of discrete state space models*	*Sampled data control systems with deadbeat response*	*State feedback with integral control*

	SLO-2	*Pulse transfer function of closed loop system*	*Digital PID controllers.*	*Cayley -Hamilton theorem*	*Introduction to software tools used in control system for compensator design*	*Digital control system with state feedback.*
S-7	SLO-1	*Introduction to the representation of discrete time systems*	*PID tuning and its importance*	*Controllability and observability*	*Coding in simulation software*	*Linear Quadratic Regulator (LQR) design*
	SLO-2	*Time response of discrete time systems*	*Techniques of controller tuning*	*Analysis of Controllability and observability*	*Exercises for solving problems related to compensators design*	*Formulation of LQR problem-*
S-8	SLO-1	*Time response specifications*	*Manual tuning Zeigler-Nichols method based on open loop and closed loop responses*	*Stability- Lyapunov stability theorem*	*Software implementation using microprocessors and microcontrollers*	*Optimal estimation- Kalman filter*
	SLO-2	*Application of the z transform for discrete time signals and systems.*	*Application of controllers used for control system*	*Analysis of Lyapunov stability*	*Microcontroller based temperature control systems*	*Solution to continuous and discrete systems - Design examples.*
S-9	SLO-1	*Problems related to time response for standard test signals*	*Controller design using root locus*	*Systems with dead time*	*Speed control of motor load system*	*Introduction to optimal control*
	SLO-2	*Problems related to time domain specifications*	*Root locus based controller design using software tools*	*Problems related to controllability and observability*	*Microcontroller based motor speed control systems.*	*Parameter optimization*

Learning Resources	*1. B. C. Kuo, Digital Control Systems, Oxford University Press, 2/e, Indian Edition, 2012.* *2.Richard C Dorf and Robert H Bishop, Modern Control Systems, 13th edition, Pearson Education, 2016.*	*3. M. Gopal, Digital Control and State Variable Methods, Tata Mcgraw Hill, 2/e, 2017.* *4.Norman S Nise, Control Systems Engineering, 7th edition, Wiley, 2015.* *5.https://nptel.ac.in/courses/108103008/*

Learning Assessment

	Bloom's Level of Thinking	Continuous Learning Assessment (50% weightage)								Final Examination (50% weightage)	
		CLA – 1 (10%)		CLA – 2 (15%)		CLA – 3 (15%)		CLA – 4 (10%)#			
		Theory	Practice	Theory	Practice	Theory	Practice	Theory	Practice	Theory	Practice
Level 1	Remember Understand	40 %	-	30 %	-	30 %	-	30 %	-	30%	-
Level 2	Apply Analyze	40 %	-	40 %	-	40 %	-	40 %	-	40%	-
Level 3	Evaluate Create	20 %	-	30 %	-	30 %	-	30 %	-	30%	-
	Total	100 %		100 %		100 %		100 %		100 %	

CLA – 4 can be from any combination of these: Assignments, Seminars, Tech Talks, Mini-Projects, Case-Studies, Self-Study, MOOCs, Certifications, Conf. Paper etc.,

Course Designers

Experts from Industry	Experts from Higher Technical Institutions	Internal Experts
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2.Mr.Jason Manoraj , L&T Technology Services Limited, Bengaluru, Karnataka, jasonmanoraj@gmail.com	*2.Dr. B. K. Panigrahi, IIT Delhi, bkpanigrahi@ee.iitd.ac.in*	*2. Dr. Raja Vikram SRMIST*

Course Code	18EEE321T	Course Name	PHOTONICS	Course Category	E	Professional Elective	L	T	P	C
							3	0	0	3

Pre-requisite Courses	Nil	Co-requisite Courses	Nil	Progressive Courses	Nil
Course Offering Department	Electrical and Electronics Engineering	Data Book / Codes/Standards	Nil		

Course Learning Rationale (CLR):	*The purpose of learning this course is to:*
CLR-1 :	*Introduce the basics principles of photonics*
CLR-2 :	*Solve the various problems in Light beams and Variable polarization*
CLR-3 :	*Analyze the performance of surface and cavity nanophononics*
CLR-4 :	*Understand the process and performance of Multiphoton*
CLR-5 :	*Analyze the basics of Electromagnetic duality, Slow and fast light principles*
CLR-6 :	*Create a over all structure for Photonics system*

Course Learning Outcomes (CLO):	*At the end of this course, learners will be able to:*	Learning 1: Level of Thinking (Bloom)	Learning 2: Expected Proficiency (%)	Learning 3: Expected Attainment (%)	PLO 1: Engineering Knowledge	2: Problem Analysis	3: Design & Development	4: Analysis, Design, Research	5: Modern Tool Usage	6: Society & Culture	7: Environment & Sustainability	8: Ethics	9: Individual & Team Work	10: Communication	11: Project Mgt. & Finance	12: Life Long Learning	13: PSO - 1	14: PSO - 2	15: PSO - 3
CLO-1 :	*Understand the basics of photonics principles*	*2*	*80*	*75*	*H*	-	-	-	-	-	-	-	-	-	-	-	*M*	*M*	-
CLO-2 :	*Calculate the parameters of Light beams and Variable polarization*	*2*	*80*	*75*	*H*	-	-	-	-	-	-	-	-	-	-	-	*M*	*M*	-
CLO-3 :	*Compute the performance of surface and cavity nanophononics*	*2*	*80*	*75*	*H*	-	-	-	-	-	-	-	-	-	-	-	*M*	*M*	-
CLO-4 :	*Acquire knowledge on Multiphoton process*	*2*	*80*	*75*	*H*	-	-	-	-	-	-	-	-	-	-	-	*H*	*H*	-
CLO-5 :	*Identify the solutions for slow and fast light*	*2*	*80*	*75*	*H*	-	-	-	-	-	-	-	-	-	-	-	*M*	*M*	-
CLO-6 :	*Design a Photonics system for Real Time Applications*	*2*	*80*	*75*	*H*	-	-	-	-	-	-	-	-	-	-	-	*M*	*M*	-

Duration (hour)		9	9	9	9	9
S-1	SLO-1	*Photon in Perspective*	*Light Beams with Spatially Variable Polarization*	*Surface and Cavity Nanophononics*	*Multiphoton Processes*	*Lighting Principles*
	SLO-2	*Photon Localization*	*Poincare Modes of Beams*	*Basic Formalism*	*Molecular Two-Photon Absorption: Basic Principles*	*Introduction to Slow and Fast Light*
S-2	SLO-1	*Wavefunction*	*Polarization Singularities*	*Dipole Emitter Near Edge*	*Molecular Two-Photon Fluorescence*	*Mechanisms of Slow Light*
	SLO-2	*The Quantum Vacuum*	*Quantum Optics*	*Quantum Correlations*	*Applications and Future Prospects*	*Physics with Slow and Fast Light*
S-3	SLO-1	*Virtual Photons*	*Open Systems: Inputs and Outputs*	*Entanglement*	*Orbital Angular Momentum*	*Some Applications of Slow and Fast Light*
	SLO-2	*Structured Light*	*Photon Counting*	*Wedge Cavities*	*Historical Introduction*	*Fundamental Limits on Slow Light*
S-4	SLO-1	*Photon Number Fluctuations*	*Cavity*	*Quantum Electrodynamics*	*Creating Beams with OAM*	*Attosecond Physics*
	SLO-2	*Photon Number Phase*	*Circuit QED*	*Molecular QED: Principle of Minimal Electromagnetic Coupling*	*Micro-Manipulation through the Use of OAM*	*Attosecond Streaking Spectroscopy of Atoms and Solids*
S-5	SLO-1	*The Reality of Photonics*	*Squeezed Light*	*Multipolar Hamiltonian*	*Beam Transformations*	*Time-Resolved Photoemission from Atoms*
	SLO-2	*Coherence and Statistical Optics*	*Salient Features of Squeezed States*	*One-Photon Absorption*	*Measuring Beams with OAM*	*Streaked Photoemission from Solids*
S-6	SLO-1	*Classical Theory of Optical Coherence in the Space-Time Domain*	*Detection*	*Emission of Light: Spontaneous and Stimulated Processes*	*OAM in Classical Imaging*	*Attosecond Streaking from Nanostructures*

	SLO-2	*Classical Theory of Optical Coherence in the Space-Frequency Domain*	*Preparation*	*Linear Light-Scattering:*	*OAM in Nonlinear and Quantum Optics*	*Attosecond Physics*
S-7	SLO-1	*Cross-Spectrally Pure Optical Fields*	*Applications in Quantum Information*	*The Kramers–Heisenberg Dispersion Formula*	*Electromagnetic Duality Transformations in Optics*	*Attosecond Streaking Spectroscopy of Atoms and Solids*
	SLO-2	*Polarization Properties of Stochastic Beams*	*Electromagnetic Theory of Materials*	*Chiroptical Effects*	*Symmetries and Operators*	*Attosecond Streaking Spectroscopy of Solids*
S-8	SLO-1	*Remarks on Partially Coherent*	*Macroscopic Viewpoint*	*Two-Photon Absorption*	*Electromagnetic Duality*	*Introduction to Photoemission*
	SLO-2	*Partially Polarized*	*Constitutive Dyadic*	*Nonlinear Light-Scattering: Sum-Frequency and Harmonic Generation*	*Optical Helicity*	*Time-Resolved Photoemission from Atoms*
S-9	SLO-1	*Beams Basics of Quantum Theory of Optical Coherence*	*Linear Materials*	*Resonance Energy Transfer*	*Electromagnetic Duality Symmetry*	*Streaked Photoemission from Solids*
	SLO-2	*Polarization of singularities*	*Nonlinear Materials*	*van der Waals Dispersion Energy*	*Duality Symmetry in Piecewise Homogeneous and Isotropic Media*	*Attosecond Streaking from Nanostructures*

Learning Resources	1. *David L. Andrews, Photonics, Volume 1: Fundamentals of Photonics and Physics, Wiley, 2015.* 2. *Lasers-Theory and Applications- Ghatak and Thyagarajan, McMillan (2010)* 3. *Optoelectronic devices and systems- S C Gupta ,Prentice Hall India (2008)* 4. *Understanding Fiber optics- J Hecht, Pearson Edu. Inc (2006)*	5. *Light Emitting Diodes-E Fred Scheubert ,Cambridge University Press,(2003)* 6. *Photonic switching technology - H T Mouftah, J M H Elmirghani - IEE Press (1999).* 7. *Online Course: IITM-NPTEL – Introduction to Photonics. https://nptel.ac.in/courses/108106135/*

Learning Assessment											
	Bloom's Level of Thinking	Continuous Learning Assessment (50% weightage)								Final Examination (50% weightage)	
		CLA – 1 (10%)		CLA – 2 (15%)		CLA – 3 (15%)		CLA – 4 (10%)#			
		Theory	Practice	Theory	Practice	Theory	Practice	Theory	Practice	Theory	Practice
Level 1	Remember Understand	40 %	-	30 %	-	30 %	-	30 %	-	30%	-
Level 2	Apply Analyze	40 %	-	40 %	-	40 %	-	40 %	-	40%	-
Level 3	Evaluate Create	20 %	-	30 %	-	30 %	-	30 %	-	30%	-
	Total	100 %		100 %		100 %		100 %		100 %	

CLA – 4 can be from any combination of these: Assignments, Seminars, Tech Talks, Mini-Projects, Case-Studies, Self-Study, MOOCs, Certifications, Conf. Paper etc.,

Course Designers		
Experts from Industry	Experts from Higher Technical Institutions	Internal Experts
1.Mr.Danrajpurkar, Founder, Danano Photonics, Bengaluru, dananophotonics.com	*1.Dr.S.Selladurai, Physics, CEG, Anna University, ssdurai@annauniv.edu*	*1.Dr.Junaid masud lascar, SRMIST*
2.Mr.Satish Bhaker, Director, Sun Photonics, Newdelhi, info@sun-photonics.com	*2.Dr.A.Mujeeb, International School of Photonics, CUSAT,mujeeb@cusat.ac.in*	*2.S.Senthilmurugan, SRMIST*

Course Code	18EEE322T	Course Name	PRINCIPLES OF BIOMEDICAL INSTRUMENTATION	Course Category	E	Professional Elective	L	T	P	C
							3	0	0	3

Pre-requisite Courses	Nil	Co-requisite Courses	Nil	Progressive Courses	Nil
Course Offering Department	Electrical and Electronics Engineering	Data Book / Codes/Standards	Nil		

Course Learning Rationale (CLR):	*The purpose of learning this course is to:*
CLR-1 :	*Understand the physiological system of the body*
CLR-2 :	*Have an in depth knowledge on the devices for physiological process measurements in the human body*
CLR-3 :	*Acquire knowledge on the measurement of non-electrical parameters in the human body*
CLR-4 :	*Enrich the students on the basic concepts of medical imaging, telemetry techniques and their applications*
CLR-5 :	*Expose the students to medical assisting and therapy equipments*
CLR-6 :	*Create overall structure of biomedical instrumentation starting from physiological system to measurements and assisting equipments*

Course Learning Outcomes (CLO):	*At the end of this course, learners will be able to:*	Learning 1: Level of Thinking (Bloom)	Learning 2: Expected Proficiency (%)	Learning 3: Expected Attainment (%)	1 Engineering Knowledge	2 Problem Analysis	3 Design & Development	4 Analysis, Design, Research	5 Modern Tool Usage	6 Society & Culture	7 Environment & Sustainability	8 Ethics	9 Individual & Team Work	10 Communication	11 Project Mgt. & Finance	12 Life Long Learning	13 PSO - 1	14 PSO - 2	15 PSO - 3
CLO-1 :	*Explain the various systems of the human body*	1	80	75	H	-	-	-	-	-	-	-	-	-	-	-	-	M	-
CLO-2 :	*Use electrodes and transducers for physiological process measurements in the human body*	2	80	75	H	-	-	-	-	-	-	L	-	-	-	-	M	M	L
CLO-3 :	*Measure the non-electrical quantities of the human body*	2	80	75	H	-	-	-	-	-	-	-	-	-	-	-	M	M	-
CLO-4 :	*Recognize the applications of medical imaging and telemetry techniques*	2	80	75	H	-	-	-	-	-	-	-	-	-	-	-	M	M	-
CLO-5 :	*Relate the medical assisting and therapy equipments*	2	80	75	H	-	-	-	-	-	-	L	-	-	-	-	H	M	L
CLO-6 :	*Identify the physiological systems of the body along with various measurements and assisting equipments*	2	80	75	H	-	-	-	-	-	-	L	-	-	-	-	M	M	L

Duration (hour)		9	9	9	9	9
S-1	SLO-1	*Physiological systems of the body*	*Electrode theory*	*Measurement of blood pressure- direct method*	*X-ray machine*	*Need for Cardiac pacemakers*
	SLO-2	*Cells and their structure*	*Needle and wire electrode*	*Measurement of blood pressure-indirect method*	*Physical parameters for X- ray detectors*	*External pacemakers: Types: Vetricular asynchronous , synchronous and inhibited pacemaker*
S-2	SLO-1	*Characteristics of living organisms*	*Surface and micro electrode*	*Introduction to the measurement of blood flow*	*Digital radiography*	*Atrial synchronous and sequential ventricular inhibited pacemaker*
	SLO-2	*General characteristics of a human cell*	*Metal micropipette electrode*	*Electromagnetic blood flow meter*	*Diagnostic ultrasound*	*Implantable pacemaker*
S-3	SLO-1	*Nernst equation*	*Resistive transducers, thermistor, strain gauge*	*Ultra sound blood flow meter*	*Echocardiography*	*Need for defibrillator*
	SLO-2	*Bioelectric potential*	*Inductive and capacitive transducer*	*Laser Doppler blood flow meter*	*Computer tomography*	*DC defibrillator*
S-4	SLO-1	*Electrical characteristics of the human cell*	*Basic recording system, direct writing recorder, Ink jet recorder*	*Dye dilution method of cardiac output measuring techniques*	*CT system components*	*Implantable defibrillator*
	SLO-2	*Bioelectric potential propagation*	*Potentiometric recorder , Digital recorder and instrumentation type recorder*	*Thermal dilution method of cardiac output measuring techniques*	*Patient dose in CT Scanners*	*Mechanics of respiration*
S-5	SLO-1	*Cardiovascular system*	*Lead system of electrocardiogram*	*Heart rate measurement*	*Principles of Magnetic resonance Imaging systems*	*Artificial ventilation*
	SLO-2	*Blood circulation*	*Standard bipolar leads and unipolar leads*	*Measurement of heart sounds*	*Basic MRI components*	*Types of ventilators: Pressure limited ventilator*
S-6	SLO-1	*Heart and its mechanical activities*	*Recording methods of electrocardiogram*	*Gas analysers*	*Image reconstruction techniques*	*Volume limited and servo controlled vetilators*
	SLO-2	*Electrical potentials generated within the heart*	*Typical waveforms of electrocardiogram*	*Blood gas analyser*	*Position Emission Tomography*	*Pressure volume flow diagram*

S-7	SLO-1	*Physiology of the respiratory system*	*Electromyography*	*Oximetry*	*Single Photon Emission Computed Tomography*	*Kidney machine, Artificial kidney*
	SLO-2	*Respiratory volumes and capacities*	*Measurement of conduction velocity*	*Ear oximeter*	*Thermography*	*Dialyzers, Types: Parallel flow dialyzer*
S-8	SLO-1	*Anatomy of the nervous system*	*Electroretinography*	*Pluse oximeter*	*Biotelemetry*	*Coil hemodialyzer, Hollw fiber hemodialyzer*
	SLO-2	*Excitation and inhibition potentials*	*Electrogastrography*	*Skin reflection oximeter*	*Wireless telemetry*	*Diathermy*
S-9	SLO-1	*Muscle action*	*Electroculography*	*spirometry*	*Single channel telemetry system*	*Endoscopes*
	SLO-2	*Sensory system*	*Pneumotachography*	*Measurement of lung volume*	*Multichannel wireless telemetry system*	*Lasers in biomedical field*

Learning Resources	1. *Leslie Cromwell, Fred. J,Weibell and Ench APleiffer, Biomedical Instrumentation and measurements Prentice Hall of India, 2nd ed., 2004* 2. *Kandpur R.S, Handbook of Biomedical Instrumentation, Tata McGraw Hill, 2nd ed., 2011*	3. *C.Raja Roa & .K Guha, Principles of medical electronics and biomedical instrumentation, Universities press,2001* 4. *G.Webster, Medical Instrumentation Application and Design, 3rd ed., Wiley India edition, 2009.* 5. *https://swayam.gov.in/nd1_noc19_bt28/preview ,NPTEL Online Course-Bioelectricity*

Learning Assessment											
	Bloom's Level of Thinking	Continuous Learning Assessment (50% weightage)								Final Examination (50% weightage)	
		CLA – 1 (10%)		CLA – 2 (15%)		CLA – 3 (15%)		CLA – 4 (10%)#			
		Theory	Practice	Theory	Practice	Theory	Practice	Theory	Practice	Theory	Practice
Level 1	Remember Understand	40 %	-	30 %	-	30 %	-	30 %	-	30%	-
Level 2	Apply Analyze	40 %	-	40 %	-	40 %	-	40 %	-	40%	-
Level 3	Evaluate Create	20 %	-	30 %	-	30 %	-	30 %	-	30%	-
	Total	100 %		100 %		100 %		100 %		100 %	

CLA – 4 can be from any combination of these: Assignments, Seminars, Tech Talks, Mini-Projects, Case-Studies, Self-Study, MOOCs, Certifications, Conf. Paper etc.,

Course Designers		
Experts from Industry	Experts from Higher Technical Institutions	Internal Experts
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2.Mr.Srinath rao, Alstrom,sreenathr.rao@alstrom.com	*2. Dr. S. Ramareddy, Jerusalem College of Engineering,srr.victory@gmail.com*	*2. Mrs. R.Uthra, SRMIST*

Course Code	18EEE323T	Course Name	AUTOMOTIVE ELECTRONICS	Course Category	E	Professional Elective	L	T	P	C
							3	0	0	3
Pre-requisite Courses		Co-requisite Courses		Progressive Courses						
Course Offering Department	Electrical and Electronics Engineering	Data Book / Codes/Standards								

Course Learning Rationale (CLR):	The purpose of learning this course is to:
CLR-1 :	*Enrich the students on the basics of batteries*
CLR-2 :	*Understand the concepts of battery starting system*
CLR-3 :	*Introduce the different methods of charging systems for batteries*
CLR-4 :	*Learn the fundamentals of Automotive Electronic devices*
CLR-5 :	*Understand different sensors and actuators used in automotive systems*
CLR-6 :	*Get idea about real time automotive electronic systems*

Course Learning Outcomes (CLO):	At the end of this course, learners will be able to:	Learning 1: Level of Thinking (Bloom)	Learning 2: Expected Proficiency (%)	Learning 3: Expected Attainment (%)	PLO 1: Engineering Knowledge	PLO 2: Problem Analysis	PLO 3: Design & Development	PLO 4: Analysis, Design, Research	PLO 5: Modern Tool Usage	PLO 6: Society & Culture	PLO 7: Environment & Sustainability	PLO 8: Ethics	PLO 9: Individual & Team Work	PLO 10: Communication	PLO 11: Project Mgt. & Finance	PLO 12: Life Long Learning	PLO 13: PSO - 1	PLO 14: PSO - 2	PLO 15: PSO - 3
CLO-1 :	*Analyze the concept of batteries & it's working*	3	80	75	H	M	M	M	-	-	-	-	-	-	-	-	M	L	-
CLO-2 :	*Gain knowledge on the concepts of battery starting system*	2	80	75	H	M	M	L	-	-	-	-	-	-	-	-	M	M	-
CLO-3 :	*Familiarize the principles of charging system for batteries*	2	80	75	H	M	L	L	-	-	-	-	-	-	-	-	M	M	-
CLO-4 :	*Acquire knowledge on automotive Electronics*	2	80	75	H	-	-	-	-	-	-	-	-	-	-	-	M	M	-
CLO-5 :	*Enhance the use of sensors and actuators in the field of automotive systems*	2	80	75	H	M	M	L	-	-	-	-	-	-	-	-	M	M	-
CLO-6 :	*Apply the idea in real time automotive electronics*	3	80	75	H	M	M	L	-	-	-	-	-	-	-	-	M	M	-

Duration (hour)		9	9	9	9	9
S-1	SLO-1	*Batteries and Accessories : Principle of lead acid battery*	*Starting System- introduction*	*Charging System - introduction*	*Introduction to Automotive Electronics*	*Sensors*
	SLO-2	*Batteries and Accessories : construction of lead acid battery*	*Starting System - Condition at starting*	*Charging System - Generation of direct current*	*Fundamentals of Automotive Electronics*	*Activators*
S-2	SLO-1	*Characteristics of battery*	*Behaviour of starter during starting*	*Evaluating state of battery health*	*Current trends in automotive electronic engine management system*	*Sensors- introduction*
	SLO-2	*Rating capacity and efficiency of batteries*	*Advantages and disadvantages*	*Fundamental in battery testing*	*Electric power Braking systems*	*Types of sensors: sensor for speed*
S-3	SLO-1	*Various tests on batteries*	*Series motor and its characteristics for starting system*	*Battery testing - Capacity*	*Electromagnetic interference suppression*	*Throttle position*
	SLO-2	*Visual inspection and voltage testing*	*Shunt motor and its characteristics for starting system*	*Battery testing – internal resistance*	*Electromagnetic compatibility*	*Exhaust oxygen level*
S-4	SLO-1	*Lighting system: insulated and earth return system*	*Principle and construction of starter motor*	*Battery testing – self discharging quantity*	*Electronic dashboard instruments*	*Manifold pressure*
	SLO-2	*Vehicle circuits and systems*	*Cranking motor construction*	*Factors for degradation and ageing process*	*Onboard diagnostic system*	*Crankshaft position*
S-5	SLO-1	*Earthing system: Types*	*Working of different starter drive units*	*Measurement methods of battery*	*Security and warning system*	*Coolant temperature*
	SLO-2	*Head light and side light*	*Care and maintenances of starter motor*	*Direct measurement method*	*Nano-electromechanical devices*	*Exhaust temperature*
S-6	SLO-1	*LED lighting system*	*Starter switches*	*Indirect measurement method*	*Engine Ignition*	*Air mass flow for engine application*
	SLO-2	*Control of LED lighting system*	*Optoelectronic devices- solar cells*	*Battery Maintenance*	*Fuel Injection*	*Solenoids*
S-7	SLO-1	*Horn system*	*Photodiodes*	*New developments on battery charging system*	*Collision Avoidance Systems*	*Various types of electric motors*
	SLO-2	*Wiper system and trafficator*	*Laser Diodes*	*Rate of charging*	*Safety Controls*	*Piezoelectric force generators*
S-8	SLO-1	*Maintenance on batteries*	*Light Absorption and Emission*	*Depth of charging*	*Security Alarms*	*Automatic transmission control systems*
	SLO-2	*Charging on batteries*	*Optical Fiber*	*Depth of discharging*	*Transmission Controls*	*stepper motors*
S-9	SLO-1	*Health monitoring of batteries*	*Surface-Emitting Lasers*	*SoC and SoH*	*Navigation System*	*Relays- Types*
	SLO-2	*Battery monitoring methods*	*Array Lasers*	*Downfall modes*	*Applications of Automotive Electronics*	*Thermal Relay*

Learning Resources	1. *William B. Ribbens, Understanding Automotive Electronics, 5th Edition, Butterworth, Heinemann Woburn, 2009.* 2. *Tom Denton, Automobile Electrical and Electronics System, Elsevier, Third Edition, 2008.* 3. *Judge. A.W., Modern Electrical Equipment of Automobiles, Chapman & Hall, London, 2010.*	4. *Judge. A.W., Modern Electrical Equipment of Automobiles, Chapman & Hall, 2nd Edition London, 1992.* 5. *Vinal. G.W., Storage Batteries, John Wiley & Sons Inc., 4th Edition New York, 1985.* 6. *https://onlinecourses-archive.nptel.ac.in/.*

Learning Assessment											
	Bloom's Level of Thinking	Continuous Learning Assessment (50% weightage)								Final Examination (50% weightage)	
		CLA – 1 (10%)		CLA – 2 (15%)		CLA – 3 (15%)		CLA – 4 (10%)#			
		Theory	Practice	Theory	Practice	Theory	Practice	Theory	Practice	Theory	Practice
Level 1	Remember Understand	40 %	-	30 %	-	30 %	-	30 %	-	30%	-
Level 2	Apply Analyze	40 %	-	40 %	-	40 %	-	40 %	-	40%	-
Level 3	Evaluate Create	20 %	-	30 %	-	30 %	-	30 %	-	30%	-
	Total	100 %		100 %		100 %		100 %		100 %	

CLA – 4 can be from any combination of these: Assignments, Seminars, Tech Talks, Mini-Projects, Case-Studies, Self-Study, MOOCs, Certifications, Conf. Paper etc.,

Course Designers		
Experts from Industry	Experts from Higher Technical Institutions	Internal Experts
1. Mr.Muralikrishna, National Instruments, emkkrishnan@gmail.com	*1. Dr. M.P.Selvan, NIT Trichy, selvanmp@nitt.edu*	*1. Mr.R.Palanisamy, SRMIST*
2. Mr.Senthilkumar,ATI,rskrd1962@gmail.com	*2. A. Venkadesan, NIT Puducherry, venkadesan@nitpy.ac.in*	*2. Dr.C.Subramani, SRMIST*

Course Code	18EEE324T	Course Name	ANALOG AND DIGITAL COMMUNICATION	Course Category	E	Professional Elective	L	T	P	C
							3	0	0	3

Pre-requisite Courses	Nil	Co-requisite Courses	Nil	Progressive Courses	Nil
Course Offering Department	Electrical and Electronics Engineering	Data Book / Codes/Standards	i		

Course Learning Rationale (CLR):	*The purpose of learning this course is to:*
CLR-1 :	*Understand various analog Communication techniques.*
CLR-2 :	*Impart knowledge on data and pulse Communication techniques.*
CLR-3 :	*Explain various digital Communication techniques*
CLR-4 :	*Illustrate source and Error control coding*
CLR-5 :	*Gain knowledge on multi-user radio Communication*
CLR-6 :	*Apply the analog and digital Communication concepts in Communication industries*

Course Learning Outcomes (CLO):	*At the end of this course, learners will be able to:*	Learning 1 Level of Thinking (Bloom)	2 Expected Proficiency (%)	3 Expected Attainment (%)	PLO 1 Engineering Knowledge	2 Problem Analysis	3 Design & Development	4 Analysis, Design, Research	5 Modern Tool Usage	6 Society & Culture	7 Environment & Sustainability	8 Ethics	9 Individual & Team Work	10 Communication	11 Project Mgt. & Finance	12 Life Long Learning	13 PSO - 1	14 PSO - 2	15 PSO - 3
CLO-1 :	*Gain knowledge on basics of analog Communication techniques*	2	80	75	H	M	M	-	-	-	-	-	-	M	-	-	L	-	-
CLO-2 :	*Analyze data and pulse Communication techniques*	2	80	75	H	M	M	L	-	-	-	L	-	M	-	-	-	L	L
CLO-3 :	*Summarize digital Communication techniques*	2	80	75	H	L	-	-	-	-	-	-	-	M	-	-	-	-	-
CLO-4 :	*Interpret Source and Error control coding.*	2	80	75	H	M	M	L	-	-	-	L	-	M	-	-	L	L	L
CLO-5 :	*Understand multi-user radio Communication*	3	80	75	H	L	-	-	-	-	-	-	-	L	-	-	-	-	-
CLO-6 :	*Acquire the overall knowledge on analog and digital Communication*	3	80	75	H	H	M	L	-	-	-	L	-	M	-	-	L	L	L

Duration (hour)		9	9	9	9	9
S-1	SLO-1	*Analog Communication:Introduction to Fourier Series*	*Pulse and data Communication:Introduction to Pulse Communication*	*Digital Communication:Introduction to digital Communication*	*Source coding and Error Control Coding: Introduction to coding*	*Multi-user radio Communication: Global System for Mobile Communications (GSM)*
	SLO-2	*Fourier Series Properties and applications*	*Introduction to Data Communication*	*Analog Communications versus digital Communications*	*Entropy and Properties of coding*	*Overview of GSM*
S-2	SLO-1	*Introduction to Fourier Transform*	*Pulse Amplitude Modulation (PAM)*	*conversion of analog signal to digital form*	*Binary Symmetric Channel*	*Code division multiple access (CDMA)*
	SLO-2	*Fourier Transform properties*	*Pulse Time Modulation (PTM)*	*baseband signal, band pass signal*	*Binary Erase Channel*	*Overview of CDMA*
S-3	SLO-1	*Modulation – Types*	*Pulse code Modulation (PCM)*	*Digital Communication systems – Functional description*	*Source Coding Theorem*	*Cellular Concept*
	SLO-2	*Need for Modulation*	*Differential pulse code modulation*	*Block diagram of digital Communications*	*Lossless data Compression Algorithms*	*Frequency Reuse*
S-4	SLO-1	*Noise: Source of Noise*	*Pulse position modulation(PPM)*	*Signal processing operations in digital Communications*	*Shannon fano coding*	*Channel Assignment*
	SLO-2	*External Noise, Internal Noise*	*Comparison of various Pulse Communication System (PAM – PTM– PCM)*	*quantitative analysis of modulation schemes*	*Huffman Coding*	*Handover Techniques*
S-5	SLO-1	*Amplitude Modulation Theory*	*Data Communication: Introduction to Data Communication*	*Amplitude Shift Keying (ASK), Frequency Shift Keying (FSK)*	*Algorithm and Problem in Shannon fano coding*	*Overview of Multiple Access Schemes*
	SLO-2	*Frequency spectrum of AM wave*	*History of Data Communication*	*Phase Shift Keying (PSK)*	*Algorithm and Problem in Huffman Coding*	*Types of Multiple access*

S-6	SLO-1	*Double Sideband (DSB) Suppressed Carrier (SC)*	*Standards Organizations for Data Communication*	*BPSK*	*Error Control Coding*	*IEEE802.11: Wireless LANs Using CSMA/CA*
	SLO-2	*Conventional AM*	*Data Communication Circuits*	*QPSK*	*Error detection*	*WLAN Fundamentals*
S-7	SLO-1	*Single Sideband Modulation (SSB)*	*Data Communication codes*	*Principles of MSK*	*Parity*	*Cellular Digital Packet Network*
	SLO-2	*Vestigial Sideband (VSB) Modulation*	*Error Control, Hardware*	*Principles of QAM*	*Redundancy*	*Overview of cellular digital packet network*
S-8	SLO-1	*Quadrature Amplitude Modulation*	*Serial Interfaces*	*Quadrature Amplitude Modulation (QAM) – 8 QAM*	*Error correction*	*Satellite Communication*
	SLO-2	*Concept synthesis for AM*	*Parallel interfaces*	*Quadrature Amplitude Modulation (QAM) - 16 QAM*	*Forward Error Correction*	*Satellite Networking*
S-9	SLO-1	*Theory of Frequency and Phase Modulation*	*Data Modems – Asynchronous Modem*	*Bandwidth Efficiency*	*Application, Convolution Codes*	*Bluetooth*
	SLO-2	*Comparison of Analog Communication Systems (AM – FM – PM)*	*Synchronous Modem*	*Comparison of various Digital Communication System (ASK – FSK – PSK – QAM)*	*Block Codes*	*Bluetooth Applications*

Learning Resources	*1. Wayne Tomasi, Advanced Electronic Communication Systems, 6th Edition, Pearson Education, 2009* *2. Simon Haykin and Michael Moher, Communication Systems, 5th Edition, John Wiley and Sons, Inc., New York, 2009*	*3. Blake, Electronic Communication Systems, Thomson Delmar Publications, 2002.* *4. Martin S. Roden, Analog and Digital Communication System, 3rd Edition, PHI, 2002* *5. https://nptel.ac.in/courses/117105143/* *6. https://nptel.ac.in/courses/117105144/*

Learning Assessment

	Bloom's Level of Thinking	Continuous Learning Assessment (50% weightage)								Final Examination (50% weightage)	
		CLA – 1 (10%)		CLA – 2 (15%)		CLA – 3 (15%)		CLA – 4 (10%)#			
		Theory	Practice	Theory	Practice	Theory	Practice	Theory	Practice	Theory	Practice
Level 1	Remember Understand	40 %	-	30 %	-	30 %	-	30 %	-	30%	-
Level 2	Apply Analyze	40 %	-	40 %	-	40 %	-	40 %	-	40%	-
Level 3	Evaluate Create	20 %	-	30 %	-	30 %	-	30 %	-	30%	-
	Total	100 %		100 %		100 %		100 %		100 %	

CLA – 4 can be from any combination of these: Assignments, Seminars, Tech Talks, Mini-Projects, Case-Studies, Self-Study, MOOCs, Certifications, Conf. Paper etc.,

Course Designers		
Experts from Industry	Experts from Higher Technical Institutions	Internal Experts
1.Mr.Senthilkumar,ATI,rskrd1962@gmail.com	*1.Dr. B. K. Panigrahi, IIT Delhi, bkpanigrahi@ee.iitd.ac.in*	*1.Mr. D. Selvabharathi, SRMIST*
2.Mr.Muralikrishna, National Instruments, emkkrishnan@gmail.com	*2.Dr. S. Ramareddy, Jerusalem College of Engineering,srr.victory@gmail.com*	*2.Dr. M. Jagabar Sathik, SRMIST*

Course Code	18EEE325T	Course Name	WAVELET TRANSFORM	Course Category	E	Professional Elective	L	T	P	C
							3	0	0	3

Pre-requisite Courses	Nil	Co-requisite Courses	Nil	Progressive Courses	Nil
Course Offering Department	Electrical and Electronics Engineering	Data Book / Codes/Standards	Nil		

Course Learning Rationale (CLR):	*The purpose of learning this course is to:*
CLR-1 :	*Introduce the learners to wavelets- its relevant fundamentals and significance*
CLR-2 :	*Establish the theory behind construction of wavelets using software tools*
CLR-3 :	*Gain knowledge on the details of discrete wavelet transform*
CLR-4 :	*Expose the students to the conceptual aspect of multi resolution analysis*
CLR-5 :	*Illustrate data compression /extraction and signal processing applications using wavelet transform*
CLR-6 :	*Introduce wavelet functions, the advancements in technology and applications*

Course Learning Outcomes (CLO):	*At the end of this course, learners will be able to:*	Learning 1: Level of Thinking (Bloom)	2: Expected Proficiency (%)	3: Expected Attainment (%)	PLO 1: Engineering Knowledge	2: Problem Analysis	3: Design & Development	4: Analysis, Design, Research	5: Modern Tool Usage	6: Society & Culture	7: Environment & Sustainability	8: Ethics	9: Individual & Team Work	10: Communication	11: Project Mgt. & Finance	12: Life Long Learning	13: PSO - 1	14: PSO - 2	15: PSO - 3
CLO-1 :	*Understand the theory and mathematics behind wavelet transform*	*1*	*75*	*75*	*H*		-	-	-	-	-	-	-	-	-	-	*M*	-	-
CLO-2 :	*Apply the coding for construction of Daubechies and other wavelet functions*	*2*	*75*	*75*	*H*	*M*	*L*	-	-	-	-	-	-	-	-	-	*M*	*M*	-
CLO-3 :	*Analyze use of wavelets and discrete wavelet transform for filter bank design.*	*2*	*75*	*75*	*H*	*M*	*L*	-	*M*	-	-	-	-	-	-	-	*M*	*M*	-
CLO-4 :	*Analyze use of wavelets for filter design and multi resolution analysis*	*2*	*75*	*75*	*H*	*M*	*L*	-	*M*	-	-	-	-	-	-	-	*M*	*M*	-
CLO-5 :	*Use software for various wavelet transform based applications*	*3*	*75*	*75*	*H*	*M*	*L*	-	*M*	-	-	-	-	-	-	-	*H*	*H*	-
CLO-6 :	*Evaluate existing and new wavelet transform based applications*	*3*	*75*	*75*	*H*	*M*	*L*	-	*M*	-	-	-	-	-	-	-	*H*	*H*	-

Duration (hour)		9	9	9	9	9
S-1	SLO-1	*Wavelets- General introduction*	*Construction of wavelets*	*Discrete wavelet transform(DWT) for filter design*	*Multi resolution analysis (MRA) - Formal definition*	*Audio compression – Audio masking*
	SLO-2	*Fields of applications, Heisenberg's un certainty*	*Relationship between two scale sequences*	*Signal decomposition- Analysis*	*Need for multi resolution based image analysis*	*Standards specifying sub band implementation*
S-2	SLO-1	*Classical wavelets, Wavelet packets, Local trigonometric bases, Multiwavelets, 2G Wavelets*	*Relationship between reconstruction and decomposition sequences*	*Filtering /Frequency response*	*Multi resolution spaces*	*Image compression*
	SLO-2	*Gaussian, Morlet, Daubechies, Mexican Hat, Symlets, Coiflets, Complex, Biorthogonal spline wavelets.*	*Construction of semi orthogonal spline wavelets*	*Decimation (Down sampling)*	*Orthogonal decomposition*	*The JPEG standard (ITU - T.81)*
S-3	SLO-1	*Wavelet transform – Translation*	*Construction of ortho- normal wavelets*	*Signal reconstruction- Synthesis*	*Bi orthogonal and Semi orthogonal decompostion*	*Spatial oriented tree (SOT) code and Generalized self-similarity tree (GST)*
	SLO-2	*Wavelet transform -Scaling and Shifting Operation*	*Shannon scaling function*	*Filtering and Stretching (Up sampling)*	*Two scale relations*	*Embedded zero tree wavelet (EZW) code*
S-4	SLO-1	*Continuous wavelet transform*	*Meyer scaling function*	*Computing input co- efficient*	*A wavelet basis for MRA*	*Huffman code*
	SLO-2	*Discrete wavelet transform*	*Battle- Lemarie scaling function*	*Lattices and Lifting*	*Functional subspace relation between scaling and wavelet functions*	*Run length encoding*
S-5	SLO-1	*Mathematical prelude – Fourier transform*	*Daubechies scaling function*	*Vanishing moments*	*Scaled and translated version of wavelet functions*	*Set partitioning in hierarchical tree (SPIHT)*
	SLO-2	*Parseval Plancherel theorem, Convolution, Dilation and its inverse…*	*Graphical display – Iteration method*	*Perfect reconstruction filter banks- Introduction*	*Wavelet series*	*Embedded block coding with optimized truncation (EBCOT)*

S-6	SLO-1	*Continuous time frequency representation of signals*	*Spectrum method*	*Spectral domain analysis of a 2 channel PR filter bank*	*PR banks- Coding tutorial - I*	*Médical Imaging*
	SLO-2	*The windowed Fourier transform*	*Eigen value method*	*Analysis and Synthesis*	*PR banks- Coding practice exercises-I*	*Other applications*
S-7	SLO-1	*Signal spaces*	*Daubechies wavelet construction-Coding tutorial - I*	*Quadrature mirror filter (QMF) approach*	*PR banks- Coding tutorial - II*	*Audio compression -Simulation using software tools – Tutorial*
	SLO-2	*Ortho-gonality and Ortho-normality in brief*	*Coding practice exercises*	*Half band filter (HBF) approach*	*PR banks- Coding practice exercises*	*Audio compression -Simulation using software tools – Practice*
S-8	SLO-1	*Haar wavelet and scaling function*	*Daubechies wavelet construction-Coding tutorial- II*	*Time domain analysis*	*PR banks- Coding tutorial - III*	*Image compression -Simulation using software tools – Tutorial*
	SLO-2	*Triangle scaling function*	*Coding practice exercises*	*PR filter requirements*	*PR banks- Coding practice exercises*	*Image compression -Simulation using software tools – Practice*
S-9	SLO-1	*Short time Fourier transform -Coding tutorial*	*Daubechies wavelet construction-Coding tutorial- III*	*Bi-orthogonal filter bank*	*PR banks- Coding practice tutorial- IV*	*Image compression -Simulation using software tools – Tutorial*
	SLO-2	*Coding practice exercises*	*Coding practice exercises*	*Simple problems(Qualitative) for practice*	*PR banks- Coding practice exercises*	*Image compression -Simulation using software tools – Practice*

Learning Resources	1. *K. P. Soman, K. I. Ramachandran ,N. G. Resmi, Insights Into Wavelets: From Theory to Practice, Third edition, PHI Learning Pvt. Ltd. 2010.* 2. *J. C. Goswami and A. K. Chan, Fundamentals of Wavelets: Theory, Algorithms and Applications, John Wiley and Sons, 2011.* 3. *Raguveer M Rao and Ajit S Bopardikar, Wavelet Transforms – Introduction and Applications, Pearson Education, 2008*	4. *S. Burns, A Ramesh, A Gopinath and Haitao Guo, Introduction to Wavelets and Wavelet Transform, Prentice Hall Inc.1998.* 5. *https://nptel.ac.in/courses/103106114/48*

Learning Assessment

	Bloom's Level of Thinking	Continuous Learning Assessment (50% weightage)								Final Examination (50% weightage)	
		CLA – 1 (10%)		CLA – 2 (15%)		CLA – 3 (15%)		CLA – 4 (10%)#			
		Theory	Practice	Theory	Practice	Theory	Practice	Theory	Practice	Theory	Practice
Level 1	Remember Understand	40 %	-	30 %	-	30 %	-	30 %	-	30%	-
Level 2	Apply Analyze	40 %	-	40 %	-	40 %	-	40 %	-	40%	-
Level 3	Evaluate Create	20 %	-	30 %	-	30 %	-	30 %	-	30%	-
	Total	100 %		100 %		100 %		100 %		100 %	

CLA – 4 can be from any combination of these: Assignments, Seminars, Tech Talks, Mini-Projects, Case-Studies, Self-Study, MOOCs, Certifications, Conf. Paper etc.,

Course Designers

Experts from Industry	Experts from Higher Technical Institutions	Internal Experts
1.Dr. S. Paramasivam, Danfoss Industries Pvt. Ltd, paramsathya@yahoo.com	*1.Dr R. Selvarasu, Adama Science and Technology University, Ethiopia, selvarasunaveen@gmail.com*	*1.Ms K Subha Sharmini, SRMIST*
2.Mr.Ravikumar A R, PayPal,ravikumar.venkataramani@gmail.com	*1.Dr A. Venkadesan, NIT,Pudhucherry, Karaikkal, venkadesan@nitpy.ac.in, avenkyeee@gmail.com*	*2.Dr K Mohanraj, SRMIST*

Course Code	18EEE326T	Course Name	ADVANCED CMOS DEVICES AND TECHNOLOGY	Course Category	E	Professional Elective	L	T	P	C
							3	0	0	3

Pre-requisite Courses	Nil	Co-requisite Courses	Nil	Progressive Courses	Nil
Course Offering Department	Electrical and Electronics Engineering	Data Book / Codes/Standards	Nil		

Course Learning Rationale (CLR):	*The purpose of learning this course is to:*
CLR-1 :	*Enrich the students to have basic knowledge in CMOS technology and scaling*
CLR-2 :	*Upgrade the students with the knowledge on design of CMOS devices*
CLR-3 :	*Buildup knowledge on fabrication and isolation of advanced CMOS*
CLR-4 :	*Outline the concept of layout dependent effect, bench marking and interconnects*
CLR-5 :	*Understand the basic of lithography and manufacturability*
CLR-6 :	*Upgrade the knowledge in Nano CMOS devices*

Course Learning Outcomes (CLO):	*At the end of this course, learners will be able to:*	Learning 1: Level of Thinking (Bloom)	2: Expected Proficiency (%)	3: Expected Attainment (%)	PLO 1: Engineering Knowledge	2: Problem Analysis	3: Design & Development	4: Analysis, Design, Research	5: Modern Tool Usage	6: Society & Culture	7: Environment & Sustainability	8: Ethics	9: Individual & Team Work	10: Communication	11: Project Mgt. & Finance	12: Life Long Learning	13: PSO - 1	14: PSO - 2	15: PSO - 3
CLO-1 :	*Describe the operation of CMOS devices and scaling technology*	*2*	*80*	*75*	*H*	-	-	-	-	-	-	-	-	-	-	-	*L*	*H*	-
CLO-2 :	*Interpret how modern CMOS devices are designed for better power performance*	*3*	*80*	*75*	*H*	-	-	-	-	-	-	-	-	-	-	-	*H*	*M*	-
CLO-3 :	*Perceive knowledge on basic fabrication process flow steps of advanced CMOS devices and isolation*	*3*	*80*	*75*	*H*	-	-	-	-	-	-	-	-	-	-	-	*H*	*H*	-
CLO-4 :	*Advance knowledge on layout dependent effect, bench marking and interconnects*	*3*	*80*	*75*	*H*	-	-	-	-	-	-	-	-	-	-	-	*H*	*M*	-
CLO-5 :	*Infer knowledge about advanced lithography and manufacturability*	*3*	*80*	*75*	*H*	-	-	-	-	-	-	-	-	-	-	-	*H*	*H*	-
CLO-6 :	*Gain knowledge to develop new improved CMOS devices*	*3*	*80*	*75*	*H*	-	-	-	-	-	-	-	-	-	-	-	*H*	*H*	-

Duration (hour)		9	9	9	9	9
S-1	SLO-1	*History of silicon technology*	*Mobility enhancement techniques*	*Fabrication issues*	*Compact modeling of analog process*	*Basics of sub wavelength lithography*
	SLO-2	*Review of CMOS scaling, moore's law*	*Gate dielectric material*	*Process integration*	*Digital benchmarking of models*	*Advanced lithography*
S-2	SLO-1	*Junction diode*	*High K material and Material selection*	*Atomic layer integration*	*Layout dependent effects*	*Design for manufacturability (DFM)*
	SLO-2	*MOS capacitor*	*Electronic structure of transition metal and rare earth metals*	*Metal organic chemical vapor deposition*	*Metallization*	*Economic motives for DFM*
S-3	SLO-1	*Circuit considerations*	*Band gap energies*	*Physical vapor deposition*	*Gate electrodes*	*Lithographic techniques and tools for advanced technology nodes*
	SLO-2	*CMOS latch-up*	*Band off-set energies*	*Etching*	*Reduction in device parasitics*	*Optical proximity correction*
S-4	SLO-1	*MOS transistor classical models*	*Bond iconicity and dielectric constant*	*Fabrication of drain and source*	*Test structures for characterization*	*Lithography limited yield*
	SLO-2	*Threshold voltage and V-I characteristcs*	*Carrier effective masses*	*Ultra shallow junctions*	*Characterization variation effects on scaling*	*Catastrophic failures*
S-5	SLO-1	*Short channel effects*	*Thermal stability*	*Isolation techniques*	*Dopant activation methods*	*Lithography driven DEM solutions*
	SLO-2	*Drain induced barrier lowering*	*Disorders and defects*	*Device, well and dielectric isolation*	*Device isolation pitch*	*Classical approach*
S-6	SLO-1	*Gate leakage current*	*Extrinsic defects*	*Integration challenges*	*Interconnects*	*Printability checkers*
	SLO-2	*Tunneling*	*High –K / Si Interface traps*	*Dopant activation methods*	*Limits of interconnects*	*ASIC cell optimization*
S-7	SLO-1	*Sub-threshold conduction*	*Fermi level pinning*	*Reduction of parasitics*	*Current interconnect technologies*	*Case study on emerging technology*
	SLO-2	*Short channel modifications*	*Progress integration of high K gate dielectrics and metal gates*	*Types of stress elements*	*Optical interconnects*	*Applications of advanced CMOS devices*
S-8	SLO-1	*Features and uniqueness of MOS transistors*	*Effect of stress*	*Strained isolation oxide*	*Scaling of device isolation*	*Challenges of advanced CMOS devices*
	SLO-2	*MOS in Deca-Nano meters*	*Strain on the band structure of silicon*	*Ultra shallow junction resistance*	*Layout dependent effect*	

						CMOS technology design for mobile applications
S-9	SLO-1	*Device structure and channel engineering*	*Effect of gate length on stress effect*	*Solution to shallow junction resistance problem*	*Characterization*	*CMOS technology designed for wireless applications*
	SLO-2	*Source , drain and gate stack engineering*	*Mobility enhancements in strained silicon MOSFETS*	*Fermi level pinning effect of strain to improve the CMOS performance*	*Test structures used for characterization*	*Special MOS devices*

Learning Resources	1. *J. M. Pimbley, M. Ghezzo, H. Parks, Advanced CMOS Process Technology, Academia Press, 2012.* 2. *HeiWong, Nano-CMOS Gate Dielectric Engineering, CRC, 2012.*	3. *S. Deleonibus, Electronic Devices Architectures for the Nano-CMOS Era, Jenny Stanford, 2009.* 4. *B. Wong, F. Zach, V. Moraz, A. Mittal, G. Starr, A. Kahng, Nano-CMOS Design for Manufacturability, Wiley, 2009.* 5. *http://www.ee.iitb.ac.in/~slodha/advanced-cmos-devices/*

Learning Assessment											
	Bloom's Level of Thinking	Continuous Learning Assessment (50% weightage)								Final Examination (50% weightage)	
		CLA – 1 (10%)		CLA – 2 (15%)		CLA – 3 (15%)		CLA – 4 (10%)#			
		Theory	Practice	Theory	Practice	Theory	Practice	Theory	Practice	Theory	Practice
Level 1	Remember Understand	40 %	-	30 %	-	30 %	-	30 %	-	30%	-
Level 2	Apply Analyze	40 %	-	40 %	-	40 %	-	40 %	-	40%	-
Level 3	Evaluate Create	20 %	-	30 %	-	30 %	-	30 %	-	30%	-
	Total	100 %		100 %		100 %		100 %		100 %	

CLA – 4 can be from any combination of these: Assignments, Seminars, Tech Talks, Mini-Projects, Case-Studies, Self-Study, MOOCs, Certifications, Conf. Paper etc.,

Course Designers		
Experts from Industry	Experts from Higher Technical Institutions	Internal Experts
1. Mr. Akash Neel Dey, Grey Orange Pvt. Ltd, akash.d@greyorange.sg	*1. Dr. E. S. Sreeraj, NIT-Goa, sreeraj@nitgoa.ac.in*	*1. Dr. R. Femi, SRMIST*
2. Mr. Prakhar Kumar Verma, Xilinx India, prakhar10692@gmail.com	*2. Dr. Pravin Mane, BITS-Pilani, pravinmane@goa.bits-pilani.ac.in*	*2. Dr. M. Jagabar Sathik, SRMIST*

Course Code	18EEE327T	Course Name	SENSORS AND TRANSDUCERS	Course Category	E	Professional Elective	L	T	P	C
							3	0	0	3

Pre-requisite Courses	Nil	Co-requisite Courses	Nil	Progressive Courses	Nil
Course Offering Department	Electrical and Electronics Engineering	Data Book / Codes/Standards	Nil		

Course Learning Rationale (CLR):	*The purpose of learning this course is to:*
CLR-1 :	*Expose the students to various sensors and transducers for measuring quantities.*
CLR-2 :	*Emphasize the general background and operational concepts in sensors and transducers*
CLR-3 :	*Elicit the characteristics of inductive and capacitive transducers.*
CLR-4 :	*Examine the advances in sensor technology.*
CLR-5 :	*Facilitate the application of microsensors and actuators*
CLR-6 :	*Analyse the performance of various sensors and transducer*

Course Learning Outcomes (CLO):	*At the end of this course, learners will be able to:*	Learning 1: Level of Thinking (Bloom)	Learning 2: Expected Proficiency (%)	Learning 3: Expected Attainment (%)	PLO 1: Engineering Knowledge	PLO 2: Problem Analysis	PLO 3: Design & Development	PLO 4: Analysis, Design, Research	PLO 5: Modern Tool Usage	PLO 6: Society & Culture	PLO 7: Environment & Sustainability	PLO 8: Ethics	PLO 9: Individual & Team Work	PLO 10: Communication	PLO 11: Project Mgt. & Finance	PLO 12: Life Long Learning	PLO 13: PSO - 1	PLO 14: PSO - 2	PLO 15: PSO - 3
CLO-1 :	*Enumerate the basics of sensors and transducers*	*2*	*75*	*75*	*H*	-	-	-	-	-	-	-	-	-	-	-	-	-	-
CLO-2 :	*Summarize the underlying principles and performance of different sensors*	*2*	*75*	*75*	*H*	*H*	-	-	-	-	-	*M*	-	-	-	-	-	-	*M*
CLO-3 :	*Acquire knowledge on the basic conditioning circuits for inductive and capacitive transducers*	*2*	*75*	*75*	*H*	*H*	-	-	-	-	-	*M*	-	-	-	-	-	-	*M*
CLO-4 :	*Upgrade the knowledge in sensor technology*	*2*	*75*	*75*	*H*	-	-	-	-	-	-	*M*	-	-	-	-	-	-	*M*
CLO-5 :	*Attain a broad area of knowledge in Micro sensors and Actuators*	*2*	*75*	*75*	*H*	-	-	-	-	-	-	-	-	-	-	-	*H*	*M*	-
CLO-6 :	*Predict correctly the expected performance of various sensors and transducers*	*2*	*75*	*75*	*H*	*H*	-	-	-	-	-	*M*	-	-	-	-	*H*	*M*	*M*

Duration (hour)		9	9	9	9	9
CVVVS-1	SLO-1	*General concepts of measurement systems*	*Resistive Transducers*	*General factors governing the design of self-inductance transducer*	*Piezoelectric transducer*	*Introduction to Micro sensor*
	SLO-2	*Terminologies of measurement systems*	*Principle of operation, construction details*	*Variable inductance transducer*	*Hall Effect transducers*	*Transducers and its interface standard*
S-2	SLO-1	*Transducer classification based on principle of transduction*	*Potentiometer ,Characteristics*	*Linear Variable Differential Transformer*	*Magnetostrictive transducers*	*Evolution of micro-fabrication*
	SLO-2	*Flow rate sensing elements*	*Applications of potentiometer*	*Expression for mutual inductance variation*	*Fiber optic Sensors*	*Evolution of Micro system and Microelectronics*
S-3	SLO-1	*Classification of errors*	*Loading effect*	*Rotary variable differential transformer*	*Geiger counters*	*The multidisciplinary nature of MEMS, Miniaturization*
	SLO-2	*Error Analysis*	*Strain Gauge, Types of Strain gauges*	*Applications of LVDTs*	*Scintillation detectors.*	*Applications of micro systems in automotive, and health care*
S-4	SLO-1	*Units and standards of measurements*	*Applications of Strain gauges*	*Output input relationship*	*Film sensor*	*Applications of micro systems in aerospace, and teleCommunication fields*
	SLO-2	*General input and output configuration*	*Gauge Factor*	*Microsyn Transducer*	*Magneto elastic sensor*	*Biomedical sensors*
S-5	SLO-1	*Analog & digital modes of operation*	*Load cells*	*Control type Synchro system*	*Digital displacement sensors*	*Biosensors*
	SLO-2	*Null & deflection methods*	*Torque measurement using strain gauges.*	*Resolvers classification and application*	*Proximity sensors*	*Chemical sensors*
S-6	SLO-1	*Methods of correction for interfering & modifying inputs*	*Pressure measurement using strain gauges*	*Capacitive Transducer*	*Pneumatic sensors*	*Optical sensors*

	SLO-2	*Static characteristics of a measurement system*	*Measurement of Linear Velocity*	*Variable Area Type Capacitive Transducers*	*Semiconductor sensor*	*Pressure sensors*
S-7	SLO-1	*Dynamic characteristics of a measurement system*	*Resistance Thermometers*	*Variable Air Gap type Capacitive Transducers*	*Smart sensors*	*Acoustic wave sensors*
	SLO-2	*Statistical analysis of measurement data*	*Thermocouples*	*variable dielectric constant type*	*Radiation sensors*	*Microactuators*
S-8	SLO-1	*Electric Transducer*	*Thermistors*	*Sensitivity factors*	*Pyroelectric type*	*Actuators using thermal forces*
	SLO-2	*Advantages of Electric Transducer*	*Thermistor material, shape, ranges and accuracy specification*	*Nonlinearity factors*	*Digital encoding Transducer*	*Actuators using shape memory alloy*
S-9	SLO-1	*Transducer actuating mechanism*	*Hotwire anemometers*	*Advantages of capacitive transducer*	*Photo optic Transducer*	*Actuators using piezoelectric crystals*
	SLO-2	*Factors influencing the choice of transducer*	*Temperature compensation*	*Applications of capacitive transducer*	*Environmental Monitoring sensors (Water Quality & Air pollution)*	*Actuators using electrostatic forces*

Learning Resources	*1.Sawhney. A.K, A Course in Electrical and Electronics Measurements and Instrumentation, 19th Edition, DhanpatRai& Company Private Limited,2014.* *2.Doebelin. E.A, Measurement Systems – Applications and Design, Tata McGraw Hill, New York, 2007..*	*3.PatranabisD, Sensors and Transducers, Prentice Hall of India, 2010.* *4.P, Bentley, Principles of Measurement Systems, III Edition, Pearson Education, 2000* *5.https://nptel.ac.in/courses/112103174/3*

Learning Assessment

	Bloom's Level of Thinking	Continuous Learning Assessment (50% weightage)								Final Examination (50% weightage)	
		CLA – 1 (10%)		CLA – 2 (15%)		CLA – 3 (15%)		CLA – 4 (10%)#			
		Theory	Practice	Theory	Practice	Theory	Practice	Theory	Practice	Theory	Practice
Level 1	Remember Understand	40 %	-	30 %	-	30 %	-	30 %	-	30%	-
Level 2	Apply Analyze	40 %	-	40 %	-	40 %	-	40 %	-	40%	-
Level 3	Evaluate Create	20 %	-	30 %	-	30 %	-	30 %	-	30%	-
	Total	100 %		100 %		100 %		100 %		100 %	

CLA – 4 can be from any combination of these: Assignments, Seminars, Tech Talks, Mini-Projects, Case-Studies, Self-Study, MOOCs, Certifications, Conf. Paper etc.,

Course Designers

Experts from Industry	Experts from Higher Technical Institutions	Internal Experts
1. Mr.Muralikrishna, National Instruments, emkkrishnan@gmail.com	*1. Dr. A. Venkadesan, NIT Puducherry, venkadesan@nitpy.ac.in*	*Ms. S.Lourdu Jame,SRMIST*
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Course Code	18EEE416T	Course Name	MEDICAL ELECTRONICS	Course Category	E	Professional Elective	L	T	P	C
							3	0	0	3

Pre-requisite Courses	Nil	Co-requisite Courses	Nil	Progressive Courses	Nil
Course Offering Department	Electrical and Electronics Engineering	Data Book / Codes/Standards	Nil		

Course Learning Rationale (CLR):	*The purpose of learning this course is to:*
CLR-1 :	*Create knowledge on physiological system of the human body*
CLR-2 :	*Learn the various biomedical sensor and amplifiers*
CLR-3 :	*Identify the bio potential electrodes used for ECG, EEG, EOG and ENG measurements*
CLR-4 :	*Understand the various analysis techniques of bio signals and data acquisition systems*
CLR-5 :	*Expose the students to various medical application using optical electronics*
CLR-6 :	*Demonstrate the physiological system, its measurements and application of electronics in the medical field*

		Learning			Program Learning Outcomes (PLO)														
		1	2	3	1	2	3	4	5	6	7	8	9	10	11	12	13	14	15
Course Learning Outcomes (CLO):	*At the end of this course, learners will be able to:*	Level of Thinking (Bloom)	Expected Proficiency (%)	Expected Attainment (%)	Engineering Knowledge	Problem Analysis	Design & Development	Analysis, Design, Research	Modern Tool Usage	Society & Culture	Environment & Sustainability	Ethics	Individual & Team Work	Communication	Project Mgt. & Finance	Life Long Learning	PSO - 1	PSO - 2	PSO - 3
CLO-1 :	*Describe the physiological system of the body*	*2*	*80*	*75*	*H*	-	-	-	-	-	-	-	-	-	-	-	-	*M*	-
CLO-2 :	*Use the biomedical sensor and amplifiers*	*3*	*80*	*75*	*H*	-	-	-	*H*	-	-	*L*	*L*	-	-	-	*L*	*M*	*L*
CLO-3 :	*Recognize the biopotential electrodes used for ECG,EEG,EMG,ERG and EOG measurements*	*2*	*80*	*75*	*H*	-	-	-	-	-	-	-	-	-	-	-	*L*	*M*	-
CLO-4 :	*Apply and analyze bio signals and data acquisition system for biomedical application*	*3*	*80*	*75*	*H*	-	-	-	*H*	-	-	-	*L*	-	-	-	*L*	*M*	-
CLO-5 :	*Interpret the various medical application using optical electronics*	*2*	*80*	*75*	*H*	-	-	-	-	-	-	*L*	-	-	-	-	*H*	*M*	*L*
CLO-6 :	*Identify the human body physiological system along with various measurements and application of electronics in the medical field*	*3*	*80*	*75*	*H*	-	-	-	*H*	-	-	*L*	*L*	-	-	-	*H*	*M*	*L*

Duration (hour)		9	9	9	9	9
S-1	SLO-1	*Introduction to the physiological system of the body*	*Sensor parameters*	*Electrode-electrolyte interface*	*Introduction to bio signal analysis*	*Introduction to medical application using optical electronics*
	SLO-2	*Cardiovascular system*	*Physical principle of sensing*	*Electrode types: Surface metal plate electrode*	*Analog and digital method*	*Charge coupled devices*
S-2	SLO-1	*Respiratory system*	*Strain gauge, Piezo electric transducer*	*Needle and wire electrode*	*Types of analog to digital converters*	*Interline transfer*
	SLO-2	*Parts of respiratory system*	*Load cell, pitot tube*	*Micro electrode*	*Flash type ADC*	*Fiber optics introduction*
S-3	SLO-1	*Nervous system*	*High impedance charge output*	*Electrocardiography: Lead system for recording ECG*	*Types of digital to analog converters*	*Fiber optics classification*
	SLO-2	*Structure of neuron and phenomenon of impulse transmission*	*Linear variable differential transformer*	*ECG measurement*	*Successive approximation DAC*	*Features of optical fibers*
S-4	SLO-1	*Sources of biomedical signals*	*Hall effect magnetic sensor*	*Electro cardio graph*	*Signal to noise improvement*	*Analysis of optical fiber*
	SLO-2	*Basic medical instrumentation system*	*Optical encoder*	*Electroencephalography: Signal sources*	*Amplitude measurements*	*The step-index fiber*
S-5	SLO-1	*Performance requirements of medical instrumentation system*	*Accelerometer*	*Placement of electrodes*	*Signal recovery*	*Graded index fiber*
	SLO-2	*Intelligent medical instrumentation system*	*RTD*	*EEG recording modes*	*Data acquisition*	*CT Scanners*
S-6	SLO-1	*Use of microprocessors in medical instruments*	*Thermistor*	*Electroencephalograph*	*Sample and hold conversion*	*Sectional imaging*
	SLO-2	*The microprocessor*	*Thermocouple*	*Electromyography: EMG electrodes*	*ECG acquisition*	*Digital imaging*
S-7	SLO-1	*The microcontroller*	*Sensor interfacing*	*Electromyograph*	*EMG acquisition*	*Endoscope*
	SLO-2	*Interfacing of analog signals to microprocessors*	*Driving bridges*	*Determination of conduction velocities in motor nerves*	*EOG acquisition*	*Digital X rays*

S-8	SLO-1	*PC based medical instruments*	*Signal conditioning amplifiers*	*Quantity of electricity associated with muscle contraction*	*EEG acquisition*	*Medical sensors from fiber optics*
	SLO-2	*General constrains in design of medical instrumentation systems*	*Instrumentation amplifiers*	*Electrical activity of EOG signal*	*ERG acquisition*	*Fiber optics for circulatory system*
S-9	SLO-1	*Regulations of medical devices*	*Isolation amplifiers*	*Electroretinograph*	*Pattern recognition*	*Fiber optics for respiratory system*
	SLO-2	*Types of standards*	*Simulation of pressure sensor*	*Electroocculograph*	*Simulation of flash type ADC*	*Lasers in biomedical field*

Learning Resources	1. *Leslie Cromwell, Fred. J,Weibell and Ench APleiffer, Biomedical Instrumentation and measurements Prentice Hall of India, 2nd ed., 2004* 2. *Kandpur R.S, Handbook of Biomedical Instrumentation, Tata McGraw Hill, 2nd ed., 2011*	3. *C.Raja Roa & .K Guha, Principles of medical electronics and biomedical instrumentation, Universities press,2001* 4. *Rrinaldo J. Perez, Design of medical electronic devices, Academic press 2002* 5. *https://swayam.gov.in/nd1_noc19_bt28/preview ,NPTEL Online Course-Biomedical nanotechnology*

Learning Assessment											
	Bloom's Level of Thinking	Continuous Learning Assessment (50% weightage)								Final Examination (50% weightage)	
		CLA – 1 (10%)		CLA – 2 (15%)		CLA – 3 (15%)		CLA – 4 (10%)#			
		Theory	Practice	Theory	Practice	Theory	Practice	Theory	Practice	Theory	Practice
Level 1	Remember Understand	40 %	-	30 %	-	30 %	-	30 %	-	30%	-
Level 2	Apply Analyze	40 %	-	40 %	-	40 %	-	40 %	-	40%	-
Level 3	Evaluate Create	20 %	-	30 %	-	30 %	-	30 %	-	30%	-
	Total	100 %		100 %		100 %		100 %		100 %	

CLA – 4 can be from any combination of these: Assignments, Seminars, Tech Talks, Mini-Projects, Case-Studies, Self-Study, MOOCs, Certifications, Conf. Paper etc.,

Course Designers		
Experts from Industry	Experts from Higher Technical Institutions	Internal Experts
1.Mr.Muralikrishna, National Instruments, emkkrishnan@gmail.com	*1.Dr. S. Ramareddy, Jerusalem College of Engineering,srr.victory@gmail.com*	*1. Dr.Y.Jeyashree, SRMIST*
2. Mr.senthilkumar,ATI,rskrd1962@gmail.com	*2.Dr Subhransu Sekhar Dash, Government College of Engineering, Keonjhar, Subhransudash_fee@gcekjr.ac.in*	*2. Mrs. R.Uthra, SRMIST*

Course Code	18EEE417T	Course Name	ADVANCED SEMICONDUCTOR DEVICES	Course Category	E	Professional Elective	L	T	P	C
							3	0	0	3

Pre-requisite Courses	Nil	Co-requisite Courses	Nil	Progressive Courses	Nil
Course Offering Department	Electrical and Electronics Engineering	Data Book / Codes/Standards	Nil		

Course Learning Rationale (CLR):	The purpose of learning this course is to:
CLR-1 :	*Outline the aspects of electrical properties of semiconductors*
CLR-2 :	*Learn about diode fabrication, properties, and characterization*
CLR-3 :	*Provide the fundamentals of MOSFET fabrication and scaling laws*
CLR-4 :	*Enrich the knowledge on structure quantum effects and development of advanced transistor devices*
CLR-5 :	*Upgrade knowledge on basic principle of operation of LED and solar cell*
CLR-6 :	*Understand the characteristics, operation and limitations of semiconductor devices*

Course Learning Outcomes (CLO):	At the end of this course, learners will be able to:	Learning 1 Level of Thinking (Bloom)	2 Expected Proficiency (%)	3 Expected Attainment (%)	PLO 1 Engineering Knowledge	2 Problem Analysis	3 Design & Development	4 Analysis, Design, Research	5 Modern Tool Usage	6 Society & Culture	7 Environment & Sustainability	8 Ethics	9 Individual & Team Work	10 Communication	11 Project Mgt. & Finance	12 Life Long Learning	13 PSO - 1	14 PSO - 2	15 PSO - 3
CLO-1 :	Enrich the knowledge on semiconductor material, properties and classical semiconductor devices	2	80	75	H	L	L	L	-	-	-	-	-	-	-	-	H	H	-
CLO-2 :	Interpret the fabrication and characterization of PN diode	3	80	75	H	L	L	L	-	-	-	-	-	-	-	-	M	H	-
CLO-3 :	Perceive knowledge on advanced MOSFET devices, characteristics, application and fabrication	3	80	75	H	L	L	L	-	-	-	-	-	-	-	-	H	H	-
CLO-4 :	Gain knowledge of hetero structure, quantum effect and transport in the development of advanced transistor devices	3	80	75	H	L	L	L	-	-	-	-	-	-	-	-	L	M	-
CLO-5 :	Infer knowledge on optoelectronics, solar cell and photovoltaic	3	80	75	H	-	-	-	-	-	-	-	-	-	-	-	H	M	-
CLO-6 :	Gain knowledge to develop new semiconductor devices	3	80	75	H	L	L	L	-	-	-	-	-	-	-	-	M	H	-

Duration (hour)		9	9	9	9	9
S-1	SLO-1	*Semiconductor materials*	*Structure of PN junction diode*	*Metal oxide semiconductor transistor structure*	*Bipolar transistor structure*	*Optoelectronic semiconductor devices*
	SLO-2	*Electrons and holes*	*Zero applied bias*	*Working of two terminal MOS structure*	*Principle and modes of operation*	*Optical absorption*
S-2	SLO-1	*Crystal structures*	*Reverse applied bias*	*Inversion channel MOSFET*	*Minority carrier distribution*	*Light emitting diode (LED)*
	SLO-2	*Atomic bonding and bond models*	*Fabrication process*	*MOSFET Scaling effect*	*Low frequency common base current gain*	*Vertical cavity surface emitting laser (VCSEL) diode*
S-3	SLO-1	*Equilibrium and non-equilibrium*	*Non uniform doped junction*	*Electrical and DC MOSFET characteristics*	*Nonlinear effects*	*Laser diode arrays*
	SLO-2	*Imperfections and Impurities in Solids*	*Equilibrium electrical properties of a PN junction*	*Capacitance - voltage characteristics*	*Equivalent circuit models*	*Hetero junction LED types*
S-4	SLO-1	*Statistical distribution*	*PN junction current*	*Current-voltage characteristics*	*Frequency limitations*	*Photoluminescence*
	SLO-2	*Drift and diffusion*	*DC electrical characteristics*	*Fabrication of MOSFET*	*Hetero structure and Quantum well*	*Electroluminescence*
S-5	SLO-1	*Generation and recombination*	*Small signal model of PN junction*	*Small signal analysis*	*Super lattice and modulation*	*Advanced semiconductors for solar cell and photovoltaic applications*
	SLO-2	*Principles of Quantum mechanics*	*Small signal characteristics*	*Frequency limitations*	*Two dimensional electron gas (2DEG)*	*Hetero junction solar Cell*
S-6	SLO-1	*Schrodinger's Wave Equation*	*Diode switching transients*	*Switching properties and circuit applications*	*Coulomb blockade effect, quantized transport*	*Amorphous Silicon solar Cells*
	SLO-2	*Extensions of the wave theory to atoms*	*Generation and recombination current*	*CMOS technology*	*Large signal switching*	*Photo detectors*
S-7	SLO-1	*Quantum theory of solids*	*Charge storage*	*Gallium nitride (GaN) and Silicon Carbide (SiC) based devices*	*Ballistic transport and Quantum capacitance*	*PIN photo diode and photo transistor*
	SLO-2	*Allowed and forbidden energy bands*	*Junction breakdown*	*Tunneling field effect transistor (TFET)*	*High electron mobility transistor (HEMT)*	*Optical switches and amplifiers*
S-8	SLO-1	*Electrical conduction in solids*	*Tunnel diode*	*Thin film transistor (TFT)*	*Modulation doped FET (MODFET)*	*Active nano crystalline devices*
	SLO-2	*Semiconductor in equilibrium*	*Schottky diode*	*Junction gate field effect transistor (JFET)*	*Single electron and hetero junction transistor*	*Nano electronics*
S-9	SLO-1	*Carrier transport phenomena*	*Metal-semiconductor junctions*	*Nonlinear effects*	*Ballistic transistor*	*Applications of nano electronics*

	SLO-2	*Non-equilibrium excess carriers in semiconductors*	*Hetero junctions*	*Threshold voltage modifications*	*Poly silicon emitter and silicon-germanium transistor*	*Organic semiconductors*

Learning Resources	1. *Donald A. Neanmen, Semiconductor Physics and Devices: Basic Principles, Fourth Edition, McGrewHill, 2012.* 2. *Streetman, S. K. Banergee, Solid State Devices, Ed. 6, Prantice Hall, 2006.*	3. *S.M. Sze, Kwok K. Ng, Physics of Semiconductor Devices, Third Edition, Wiley, 2007* 4. *Chih-Tang Sah, Fundamentals of Soild-State Electronics, World Scientific, 1996.* 5. *http://www.ioffe.ru/SVA/NSM/Semicond/index.html*

Learning Assessment											
	Bloom's Level of Thinking	Continuous Learning Assessment (50% weightage)								Final Examination (50% weightage)	
		CLA – 1 (10%)		CLA – 2 (15%)		CLA – 3 (15%)		CLA – 4 (10%)#			
		Theory	Practice	Theory	Practice	Theory	Practice	Theory	Practice	Theory	Practice
Level 1	Remember Understand	40 %	-	30 %	-	30 %	-	30 %	-	30%	-
Level 2	Apply Analyze	40 %	-	40 %	-	40 %	-	40 %	-	40%	-
Level 3	Evaluate Create	20 %	-	30 %	-	30 %	-	30 %	-	30%	-
	Total	100 %		100 %		100 %		100 %		100 %	

CLA – 4 can be from any combination of these: Assignments, Seminars, Tech Talks, Mini-Projects, Case-Studies, Self-Study, MOOCs, Certifications, Conf. Paper etc.,

Course Designers		
Experts from Industry	Experts from Higher Technical Institutions	Internal Experts
1. Mr. Prakhar Kumar Verma, Xilinx India,, prakhar10692@gmail.com	*1. Dr. E. S. Sreeraj, NIT-Goa, sreeraj@nitgoa.ac.in*	*1. Dr. R. Femi, SRMIST*
2. Mr. Akash Neel Dey, Grey Orange Pvt. Ltd, akash.d@greyorange.sg	*2. Dr. Dipankar Pal, BITS-Pilani, dipankarp@goa.bits-pilani.ac.in*	*2. Dr. M. Jagabar Sathik, SRMIST*

Course Code	18EEE418T	Course Name	MOBILE COMMUNICATION	Course Category	E	Professional Elective	L	T	P	C
							3	0	0	3

Pre-requisite Courses	Nil	Co-requisite Courses	Nil	Progressive Courses	Nil
Course Offering Department	Electrical and Electronics Engineering	Data Book / Codes/Standards	Nil		

Course Learning Rationale (CLR):	*The purpose of learning this course is to:*
CLR-1 :	*Educate on Cellular Concepts and Wireless Standards*
CLR-2 :	*Understand the Statistical Multipath Channel Models.*
CLR-3 :	*Provide adequate knowledge on Digital Modulation & Multiple Access Schemes*
CLR-4 :	*Give a basic knowledge in Capacity of Wireless Channels*
CLR-5 :	*Educate on Multiple Antennas & Space Time Communications*
CLR-6 :	*Create overall understanding of cellular concepts, multiple antennas and space time Communication.*

Course Learning Outcomes (CLO):	*At the end of this course, learners will be able to:*	Learning 1: Level of Thinking (Bloom)	2: Expected Proficiency (%)	3: Expected Attainment (%)	PLO 1: Engineering Knowledge	2: Problem Analysis	3: Design & Development	4: Analysis, Design, Research	5: Modern Tool Usage	6: Society & Culture	7: Environment & Sustainability	8: Ethics	9: Individual & Team Work	10: Communication	11: Project Mgt. & Finance	12: Life Long Learning	13: PSO - 1	14: PSO - 2	15: PSO - 3
CLO-1 :	*Gain Knowledge in the concepts of cellular Communication.*	1	80	75	H	M	-	-	-	-	-	M	-	-	-	-	H	M	M
CLO-2 :	*Comprehend the statistical multipath channel models*	2	80	75	H	M	-	-	-	-	-	-	-	-	-	-	H	M	-
CLO-3 :	*Infer the various schemes in the digital modulation and multiple access*	2	80	75	H	M	-	-	-	-	-	-	-	-	-	-	M	L	-
CLO-4 :	*Identify the capacity of wireless channels*	2	80	75	H	M	-	-	-	-	-	-	-	-	-	-	H	L	-
CLO-5 :	*Recognize the concepts on multiple antennas & space time Communications*	3	80	75	H	M	-	-	-	-	-	M	-	-	-	-	H	M	M
CLO-6 :	*Gain Knowledge on the overall Communication process involved in cellular Communication.*	3	80	75	H	M	-	-	-	-	-	M	-	-	-	-	H	M	M

Duration (hour)		9	9	9	9	9
S-1	SLO-1	*Evolution of Mobile Radio Communication*	*Signal propagation*	*Multiple access schemes-FDMA (Frequency Division Multiple Access)*	*Capacity in Additive White Gaussian Noise Channel*	*MIMO*
	SLO-2	*Cellular Telephone Systems-Cell structures*	*Propagation mechanism- reflection,*	*Non-linear effects in FDMA*	*Capacity of flat fading channels-Channel and System Model*	*Space time signal processing*
S-2	SLO-1	*Frequency Reuse*	*Refraction*	*TDMA (Time Division Multi Access)*	*Channel and Distribution Information Known*	*spatial multiplexing*
	SLO-2	*Example Problems in Frequency Reuse*	*Diffraction*	*Efficiency of TDMA and number of channels in TDMA system*	*Channel side information at receiver*	*Diversity/Multiplexingtradeoff*
S-3	SLO-1	*Improving Coverage and Capacity in Cellular Systems-Cell Splitting*	*Scattering*	*Spread spectrum multiple access: CDMA (Code-Division Multiple Access)*	*Shannon (Ergodic) Capacity*	*Performance measures- Outage*
	SLO-2	*Sectoring*	*Large scale signal propagation*	*Hybrid FDMA/CDMA(FCDMA)*	*Capacity with outage*	*Average SNR*
S-4	SLO-1	*Repeaters for Range Extension*	*Lognormal Shadowing*	*SDMA(Space Division Multiple Access)*	*Channel side information at transmitter and receiver*	*Average symbol*
	SLO-2	*A Microcell Zone Concept*	*Small-Scale Fading and Multipath -Small-Scale Multipath Propagation*	*Modulation schemes- BPSK (Binary Phase-shift keying)*	*Shannon Capacity*	*Bit error rate*
S-5	SLO-1	*Channel assignment Strategies*	*Doppler shift, Parameters of Mobile Multipath Channels*	*Spectrum and Bandwidth of BPSK*	*Zero-Outage capacity and channel inversion*	*Receiver structure*
	SLO-2	*Handoff Strategies - Prioritizing Handoffs*	*Types of Small-Scale Fading*	*QPSK (Quadrature Phase Shift Keying), Spectrum and Bandwidth of QPSK Signals*	*Outage capacity*	*Diversity receivers- selection*
S-6	SLO-1	*Practical Handoff Considerations*	*Statistical multipath channel models*	*QPSK Transmission and Detection*	*Truncated Channel Inversion*	*MRC receivers*
	SLO-2	*Interference and System Capacity*	*Narrowband Wideband Fading Models*	*Offset QPSK*	*Capacity with receiver Diversity*	*DFE*
S-7	SLO-1	*Channel Planning for Wireless Systems*	*Power delay profile*	*π/4 QPSK*	*Capacity comparisons*	*System examples- GSM*

	SLO-2	*Adjacent Channel Interference*	*Average and RMS delay spread*	*π/4 QPSK transmission and detection techniques*	*Channel and System Model*	*EDGE*
S-8	SLO-1	*Power Control for Reducing Interference- Power control of Cellular Circuits*	*Coherence bandwidth and Coherence time*	*QAM (quadrature amplitude modulation)*	*Capacity of frequency selective fading channels*	*GPRS*
	SLO-2	*Wireless Standards: Overview of 2G*	*Flat and Frequency selective fading*	*MSK (minimum-shift keying) and GMSK (Gaussian minimum shift keying)*	*Time Invariant Channels*	*IS-95*
S-9	SLO-1	*3G cellular standards*	*Slow and fast fading*	*Multicarrier Modulation*	*Time Varying Channels*	*CDMA 2000*
	SLO-2	*Channel Planning for Wireless Systems*	*Average fade duration and Level crossing rate*	*OFDM (Orthogonal Frequency-Division Multiplexing)*	*Optimal Power allocation of Block Frequency -Selective Fading*	*WCDMA.*

Learning Resources	1. *Andrea Goldsmith, Wireless Communications, Cambridge University Press, 2005.* 2. *Theodore Rappaport, Wireless Communications: Principles and Practice, 2nd edition, Prentice Hall, 2001.*	3. *David Tse and Pramod Viswanath, Fundamentals of Wireless Communication, Cambridge University Press, 2005.* 4. *Rishi Kappal and Milind Pande, Nex Gen Mobile Communication, Mc Graw, 2015.* 5. *https://www.youtube.com/playlist?list=PL1A4AFAC7AC1909C9*

Learning Assessment

	Bloom's Level of Thinking	Continuous Learning Assessment (50% weightage)								Final Examination (50% weightage)	
		CLA – 1 (10%)		CLA – 2 (15%)		CLA – 3 (15%)		CLA – 4 (10%)#			
		Theory	Practice	Theory	Practice	Theory	Practice	Theory	Practice	Theory	Practice
Level 1	Remember Understand	40 %	-	30 %	-	30 %	-	30 %	-	30%	-
Level 2	Apply Analyze	40 %	-	40 %	-	40 %	-	40 %	-	40%	-
Level 3	Evaluate Create	20 %	-	30 %	-	30 %	-	30 %	-	30%	-
	Total	100 %		100 %		100 %		100 %		100 %	

CLA – 4 can be from any combination of these: Assignments, Seminars, Tech Talks, Mini-Projects, Case-Studies, Self-Study, MOOCs, Certifications, Conf. Paper etc.,

Course Designers

Experts from Industry	Experts from Higher Technical Institutions	Internal Experts
1. Mr. C. Madesh, Bharti Airtel, madesh.c@airtel.com	*1. Dr. G. Lakshmi Narayanan, NIT,Trichy, laksh@nitt.edu*	*1. Mr. T. Vigneswaran, SRMIST*
2. Mr. K .Muniyandi, Omantel TeleCommunication, muniyandi.kannadasan@omantel.com	*2. Dr. G. Thavasi Raja, NIT Trichy, thavasi@nitt.edu*	*2. Dr. M. Jagabar sathik, SRMIST*

Course Code	18EEE419T	Course Name	SATELLITE COMMUNICATION	Course Category	E	Professional Elective	L	T	P	C
							3	0	0	3

Pre-requisite Courses	Nil	Co-requisite Courses	Nil	Progressive Courses	Nil
Course Offering Department	Electrical and Electronics Engineering	Data Book / Codes/Standards	Nil		

Course Learning Rationale (CLR):	*The purpose of learning this course is to:*
CLR-1 :	*Educate on Elements of Satellite Communications and Orbital Aspects*
CLR-2 :	*Understand the role of Satellite Link*
CLR-3 :	*Provide adequate knowledge on Modulation for Satellite Links*
CLR-4 :	*Extend knowledge on Multiple Access for Satellite Links*
CLR-5 :	*Enlighten the Error Control For Digital Satellite Links*
CLR-6 :	*Educate various concepts in Satellite Communication*

Course Learning Outcomes (CLO):	*At the end of this course, learners will be able to:*	Learning 1: Level of Thinking (Bloom)	Learning 2: Expected Proficiency (%)	Learning 3: Expected Attainment (%)	PLO 1: Engineering Knowledge	PLO 2: Problem Analysis	PLO 3: Design & Development	PLO 4: Analysis, Design, Research	PLO 5: Modern Tool Usage	PLO 6: Society & Culture	PLO 7: Environment & Sustainability	PLO 8: Ethics	PLO 9: Individual & Team Work	PLO 10: Communication	PLO 11: Project Mgt. & Finance	PLO 12: Life Long Learning	PLO 13: PSO - 1	PLO 14: PSO - 2	PLO 15: PSO - 3
CLO-1 :	*Gain knowledge on elements of satellite Communications and the concepts of Satellite Orbits*	1	80	75	H	M	-	-	-	-	-	-	-	-	-	-	M	M	-
CLO-2 :	*Relate the role of Satellite Link*	2	80	75	H	M	-	-	-	-	-	-	-	-	-	-	M	M	-
CLO-3 :	*Infer the necessity of Modulation for Satellite Links*	2	80	75	H	M	-	-	-	-	-	-	-	-	-	-	M	M	-
CLO-4 :	*Interpret the Multiple Access For Satellite Links*	2	80	75	H	H	-	-	-	-	-	-	-	-	-	-	H	H	-
CLO-5 :	*Inspect Error Control For Digital Satellite Links*	3	80	75	H	H	-	-	-	-	-	-	-	-	-	-	H	H	-
CLO-6 :	*Gain Knowledge on various concepts related to Satellite Communication*	3	80	75	H	H	-	-	-	-	-	-	-	-	-	-	H	H	-

Duration (hour)		9	9	9	9	9
S-1	SLO-1	*Satellite systems-Attitude and Orbit Control System(AOCS)*	*Basic Transmission Theory*	*Frequency modulation, Waveform Equation for FM*	*Frequency Division Multiple Access (FDMA)*	*Error detection and correction*
	SLO-2	*Telemetry, Tracking, Command and Monitoring (TTC&M)*	*Example Problems in Transmission Theory*	*Bandwidth of FM Signals: Carson's Rule*	*Inter Modulation, Inter Modulation Example*	*Channel Capacity*
S-2	SLO-1	*Power Systems, Communication Subsystems*	*System noise temperature*	*Baseband S/N Ration for FM Signals*	*Calculation of C/N with Intermodulation*	*Error Control Coding*
	SLO-2	*Satellite Antennas*	*Calculation of System noise temperature*	*Pre-emphasis and de-emphasis*	*Time Division Multiple Access (TDMA)*	*Linear and Cyclic Block Codes*
S-3	SLO-1	*Transmission and Multiplexing*	*Noise figure and Noise Temperature*	*Analog FM Transmission by satellite*	*Bits, Sample and Channels*	*Golay Codes*
	SLO-2	*Modulation Multiple access-advent of Digital satellite Communications*	*G/T ratio for Earth Stations*	*Television Signals*	*TDMA Frame Structure*	*Performance of Block Error Correction Codes*
S-4	SLO-1	*The Equations of the Orbit*	*Design of Downlink*	*S/N Rations for FM Video Transmission*	*Synchronization in TDMA Networks*	*Convolution Codes*
	SLO-2	*Locating the Satellite in the Orbit*	*Link Budgets*	*FM Threshold, SCPC FM Links*	*Transmitter Power in TDMA Networks*	*Implementation of Error Detection on Satellite Links*
S-5	SLO-1	*Orbital elements*	*Design of Uplink*	*Concept of FM Squared of transmitting analog satellite audio*	*Satellite Switched TDMA*	*Concatenate Coding*
	SLO-2	*Look angle Determination- The Sub-satellite point*	*Limits on link performance*	*Digital Transmission*	*On-board Processing*	*Interleaving*
S-6	SLO-1	*Elevation angle Calculation*	*Design of Satellite links for specified (C/N)*	*Baseband Digital Signals,*	*Baseband Processing Transponders*	*Turbo Codes*

	SLO-2	*Azimuth angle Calculation*	*Overall $(C/N)_0$ with Uplink and Downlink Attenuation*	*Base Band Transmission of Digital Data*	*Satellite Switched TDMA with Onboard Processing*	*Repetition Codes*
S-7	SLO-1	*Geostationary orbit*	*Uplink and Downlink Attenuation in Rain*	*Band-pass Transmission of Digital Data*	*Concept of Pre-assignment*	*Cyclic Codes*
	SLO-2	*Visibility*	*Uplink attenuation and $(C/N)_{up}$, Downlink attenuation and $(C/N)_{dn}$*	*Analysis of Digital Transmission*	*Demand Access Multiple Access (DAMA)*	*Basic of Convolution codes*
S-8	SLO-1	*Orbital perturbations Longitudinal Changes: Effects of the Earth's Oblateness*	*Satellite Design for Specific Performance*	*Digital Modulation*	*Random Access*	*Catastrophic Convolutional Code*
	SLO-2	*Inclination Changes: Effects of the Sun and the Moon*	*Satellite Communication Link Design Procedure*	*Digital Demodulation*	*Packet Radio Systems and Protocols*	*Performance of block error correction codes*
S-9	SLO-1	*Orbit Determination*	*Propagation effects and their Impact on Satellite-Earth Links Quantifying Attenuation and Depolarization: Rain and Ice efffects*	*Digital transmission of Analog signals PCM*	*Code Division Multiple Access (CDMA)*	*Implementation of Error Detection on Satellite Links.*
	SLO-2	*Orbital effects in Communication system performance*	*Prediction of Rain Attenuation*	*DPCM and DM*	*CDMA Capacity*	*Example Problem on Error Detection on Satellite Links*

Learning Resources	1. *Dennis Roddy, Satellite Communications, 4th Edition, Mc Graw-Hill, 2017.* 2. *Timothy Pratt, Charles W Bostian, and Jeremy Allnutt, Satellite Communications, John Wiley and Sons, New Delhi, 2008*	3. *Tri T Ha, Digital Satellite Communications, Tata McGraw Hill, New Delhi, 2010.* 4. *Richaria M, Satellite Communication Systems Design Principles, McGraw Hill, Inc., New York, 1999.* 5. *https://www.isro.gov.in/applications/satellite-Communication*

Learning Assessment											
	Bloom's Level of Thinking	Continuous Learning Assessment (50% weightage)								Final Examination (50% weightage)	
		CLA – 1 (10%)		CLA – 2 (15%)		CLA – 3 (15%)		CLA – 4 (10%)#			
		Theory	Practice	Theory	Practice	Theory	Practice	Theory	Practice	Theory	Practice
Level 1	Remember Understand	40 %	-	30 %	-	30 %	-	30 %	-	30%	-
Level 2	Apply Analyze	40 %	-	40 %	-	40 %	-	40 %	-	40%	-
Level 3	Evaluate Create	20 %	-	30 %	-	30 %	-	30 %	-	30%	-
	Total	100 %		100 %		100 %		100 %		100 %	

CLA – 4 can be from any combination of these: Assignments, Seminars, Tech Talks, Mini-Projects, Case-Studies, Self-Study, MOOCs, Certifications, Conf. Paper etc.,

Course Designers		
Experts from Industry	Experts from Higher Technical Institutions	Internal Experts
1. Mr. C. Madesh, Bharti Airtel, madesh.c@airtel.com	*1. Dr. G. Lakshmi Narayanan, NIT,Trichy,laksh@nitt.edu*	*1. Mr. T. Vigneswaran,SRMIST*
2. Mr. K .Muniyandi, Omantel TeleCommunication, muniyandi.kannadasan@omantel.com	*2. Dr. G. Thavasi Raja, NIT Trichy, thavasi@nitt.edu*	*2. Dr. A.Rathinam, SRMIST*

Course Code	18EEE420T	Course Name	EMBEDDED SYSTEM	Course Category	E	Professional Elective	L	T	P	C
							3	0	0	3

Pre-requisite Courses	Nil	Co-requisite Courses	Nil	Progressive Courses	Nil
Course Offering Department	Electrical and Electronics Engineering	Data Book / Codes/Standards	Nil		

Course Learning Rationale (CLR):	*The purpose of learning this course is to:*
CLR-1 :	*Illustrate the concept of embedded system .*
CLR-2 :	*Discuss the various Embedded Controllers with its Interfacing Components*
CLR-3 :	*Explain the different Embedded System protocol layers and bit configurations.*
CLR-4 :	*Understand the basics of the RTOS, its challenges and issues.*
CLR-5 :	*Impart knowledge on the programming skills and execute the different programs using Embedded C*
CLR-6 :	*Understand the concept of embedded system and develop code for real time applications*

		Learning			Program Learning Outcomes (PLO)														
		1	2	3	1	2	3	4	5	6	7	8	9	10	11	12	13	14	15
Course Learning Outcomes (CLO):	*At the end of this course, learners will be able to:*	Level of Thinking (Bloom)	Expected Proficiency (%)	Expected Attainment (%)	Engineering Knowledge	Problem Analysis	Design & Development	Analysis, Design, Research	Modern Tool Usage	Society & Culture	Environment & Sustainability	Ethics	Individual & Team Work	Communication	Project Mgt. & Finance	Life Long Learning	PSO - 1	PSO - 2	PSO - 3
CLO-1 :	*Understand the fundamentals of Embedded System*	*1*	75	75	*H*	-	-	-	-	-	-	-	-	-	-	-	-	*M*	-
CLO-2 :	*Comprehend the various bus and interfacing components in digital controller.*	*2*	75	75	*H*	-	-	-	-	-	-	-	-	-	-	-	-	*M*	-
CLO-3 :	*Implement the embedded networking concept and various bus protocols*	*3*	75	75	*H*	*M*	*M*	*M*	-	-	-	*M*	-	-	-	-	*H*	*M*	*M*
CLO-4 :	*Analysis the concept of RTOS, the challenges and issues in RTOS.*	*3*	75	75	*H*	*M*	*H*	*M*	*H*	-	-	-	-	-	-	-	*M*	*M*	-
CLO-5 :	*Develop the embedded system programs for different Real Time applications*	*3*	75	75	*H*	*H*	*H*	*H*	*H*	-	-	*M*	-	-	-	-	*H*	*M*	*M*
CLO-6 :	*Design and development of Embedded coding for electrical engineering applications*	*3*	75	75	*H*	*M*	*H*	*H*	*H*	-	-	*M*	-	-	-	-	*H*	*M*	*M*

Duration (hour)		9	9	9	9	9
S-1	SLO-1	*Introduction To Embedded System: Embedded system,*	*Memory system mechanisms - Various memory systems*	*Serial Bus Communication protocols*	*Message Queues*	*Programming for LED Display*
	SLO-2	*Functional building block of embedded system*	*CPU bus - Memory devices - I/O devices*	*RS232 standard – RS422,RS 485*	*Mailboxes and Pipes*	*Embedded C Seven Segment Display*
S-2	SLO-1	*Characteristics of embedded system applications*	*Component interfacing Interrupt – Handler*	*Characteristics of RS232, RS422, RS423 and RS485*	*Time functions - Events*	*Communication Protocols:-I²C initialization and formation*
	SLO-2	*Reliability, life time, power consumption*	*Saving and Restoring the content - Disabling Interrupts.*	*CAN Bus with control word registers*	*Memory Management*	*programming using embedded C*
S-3	SLO-1	*Challenges in embedded system design*	*The Shared data Problem – Shared data bug*	*Serial Peripheral Interface (SPI)*	*Interrupt Routine in RTOS Environment.*	*Programming Using SPI Protocols.*
	SLO-2	*Optimizing the Power Dissipation, reliability, upgradability*	*Atomic and Critical sections – Interrupt Latency*	*Inter Integrated Circuits (I²C)*	*Design Using RTOS : Design Principles – Short Interrupt Routines*	*Programming for CAN Bus Protocols*
S-4	SLO-1	*Embedded system design processes.*	*Embedded Software Architecture : Round – Robin and other cycles*	*ZigBee*	*RTOS Tasks – Tasks for Priority*	*Commercial Applications: Washing Machine,*
	SLO-2	*Characteristics of embedded system applications*	*Round-Robin with interrupts– A Communication Bridge as an Example*	*Bluetooth with various protocol*	*Tasks for Encapsulation*	*Vending machine with flow diagram*
S-5	SLO-1	*types of embedded system with examples*	*Characteristics – Functions – Queue – Scheduling*	*Interfacing Protocols- GPIB*	*Creating and Destroying tasks*	*Laser Printer, underground tank monitor,*
	SLO-2	*Performance & Design issues*	*Various Queue and scheduling methods*	*FIREWIRE(IEEE 1394 standard)*	*Avoidance - Tank Monitoring System*	*Cordless Bar, Code Scanner*
S-6	SLO-1	*Performance & Design issues – Throughput – Response – Testability –*	*Software development process Architecture – Assembly and compiling*	*Universal Serial Bus (USB)*	*Design as example – Time Scheduling*	*Power Electronics Applications: Operation of DC/DC Converter*
	SLO-2	*Debuggability – Reliability – Memory space – Program Installation*	*Linking and loading, programme flow*	*need for device drivers*	*Embedded Programming and Communication Protocols: Introduction*	*Embedded C programming for DC-DC Converter pulse generation.*

S-7	SLO-1	*Power Consumption – Processor Hogs – Cost*	*Basic compilation techniques*	*Real Time Operating Systems : Tasks and Task states*	*Importance of Communication protocol and types of protocols*	*Introduction to 180Degree mode Three phase inverter*
	SLO-2	*Small size and weight, Real time/reactive operation, End-product utility, System-level requirements*	*Program optimization*	*Tasks and Data share*	*Embedded C Programming for 8051*	*Various mode of operation and switching sequence*
S-8	SLO-1	*Embedded System Architecture : Computer architecture taxonomy*	*Difference between task and process Multiple tasks*	*Shared data problems – Re-entrancy-Reentrancy Rules*	*Various programming language and advantage of embedded C*	*Programming for Three phase 180◦ Mode Inverter PWM pulse generation*
	SLO-2	*Harvard , von Neumann, and hybrid architectures*	*multiple processes with simple example*	*Semaphores and Shared data*	*Syntax, variable initialization and assigning a port address*	*Applications of Three phase inverter*
S-9	SLO-1	*CPUs, various processing unit and control units*	*Embedded Networking: Introduction, I/O ports*	*RTOS Semaphores*	*Header file inclusions, condition loop,*	*Basic concept of induction motor drive and speed control of V/F method*
	SLO-2	*Programming input and output, Supervisor mode, Exceptions & Traps, Co - processors*	*Different type of buses*	*Initializing semaphores Reentrancy and Semaphores – Multiple semaphores*	*Simple programme using embedded C*	*Controller Implementation for induction motor drive applications*

Learning Resources	1. *Wayne Wolf, Computers as Components: Principles of Embedded Computer Systems Design, The Morgan Kaufmann Series in Computer Architecture and Design, Elsevier Publications, 2008.* 2. *Rajkamal, Embedded Systems – Architecture, Programming and Design, Tata McGraw-Hill Publishing Company Ltd.,New Delhi, 3rd Edition 2010.* 3. *Sriram V Iyer, Pankaj Gupta, Embedded Real-time Systems Programming, Tata McGraw-Hill Publishing Company Ltd, New Delhi, 1st Edition 2017* 4. *David E.Simon, An Embedded Software Primer, Pearson Education, 1999.*	5. *Muhammad Ali Mazid, The 8051 Microcontrollers & Embedded Systems, Pearson, 2008* 6. *Kenneth Ayala, The 8051 Microcontroller & Embedded Systems using Assembly and C with CD* 7. *https://nptel.ac.in/courses/108102045/*

Learning Assessment

	Bloom's Level of Thinking	Continuous Learning Assessment (50% weightage)								Final Examination (50% weightage)	
		CLA – 1 (10%)		CLA – 2 (15%)		CLA – 3 (15%)		CLA – 4 (10%)#			
		Theory	Practice	Theory	Practice	Theory	Practice	Theory	Practice	Theory	Practice
Level 1	Remember Understand	40%	-	30%	-	30%	-	30%	-	30%	-
Level 2	Apply Analyze	40%	-	40%	-	40%	-	40%	-	40%	-
Level 3	Evaluate Create	20%	-	30%	-	30%	-	30%	-	30%	-
	Total	100 %		100 %		100 %		100 %		100 %	

CLA – 4 can be from any combination of these: Assignments, Seminars, Tech Talks, Mini-Projects, Case-Studies, Self-Study, MOOCs, Certifications, Conf. Paper etc.,

Course Designers		
Experts from Industry	Experts from Higher Technical Institutions	Internal Experts
1. *Mr. P.Pangayaselvan, Embedded Engineer, Verizon Technologies, vpangayaselvan@yahoo.co.in*	*1. Dr. S.Moorthi, NIT, Trichy, srimoorthi@nitt.edu*	*1. Dr. M.Jagabar Sathik,SRMIST*
2. *Mr. V.Suresh, Vi-Microsystem, Chennai*	*2. Dr.M.Manimara Boopathi, Vel Tech University*	*2. Dr.A.Rathinam,SRMIST*

Course Code	18EEE421T	Course Name	VLSI DESIGN	Course Category	E	Professional Elective	L	T	P	C
							3	0	0	3

Pre-requisite Courses	Nil	Co-requisite Courses	Nil	Progressive Courses	Nil
Course Offering Department	Electrical and Electronics Engineering	Data Book / Codes/Standards	Nil		

Course Learning Rationale (CLR):	The purpose of learning this course is to:
CLR-1 :	*Illustrate the MOS fabrication technologies and understand the electrical properties of MOS, CMOS and Bi CMOS circuits*
CLR-2 :	*Describe CMOS technology-specific layout rules in the placement and routing of transistors and interconnect and to verify the functionality, timing, power, and parasitic effects*
CLR-3 :	*Describe the various parameters and its characteristics of CMOS technology*
CLR-4 :	*Identify the real-time VLSI tools and its applications*
CLR-5 :	*Interpret the various testing methods, design tools and chip-level design techniques*
CLR-6 :	*Construct the digital logic gate using VLSI design tools*

Course Learning Outcomes (CLO):	At the end of this course, learners will be able to:	Learning 1: Level of Thinking (Bloom)	Learning 2: Expected Proficiency (%)	Learning 3: Expected Attainment (%)	PLO 1: Engineering Knowledge	PLO 2: Problem Analysis	PLO 3: Design & Development	PLO 4: Analysis, Design, Research	PLO 5: Modern Tool Usage	PLO 6: Society & Culture	PLO 7: Environment & Sustainability	PLO 8: Ethics	PLO 9: Individual & Team Work	PLO 10: Communication	PLO 11: Project Mgt. & Finance	PLO 12: Life Long Learning	PLO 13: PSO - 1	PLO 14: PSO - 2	PLO 15: PSO - 3
CLO-1 :	*Understand the steps for MOS fabrication technologies and analyze electrical behavior of MOS, CMOS and Bi CMOS circuits.*	2	75	75	H	-	-	-	-	-	-	-	-	-	-	-	-	M	-
CLO-2 :	*Draw the layout of integrated circuits following design rules*	2	75	75	H	-	-	-	-	-	-	-	-	-	-	-	-	M	-
CLO-3 :	*Analyze the different CMOS technology and its characteristics*	3	75	75	H	H	H	H	M	-	-	-	-	-	-	-	M	H	-
CLO-4 :	*Develop the coding for FPGA*	3	75	75	H	H	H	H	M	-	-	-	-	-	-	-	H	H	-
CLO-5 :	*Design a VLSI project having a set of objective criteria and design constraints*	3	75	75	H	H	H	H	H	-	-	-	-	-	-	-	H	H	-
CLO-6 :	*Design a digital components and basic logic gates circuits using VLSI tools*	2	75	75	H	H	H	H	H	-	-	-	-	-	-	-	H	M	-

Duration (hour)		9	9	9	9	9
S-1	SLO-1	*Introduction to IC Technology–MOS*	*VLSI circuit design processes: MOS Layers- Mask Layout, Layer contact mask layout representation*	*Gate level design: Transmission Gates*	*Introduction to design tools FPGAs (Xilinx 4000series)–Features and basic details of FPGA*	*Design Approach*
	SLO-2	*Introduction to IC Technology -PMOS*	*Coloured Stick Diagrams:- capabilities and limitations of stick diagram*	*Gate level design: Alternate gate circuits*	*Various functional block diagram with merits and demerits*	*VLSI Design Flows & Design Verification*
S-2	SLO-1	*Introduction to IC Technology NMOS, CMOS*	*Types of Design Rules VLSI circuit design*	*Basic circuit concepts: Sheet Resistance RS*	*Different syntax of fpga coding and variables*	*Design methods, Design capture tools*
	SLO-2	*Introduction to IC Technology Bi-CMOS Historical Perspective& Bi-CMOS technologies.*	*Layout of circuit diagram*	*Concept of RS in MOS*	*Simple basic programme*	*Design Flow, Design Languages, High-level Synthesis (HLS)*
S-3	SLO-1	*basic electrical properties: Basic Electrical Properties of MOS Circuits:*	*Layer Representations*	*Area Capacitance Units, Calculations, Delays*	*CPLDs (Xilinx 9500series)- Features and basic details*	*Design Verification Tools*
	SLO-2	*basic electrical properties: Basic Electrical Properties of Bi-CMOS Circuits:*	*Example of layer presentation*	*Estimation of Delay and INVERTER DELAYS Estimation of CMOS inverter delay Rise & Fall time estimation*	*Various functional block diagram with merits and demerits*	*Various Steps of verifications with one example*
S-4	SLO-1	*Ids-Vds relationships*	*CMOS Design rules for wires*	*Capacitance Modeling Driving large Capacitive Loads*	*Different syntax of CPLDs coding and variables*	*CMOS Testing:- Fault models, Test pattern generation*
	SLO-2	*Ids-Vds its characteristics*	*Layout Design rules & Lambda (λ)*	*Sizing Factor (s) , Inverter gain, Delay Optimization Problem*	*Simple basic programme*	*Need for testing:- Physical defects*

:S-5	SLO-1	MOS characteristics - transistor threshold Voltage,Wo	Design rules of Contacts	Wiring Capacitances, Fan-in and fan-out	Programmable Array Logic: introduction and applications	Test Principles, Design Strategies for test
	SLO-2	MOS characteristics -gm, gds characteristics	Design rules of Transistors	Effect of Capacitive Loading,Propagation Delay in Timing Diagrams	Operation and logic with simple problem	Fault Modeling, Design-for-Testability
S-6	SLO-1	Basic design parameters:- Figure of merit, Pass transistor	Layout Diagrams for NMOS Inverters and Gates	Choice of layers. SUBSYSTEM DESIGN: Shifters,	Design Approach with various steps	Chip-level Test Techniques
	SLO-2	MOS Transistor circuit model, Latch-up in CMOS circuits	Example layout of basic logic gates	Choice of layers. Adders, ALUs	Fuse mapping examples	Moving test up the flowFlop Factor
S-7	SLO-1	characteristics of NMOS Inverter, Various pull ups	Layout Diagrams :-CMOS Inverters and Gates	Choice of layers. Multipliers	Multiplier logic	System-level Test Techniques
	SLO-2	Resistive Load, Inverter with N type MOSFET Load	Example layout of CMOS inverters	Choice of layers. Parity generators	Alternate representation of high Fan-in structures	Characterization Test, Functional Board Testing, In-circuit testing
S-8	SLO-1	CMOS Inverter circuit operation	Scaling of MOS circuits	Comparators, Zero/One Detectors	Parameters influencing low power design	Layout Design for Improved Testability
	SLO-2	CMOS and complex CMOS logic circuit	Figure(s) of Merit (FoM) for scaling, Scaling factors for device parameters	Example of problems	Dynamic Power Consumption, Leakage power dissipation	Bridge Fault Model, Bridge Fault Simulation, Test Generation for Bridge Fault
S-9	SLO-1	Performance of the BiCMOS Inverter	Implications of scaling ondesign of Scaling	High-Density Memory Elements	Low Power Strategies: Sources of Power Dissipation	Observability and controllability
	SLO-2	Power Consumption, Designing BiCMOS Digital Gates	Limitations of Scaling	Bitline IO Circuit, SRAM	Degrees of Freedom, Supply Voltage Scaling, Ultra Low Power System Design	False Path problem

Learning Resources	1. K. Eshraghian Eshraghian. D, A.Pucknell, Essentials of VLSI Circuits and Systems,, Edition II PHI, 2009. 2. Modern VLSI Design : Ip - Based Design 4th Edition, 2015, PHI. 3. Basic VLSI Design, 2009, reprint 2017, PHI	3. N.H.E Weste, K.Eshraghian,Principals of CMOS VLSI Design, 2nd ed., Adisson Wesley, 1993. 4. Neil Weste,David Harris,CMOS VLSI Design: A Circuits and Systems Perspective ,4th Edition, 2011 4. http://nptel.ac.in/courses/117106092/#

Learning Assessment

	Bloom's Level of Thinking	Continuous Learning Assessment (50% weightage)								Final Examination (50% weightage)	
		CLA – 1 (10%)		CLA – 2 (15%)		CLA – 3 (15%)		CLA – 4 (10%)#			
		Theory	Practice	Theory	Practice	Theory	Practice	Theory	Practice	Theory	Practice
Level 1	Remember Understand	40%	-	30%	-	30%	-	30%	-	30%	-
Level 2	Apply Analyze	40%	-	40%	-	40%	-	40%	-	40%	-
Level 3	Evaluate Create	20%	-	30%	-	30%	-	30%	-	30%	-
	Total	100 %		100 %		100 %		100 %		100 %	

CLA – 4 can be from any combination of these: Assignments, Seminars, Tech Talks, Mini-Projects, Case-Studies, Self-Study, MOOCs, Certifications, Conf. Paper etc.,

Course Designers

Experts from Industry	Experts from Higher Technical Institutions	Internal Experts
1 Mr.V.Pangayselvan. Aricent Technologies,Senior analysist, Chennai, pangaya.v@aricent.com	1. Dr .Shady Abdel Aleem. Higher Institute of Engineering, Mathematical, Physical and Engineering Sciences Department, Cairo, Egypt. engyshady@ieee.org	1. Dr. M.Jagabar Sathik, SRMIST
2.Mr. M.Sathisk Kumar, Senior Manager and Programme Specialist, ORCALE DB ,Bangalore	2. Dr. B.Moorthy, Associate professor, NIT Trichy	2. Dr.A.Rathinam, SRMIST

Course Code	18EEE328T	Course Name	DATA STRUCTURES	Course Category	E	Professional Elective	L	T	P	C
							3	0	0	3

Pre-requisite Courses	Nil	Co-requisite Courses	Nil	Progressive Courses	Nil
Course Offering Department	Electrical and Electronics Engineering	Data Book / Codes/Standards	Nil		

Course Learning Rationale (CLR):	*The purpose of learning this course is to:*
CLR-1 :	*Illustrate the basic concepts of data structures, Search techniques and their algorithms*
CLR-2 :	*Educate with the basic knowledge of stacks and queues*
CLR-3 :	*Discuss the concepts of linked lists*
CLR-4 :	*Impart knowledge on trees and its algorithm*
CLR-5 :	*Outline the basics of sorting and graph*
CLR-6 :	*Create an overall knowledge of different data structure algorithms*

Course Learning Outcomes (CLO):	*At the end of this course, learners will be able to:*	Learning 1: Level of Thinking (Bloom)	Learning 2: Expected Proficiency (%)	Learning 3: Expected Attainment (%)	PLO 1: Engineering Knowledge	PLO 2: Problem Analysis	PLO 3: Design & Development	PLO 4: Analysis, Design, Research	PLO 5: Modern Tool Usage	PLO 6: Society & Culture	PLO 7: Environment & Sustainability	PLO 8: Ethics	PLO 9: Individual & Team Work	PLO 10: Communication	PLO 11: Project Mgt. & Finance	PLO 12: Life Long Learning	PLO 13: PSO - 1	PLO 14: PSO - 2	PLO 15: PSO - 3
CLO-1 :	*Implement and analyze the different searching algorithms*	*2*	*80*	*75*	*H*	*H*	*M*	-	-	-	-	-	-	-	-	-	*H*	*M*	-
CLO-2 :	*Employ different stacks and queues algorithms*	*2*	*80*	*75*	*H*	*H*	*M*	-	-	-	-	-	-	-	-	-	*M*	*M*	-
CLO-3 :	*Analyze the different linked list algorithms*	*2*	*80*	*75*	*H*	*H*	*M*	-	-	-	-	-	-	-	-	-	*H*	*M*	-
CLO-4 :	*Determine the time and computation complexity in Binary tree and AVL tree*	*2*	*80*	*75*	*H*	*M*	*M*	-	-	-	-	-	-	-	-	-	*H*	*H*	-
CLO-5 :	*Develop an algorithm for graph and compare the performance of sorting methods*	*2*	*80*	*75*	*H*	*H*	*M*	-	-	-	-	-	-	-	-	-	*H*	*M*	-
CLO-6 :	*Develop application using data structure algorithms*	*2*	*80*	*75*	*H*	*H*	*M*	-	-	-	-	-	-	-	-	-	*H*	*M*	-

Duration (hour)		9	9	9	9	9
S-1	SLO-1	*Basic Terminologies*	*Array implementation of Stack ADT*	*Singly linked lists*	*Basic Tree Terminologies*	*Basic Terminologies of Graph*
	SLO-2	*Elementary Data Organizations*	*Stack ADT operations with example*	*Singly linked lists - Representation in memory*	*Basic Tree Operations*	*Representations of Graph*
S-2	SLO-1	*Abstract data type*	*Application of Stack: Infix to Postfix Conversion*	*Algorithm of Traversing operation*	*Binary Tree operations*	*Graph traversal algorithms - breadth first search with example*
	SLO-2	*Abstract data type Example*	*Infix to Postfix Conversion Algorithm*	*Algorithm of Searching operation*	*Algorithm of Binary Tree operations*	*Graph traversal algorithms - depth first search with example*
S-3	SLO-1	*Data Structure Operations*	*Application of Stack: Evaluation of postfix expression*	*Insertion into linked list*	*Binary Search Tree - operations - insertion*	*Prims Minimum spanning tree algorithm*
	SLO-2	*Types of Data Structure Operations*	*Evaluation of postfix expression Algorithm*	*Algorithm of Insertion into linked list*	*Algorithm of Binary Search Tree - insertion*	*Prims Minimum spanning tree algorithm - Example*
S-4	SLO-1	*Analysis of an Algorithm*	*Application of Stack: Balancing symbols*	*Deletion from linked list*	*Binary Search Tree - operations - deletion*	*Kruskal's Minimum spanning tree algorithm*
	SLO-2	*Applications: Analysis of an Algorithm*	*Balancing symbols Algorithm with example*	*Algorithm of Deletion from linked list*	*Algorithm of Binary Search Tree - deletion*	*Kruskal's Minimum spanning tree algorithm – Example*
S-5	SLO-1	*Asymptotic Notations*	*Queue ADT- OperationsIntroduction*	*Linked representation of Stack*	*Binary tree traversal*	*Bubble sort*
	SLO-2	*Properties of Asymptotic Notations*	*Queue ADT- Operations Examples*	*Linked representation of Stack - Example*	*Binary tree traversal - inorder, preorder, postorder*	*Bubble sort – Example*
S-6	SLO-1	*Time-Space trade off*	*Simple Queue- Operations*	*Linked representation of Queue*	*Example of Binary tree traversal*	*Insertion Sort algorithm*

	SLO-2	*Time-Space trade off Example*	*Algorithm of Simple Queue – Operations with examples*	*Linked representation of Queue - Example*	*Applications of Binary Trees*	*Insertion Sort algorithm – Example*
S-7	SLO-1	*Linear Search Technique*	*Circular Queue - Operations*	*Doubly linked list*	*AVL Tree- operations: Rotations*	*Selection Sort algorithm*
	SLO-2	*Linear Search Technique Example*	*Algorithm of Circular Queue - Operations*	*Operations on Doubly linked list*	*AVL Tree- operations: Rotations - Example*	*Selection Sort algorithm – Example*
S-8	SLO-1	*Complexity analysis of Linear Search Technique*	*Example of Circular Queue - Operations*	*Example of Doubly linked list*	*AVL Tree- operations: Insertion*	*Merge sort algorithm*
	SLO-2	*Example of Linear Search Technique*	*Priority Queue - Operations*	*Circular Linked List*	*AVL Tree- operations: Insertion - Example*	*Merge sort algorithm – Example*
S-9	SLO-1	*Binary Search Technique*	*Algorithm of Priority Queue - Operations*	*Circular Linked List algorithms*	*AVL Tree- operations: Deletion*	*Quick sort algorithm*
	SLO-2	*Complexity analysis of Binary Search Technique*	*Example of Priority Queue - Operations*	*Circular Linked List example*	*AVL Tree- operations: Deletion – Example*	*Quick sort algorithm – Example*

Learning Resources	*1. Aaron M.Tenenbaum, Yedidyah Langsam and Moshe J.Augenstein, Data Structures Using C, Seventh Edition, 2009, Pearson Education in South Asia.* *2. G A Vijayalakshmi Pai, Data Structures and Algorithms - Concepts, Techniques and Applications, Tata McGraw-Hill Publishing Company Limited, 2008.*	*3. https://www.youtube.com/watch?v=coxWfcz_slk&list=PLrjkTql3jnm8ikiQIeIHrMYCaBfkBkfYR&index=1* *4. Mark Allen Weiss, "Data Structures and Algorithm Analysis in C++", Third Edition, 2009, Pearson Education in South Asia.*

Learning Assessment

	Bloom's Level of Thinking	Continuous Learning Assessment (50% weightage)								Final Examination (50% weightage)	
		CLA – 1 (10%)		CLA – 2 (15%)		CLA – 3 (15%)		CLA – 4 (10%)#			
		Theory	Practice	Theory	Practice	Theory	Practice	Theory	Practice	Theory	Practice
Level 1	Remember Understand	40 %	-	30 %	-	30 %	-	30 %	-	30%	-
Level 2	Apply Analyze	40 %	-	40 %	-	40 %	-	40 %	-	40%	-
Level 3	Evaluate Create	20 %	-	30 %	-	30 %	-	30 %	-	30%	-
	Total	100 %		100 %		100 %		100 %		100 %	

CLA – 4 can be from any combination of these: Assignments, Seminars, Tech Talks, Mini-Projects, Case-Studies, Self-Study, MOOCs, Certifications, Conf. Paper etc.,

Course Designers

Experts from Industry	Experts from Higher Technical Institutions	Internal Experts
1.Mr.Balachandrasekar.K,CTS,dyaksha@gmail.com	*1.Dr. B. K. Panigrahi, IIT Delhi, bkpanigrahi@ee.iitd.ac.in*	*1. Dr.R.Annie Uthra, SRMIST*
2.Mr. Tripathi patro,visam pvt ltd,btp@visom.co.in	*2.Dr. M.P.Selvan, NIT Trichy, selvanmp@nitt.edu*	*2. Mr.P.Kanakaraj, SRMIST*

Course Code	18EEE329T	Course Name	COMPUTER SYSTEM ARCHITECTURE	Course Category	E	Professional Elective	L	T	P	C
							3	0	0	3

Pre-requisite Courses	NIL	Co-requisite Courses	NIL	Progressive Courses	NIL
Course Offering Department	Electrical and Electronics Engineering	Data Book / Codes/Standards	Nil		

Course Learning Rationale (CLR):	*The purpose of learning this course is to:*
CLR-1 :	*Acquire knowledge about the modern computer organization technologies*
CLR-2 :	*Educate the students' on machine instructions*
CLR-3 :	*Explain the modern Acorn RISC Machine (ARM) Instruction set*
CLR-4 :	*Impart knowledge about the interfacing devices*
CLR-5 :	*Identify potential of memory unit*
CLR-6 :	*Educate the students' onadvances in computer technology*

Course Learning Outcomes (CLO):	*At the end of this course, learners will be able to:*	Learning 1: Level of Thinking (Bloom)	Learning 2: Expected Proficiency (%)	Learning 3: Expected Attainment (%)	PLO 1: Engineering Knowledge	PLO 2: Problem Analysis	PLO 3: Design & Development	PLO 4: Analysis, Design, Research	PLO 5: Modern Tool Usage	PLO 6: Society & Culture	PLO 7: Environment & Sustainability	PLO 8: Ethics	PLO 9: Individual & Team Work	PLO 10: Communication	PLO 11: Project Mgt. & Finance	PLO 12: Life Long Learning	PLO 13: PSO - 1	PLO 14: PSO - 2	PLO 15: PSO - 3
CLO-1 :	*Understand the concepts of modern computer organization*	2	75	75	H	H	M	L	-	-	-	-	-	-	-	-	M	M	-
CLO-2 :	*Analyze the machine instruction concept and operation*	2	75	75	H	H	M	L	-	-	-	-	-	-	-	-	M	M	-
CLO-3 :	*Examine and solve issues related to Acorn RISC Machine (ARM) Instruction set*	2	75	75	H	H	M	L	-	-	-	-	-	-	-	-	M	M	-
CLO-4 :	*Describe the operation of input and output units*	2	75	75	H	H	M	L	-	-	-	-	-	-	-	-	M	M	-
CLO-5 :	*Examine and solve issues related to memory mapping techniques*	2	75	75	M	H	M	L	-	-	-	-	-	-	-	-	M	M	-
CLO-6 :	*Acquire knowledge on the recent trends in computer technologies*	2	75	75	H	H	M	L	-	-	-	-	-	-	-	-	M	M	-

Duration (hour)		9	9	9	9	9
S-1	SLO-1	*Computer types*	*Numbers ,arithmetic operations and characters*	*Memory access and data transfer*	*Accessing I/O devices*	*Semiconductor RAM memories*
	SLO-2	*functional units of computer architecture*	*Memory locations*	*Acorn RISC Machine(ARM)- Registers*	*Interrupts*	*Read only memories*
S-2	SLO-1	*Operational concepts*	*Memory addresses*	*Arithmetic and logic instructions*	*ARM Interrupt structure*	*Speed size and cost*
	SLO-2	*bus structures*	*Addressing mode*	*Branch Instructions*	*Direct memory access*	*Mapping techniques*
S-3	SLO-1	*Software Performance*	*Instructions and sequencing*	*Setting condition codes*	*Buses-Synchronous bus*	*Hit rate and miss penalty*
	SLO-2	*Performance and metrics*	*Assembly language*	*Loop program*	*Asynchronous bus*	*Caches on the processor chip*
S-4	SLO-1	*compiler*	*Basic input/output operations*	*Pseudo instructions*	*Interface circuits-Serial port*	*Virtual memories*
	SLO-2	*Uniprocessors to multiprocessors*	*Subroutines*	*Byte sorting*	*Parallel port*	*Memory management requirements*
S-5	SLO-1	*operations and operands*	*Logic instructions*	*Linked list insertion subroutines*	*Standard I/O interfaces*	*Second storage system*
	SLO-2	*representing instructions*	*Branch Instructions*	*Linked list deletion subroutines*	*PCI buses*	*Memory hierarchy*
S-6	SLO-1	*Logical operations*	*Execution of a complete instruction*	*Data hazards*	*Universal serial bus*	*Memory technologies*
	SLO-2	*control operations*	*Addition algorithm*	*Instruction hazards*	*Overview of parallelism*	*Cache basics*
S-7	SLO-1	*Multiple bus organization*	*Subtractionalgorithm*	*Influence on instruction sets*	*Instruction-level-parallelism*	*Measuring cache performance*
	SLO-2	*Hardwired control*	*Multiplicationalgorithm*	*Data path and control considerations*	*Parallel processing challenges*	*Improving cache performance*
S-8	SLO-1	*Micro programmed control*	*Divisionalgorithm*	*Performance considerations of pipelining*	*Flynn's classification*	*Virtual memory*
	SLO-2	*Multi computers*	*Floating Point operations*	*Overview of data path control*	*Hardware multithreading*	*Translation Lookaside Buffer*
S-9	SLO-1	*Multiprocessors*	*Sub-word parallelism*	*Pipelined datapath and control*	*Analysis of parallelism methods*	*Direct Memory Access*
	SLO-2	*Nano programming*	*Write-through and Write-back cache write method*	*Exception handling*	*Multi-core computing in parallelism*	*Interrupts*

Learning Resources	1. *M. Morris R. Mano Computer System Architecture, Pearson publishers,3rd Edition, 2007.* 2. *Carl hamachar Computer Architecture and Organization, Tata McGraw hill,5th edition, 2015.*	3. *David A. PattersonComputer Organization and Design MIPS Edition: The Hardware/Software Interface (The Morgan Kaufmann Series in Computer Architecture and Design)Morgan Kaufmann; 5 edition 2013.* 4. *https://ocw.mit.edu/courses/electrical-engineering-and-computer-science*

Learning Assessment											
	Bloom's Level of Thinking	Continuous Learning Assessment (50% weightage)								Final Examination (50% weightage)	
		CLA – 1 (10%)		CLA – 2 (15%)		CLA – 3 (15%)		CLA – 4 (10%)#			
		Theory	Practice	Theory	Practice	Theory	Practice	Theory	Practice	Theory	Practice
Level 1	Remember Understand	40 %	-	30 %	-	30 %	-	30 %	-	30%	-
Level 2	Apply Analyze	40 %	-	40 %	-	40 %	-	40 %	-	40%	-
Level 3	Evaluate Create	20 %	-	30 %	-	30 %	-	30 %	-	30%	-
	Total	100 %		100 %		100 %		100 %		100 %	

CLA – 4 can be from any combination of these: Assignments, Seminars, Tech Talks, Mini-Projects, Case-Studies, Self-Study, MOOCs, Certifications, Conf. Paper etc.,

Course Designers		
Experts from Industry	Experts from Higher Technical Institutions	Internal Experts
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2.Mr.Ravikumar A R, PayPal,ravikumar.venkataramani@gmail.com	*2.Dr. S. Ramareddy, Jerusalem College of Engineering,srr.victory@gmail.com*	*2.Ms.R.Rajarajeswari, SRMIST*

Course Code	18EEE330T	Course Name	COMPUTER NETWORKING	Course Category	E	Professional Elective	L	T	P	C
							3	0	0	3

Pre-requisite Courses	Nil	Co-requisite Courses	Nil	Progressive Courses	Nil
Course Offering Department	Electrical and Electronics Engineering	Data Book / Codes/Standards	Nil		

Course Learning Rationale (CLR):	*The purpose of learning this course is to:*
CLR-1 :	*Understand the protocols of modern networking technologies*
CLR-2 :	*Educate the students' on data format& data transfer at high speed Communication*
CLR-3 :	*Explain the modern transport layer technologies*
CLR-4 :	*Identify advances in technology that may solve the actual limitations with existing networks*
CLR-5 :	*Impart knowledge about modern technologies used in application layer*
CLR-6 :	*Educate the students on network security*

Course Learning Outcomes (CLO):	*At the end of this course, learners will be able to:*	Learning 1 Level of Thinking (Bloom)	2 Expected Proficiency (%)	3 Expected Attainment (%)	PLO 1 Engineering Knowledge	2 Problem Analysis	3 Design & Development	4 Analysis, Design, Research	5 Modern Tool Usage	6 Society & Culture	7 Environment & Sustainability	8 Ethics	9 Individual & Team Work	10 Communication	11 Project Mgt. & Finance	12 Life Long Learning	13 PSO - 1	14 PSO - 2	15 PSO - 3
CLO-1 :	*Acquire knowledge about the protocols of modern networking technologies*	2	75	75	H	H	M	L	-	-	-	M	-	-	-	-	H	M	M
CLO-2 :	*Analyze the physical properties and performance characteristics of Communication media*	2	75	75	H	H	M	L	-	-	-	M	-	-	-	-	H	M	M
CLO-3 :	*Examine and solve issues related to congestion management*	2	75	75	H	H	M	L	-	-	-	M	-	-	-	-	H	H	M
CLO-4 :	*Describe the importance of reliability and quality of service, for error recovery, traffic differentiation and prioritization.*	2	75	75	H	H	M	L	-	-	-	M	-	-	-	-	H	H	M
CLO-5 :	*Develop an appreciation of the theory of common application layer.*	2	75	75	H	H	M	L	-	-	-	M	-	-	-	-	H	M	M
CLO-6 :	*Acquire knowledge about the network security system.*	2	75	75	H	H	M	L	-	-	-	M	-	-	-	-	H	M	M

Duration (hour)		9	9	9	9	9
S-1	SLO-1	*Historical perspective of computer networking*	*Theoretical basis for data Communication*	*Overview of Transport layer*	*Causes of errors on data transmission*	*Traditional applications*
	SLO-2	*Theoretical models of network architecture*	*Guided transmission media*	*Elements of transport protocol*	*Impact of errors on data transmission*	*Electronic Mail*
S-2	SLO-1	*Practical models of network architecture*	*Bounded type transmission mode*	*Functions of transport layer*	*Single bit errors*	*Simple Mail Transfer Protocol*
	SLO-2	*Introduction to ISO*	*Unbounded type transmission mode*	*Addressing modes*	*Burst errors*	*POP3*
S-3	SLO-1	*ISO OSI Seven-layer model*	*Magnetic Media*	*Service point addressing*	*Need for error detection*	*Web Services*
	SLO-2	*TCP protocol*	*Issues with magnetic media*	*Segmentation process*	*error detection strategies*	*Http*
S-4	SLO-1	*IP protocol*	*Need for cable transmission modeS*	*Reassembling process*	*Overview of error correction*	*Multimedia*
	SLO-2	*Comparison of OSI and TCP/IP reference models*	*Twisted Pair cable*	*User datagram protocol*	*error correction strategies*	*Domain Name System*
S-5	SLO-1	*Synchronous transfer mode protocol*	*Baseband Coaxial Cable*	*Reliable byte stream*	*Parity Checks*	*Simple Network Management Protocol*
	SLO-2	*Asynchronous transfer mode protocol*	*Broadband Coaxial Cable*	*Connection management*	*block sum Check*	*File Access and Management*
S-6	SLO-1	*Frame relay protocol*	*narrowband ISDN*	*Causes of Congestion*	*Sliding window protocol*	*Overview of Network security*
	SLO-2	*Frame Relay and the OSI Reference Model*	*broadband ISDN*	*Retransmission*	*Elementary data link protocol*	*Cryptography*
S-7	SLO-1	*Digital subscriber line technology*	*Microwave transmission*	*Congestion Control*	*Protocol identification*	*Symmetric key algorithm*
	SLO-2	*Variation in DSL technology*	*Electromagnetic Spectrum*	*Flow control*	*Protocol verification*	*Public key algorithm*
S-8	SLO-1	*2G technology*	*Radio transmission*	*Performance issues*	*Forward error control*	*Digital signature*
	SLO-2	*3G,4G technology*	*Fiber optics*	*Quality of service*	*Backward error control*	*Management of public keys*
S-9	SLO-1	*Wi-Fi technology*	*Microwave Transmission*	*Application requirements*	*Statistical analysis of the effectiveness of error detection code*	*Communication security*
	SLO-2	*Wi-MAX technology*	*Comparison of transmission medium*	*Design issues with transport layer*	*Statistical analysis of the effectiveness of error correction code*	*Social issues*

Learning Resources	1. *Andrew S. Tanenbaum, Computer Networks, 4th edition, Prentice Hall, 2003.* 2. *William Stallings, Data and Computer Communications, 5th edition, PHI, 2005.*	3. *James F. Kurose,Computer networking : a top-down approach, 6th ed.Pearson publishers.* 4. *https://ocw.mit.edu/courses/electrical-engineering-and-computer-science*

Learning Assessment											
	Bloom's Level of Thinking	Continuous Learning Assessment (50% weightage)								Final Examination (50% weightage)	
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		Theory	Practice	Theory	Practice	Theory	Practice	Theory	Practice	Theory	Practice
Level 1	Remember Understand	40 %	-	30 %	-	30 %	-	30 %	-	30%	-
Level 2	Apply Analyze	40 %	-	40 %	-	40 %	-	40 %	-	40%	-
Level 3	Evaluate Create	20 %	-	30 %	-	30 %	-	30 %	-	30%	-
	Total	100 %		100 %		100 %		100 %		100 %	

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Course Designers		
Experts from Industry	Experts from Higher Technical Institutions	Internal Experts
1. Mr.Ravikumar A R, PayPal,ravikumar.venkataramani@gmail.com	*1. Dr. A. Venkadesan, NIT Puducherry, venkadesan@nitpy.ac.in*	*1. Mr.George Fernandez.S, SRMIST*
2. Mr.Balachandrasekar.K,CTS,dyaksha@gmail.com	*2.Dr Subhransu Sekhar Dash, Government College of Engineering, Keonjhar, Subhransudash_fee@gcekjr.ac.in*	*2. Dr.J.Divyanavamani, SRMIST*

Course Code	18EEE331T	Course Name	INTERNET OF THINGS	Course Category	E	Professional Elective	L	T	P	C
							3	0	0	3

Pre-requisite Courses	Nil	Co-requisite Courses	Nil	Progressive Courses	Nil
Course Offering Department	Electrical and Electronics Engineering	Data Book / Codes/Standards	Nil		

Course Learning Rationale (CLR):	The purpose of learning this course is to:
CLR-1 :	*Outline the basic architectural overview of IoT .*
CLR-2 :	*Enable the students to differentiate between IoT and M2M.*
CLR-3 :	*Enrich the knowledge about IoT platforms and design methodology*
CLR-4 :	*Examine the various hardware platforms of IoT*
CLR-5 :	*Acquire the concept of IoT in application sectors.*
CLR-6 :	*Enable the students to acquire the basic knowledge of IoT architecture, various platforms and applications.*

Course Learning Outcomes (CLO):	At the end of this course, learners will be able to:	Learning 1: Level of Thinking (Bloom)	2: Expected Proficiency (%)	3: Expected Attainment (%)	PLO 1: Engineering Knowledge	2: Problem Analysis	3: Design & Development	4: Analysis, Design, Research	5: Modern Tool Usage	6: Society & Culture	7: Environment & Sustainability	8: Ethics	9: Individual & Team Work	10: Communication	11: Project Mgt. & Finance	12: Life Long Learning	13: PSO - 1	14: PSO - 2	15: PSO - 3
CLO-1 :	*Understand the issues and design challenges in IoT architecture*	1	75	75	H	-	-	-	-	H	-	-	-	-	-	-	H	M	H
CLO-2 :	*Gain knowledge on M2M and IoT*	1	75	75	H	-	-	-	M	H	-	-	-	-	-	-	M	M	M
CLO-3 :	*Interpret about various network topologies and design methodologies*	1	75	75	H	-	-	-	M	H	-	M	-	-	-	-	H	M	M
CLO-4 :	*Analyze on hardware platforms relevant to IoT.*	2	75	75	H	-	-	-	M	H	-	-	-	-	-	-	H	H	M
CLO-5 :	*Apply knowledge of IoT in various applications.*	2	75	75	H	-	-	-	M	H	-	-	H	-	-	H	H	M	M
CLO-6 :	*Understand IoT platforms, interfacing and applications.*	2	75	75	H	-	-	-	M	H	-	M	H	-	-	H	H	M	M

Duration (hour)		9	9	9	9	9
S-1	SLO-1	*Definitions of IoT*	*M2M towards IoT - the global context,*	*IoT platforms*	*IoT Physical Devices & Endpoints*	*Case Studies- IoT Design and Cloud incorporation*
	SLO-2	*Functional requirements of IoT.*	*Game changers*	*IoT platforms design methodology*	*Basic building blocks of an IoT Device*	*Introduction to IoT Design*
S-2	SLO-1	*Building an IoT architecture- SOA based architecture*	*M2M to IoT - building an architecture*	*IoT design methodology - Purpose & Requirements Specification, Process Specification*	*Exemplary Device: Raspberry Pi*	*Home Automation – smart lighting, smart appliances*
	SLO-2	*API oriented architecture*	*Main design principles and needed capabilities*	*Domain Model Specification, Information Model Specification*	*Linux on Raspberry Pi*	*Intrusion detection, Smoke /Gas detectors*
S-3	SLO-1	*Physical things of IoT- Things in IoT,*	*IoT architecture outline*	*Service Specifications, IoT Level Specification, Functional View Specification*	*Raspberry Pi Interfaces - serial*	*Cities –Smart Parking, Smart Lighting, Smart Roads*
	SLO-2	*IoT Protocols*	*Standard considerations*	*Operational View Specification, Device & Component, Application development.*	*Raspberry Pi Interfaces - SPI, I2C*	*Structural health Monitoring, Surveillance, Emergency Response*
S-4	SLO-1	*Logical Design of IoT - IoT functional Blocks,*	*Introduction to M2M*	*IoT Design methodology-case study on IoT system for Weather Monitoring*	*Programming Raspberry Pi with Python – controlling LED with Raspberry pi*	*Environment - Weather Monitoring, Air Pollution Monitoring*
	SLO-2	*Communication model, Communication APIs*	*Difference between IOT and M2M*	*Case study on IOT system for Weather Monitoring*	*Programming Raspberry Pi with Python – interfacing an LED and switch with Raspberry pi*	*Noise Pollution Monitoring, Forest Fire Detection, River Floods Detections*
S-5	SLO-1	*IoT enabling technologies- wireless sensor networks*	*Software defined networking (SDN)*	*Python data types*	*Programming Raspberry Pi with Python- interfacing a light sensor with Raspberry Pi*	*Energy - Smart grids , Renewable Energy Systems, Prognostics*
	SLO-2	*Cloud Computing*	*Network function visualization (NFV) for IOT.*	*Python data structures.*	*Other IoT Devices- pcDuino, BeagleBone Black*	*Retail - Inventory Management, Smart Payment, Smart Vending Machines*

S-6	SLO-1	*IoT enabling technologies - Embedded Systems,*	*Needs for IoT system management*	*Logical Design using Python- control flow*	*Other IoT Devices - Cubieboard*	*Smart Vending Machines*
	SLO-2	*Big data analytics*	*Simple Network Management Protocols (SNMP)*	*Logical Design using Python - functions*	*Controlling LED with Raspberry Pi*	*Logistics - Route Generation and scheduling, Fleet Tracking*
S-7	SLO-1	*IoT enabling technologies - Communication protocols for IoT,*	*Limitations of SNMP*	*Logical Design using Python - modules*	*Controlling LED with Myrio*	*Shipment Monitoring, Remote Vehicle Diagnotics*
	SLO-2	*Embedded systems*	*Network operator requirements*	*Logical Design using Python - packages*	*Interfacing an LED and Switch with Raspberry Pi*	*Agriculture - Smart irrigation, Green House Control*
S-8	SLO-1	*IoT levels and deployment templates- level 1, level 2,level 3*	*Network configuration protocol (NETCONF) layer*	*Logical Design using Python - file handling,*	*Interfacing an LED and Switch with Myrio*	*Industry – Machine Diagnosis and prognosis*
	SLO-2	*IoT levels and deployment templates- level 4, level 5, level 6*	*YANG data modelling language.*	*Logical Design using Python - date/time operations, classes*	*Interfacing a Light Sensor (LDR) with Raspberry Pi Other IoT Devices - BeagleBone Black,*	*Indoor Air Quality Monitoring*
S-9	SLO-1	*IoT data management and Analytics- IoT and the cloud*	*IOT system management with NETCONF - YANG*	*Python Packages of Interest for IoT - JSON,XML*	*Interfacing a temperature and humidity sensors with Raspberry Pi Other IoT Devices -BeagleBone Black*	*Health and lifestyle - Health and fitness Monitoring*
	SLO-2	*IoT data management and Analytics- Real time analytics in IoT and Fog computing*	*NETOPEER*	*Python Packages of Interest for IoT - XML*	*Interfacing a temperature and humidity sensors with Raspberry Pi Other IoT Devices -BeagleBone Black*	*Wearable Electronics*

Learning Resources	1. *Arshdeep Bahga, Vijay Madisetti, Internet of Things – A hands-on approach, Universities Press, 2015* 2. *Jan Holler, Vlasios Tsiatsis, Catherine Mulligan, Stamatis Karnouskos, David Boyle, From Machine-to-Machine to the Internet of Things: Introduction to a New Age of Intelligence, Elsevier, 1st Edition ,2014* 3. *Rajkumar Buyya , James Broberg, Andrzej Goscinski, Cloud Computing Principles and Paradigms, Willey, 1st Edition 2014.*	4. *Honbo Zhou, The Internet of Things in the Cloud: A Middleware Perspective ,CRC Press 2013.* 5. *Soyata, Tolga, Enabling Real-Time Mobile Cloud Computing through Emerging Technologies, IGI Global, 2015* 6. *https://www.cse.wustl.edu/~jain/cse570-15/ftp/iot_prot/index.html*

Learning Assessment

	Bloom's Level of Thinking	Continuous Learning Assessment (50% weightage)								Final Examination (50% weightage)	
		CLA – 1 (10%)		CLA – 2 (15%)		CLA – 3 (15%)		CLA – 4 (10%)#			
		Theory	Practice	Theory	Practice	Theory	Practice	Theory	Practice	Theory	Practice
Level 1	Remember Understand	40 %	-	30 %	-	30 %	-	30 %	-	30%	-
Level 2	Apply Analyze	40 %	-	40 %	-	40 %	-	40 %	-	40%	-
Level 3	Evaluate Create	20 %	-	30 %	-	30 %	-	30 %	-	30%	-
	Total	100 %		100 %		100 %		100 %		100 %	

CLA – 4 can be from any combination of these: Assignments, Seminars, Tech Talks, Mini-Projects, Case-Studies, Self-Study, MOOCs, Certifications, Conf. Paper etc.,

Course Designers

Experts from Industry	Experts from Higher Technical Institutions	Internal Experts
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2. Mr.Ravikumar A R, PayPal,ravikumar.venkataramani@gmail.com	*2. Dr.B.ChittiBabu, IIITD, Kanchipuram,chittibabu@gmail.com*	*2. Dr.J.Preetha Roselyn, SRMIST*

Course Code	18EEE332T	Course Name	PRINCIPLES OF OBJECT ORIENTED PROGRAMMING	Course Category	E	Professional Elective	L	T	P	C
							3	0	0	3

Pre-requisite Courses	Nil	Co-requisite Courses	Nil	Progressive Courses	Nil
Course Offering Department	Electrical and Electronics Engineering	Data Book / Codes/Standards	Nil		

Course Learning Rationale (CLR):	The purpose of learning this course is to:
CLR-1 :	*Explain the basics of OOPS*
CLR-2 :	*Demonstrate and develop the concepts of C++*
CLR-3 :	*Illustrate the importance of the advancements in C++*
CLR-4 :	*Explain the basics of JAVA*
CLR-5 :	*Elaborate the advanced features of JAVA*
CLR-6 :	*Discover the basics of C++ and JAVA*

Course Learning Outcomes (CLO):	At the end of this course, learners will be able to:	Learning 1: Level of Thinking (Bloom)	2: Expected Proficiency (%)	3: Expected Attainment (%)	PLO 1: Engineering Knowledge	2: Problem Analysis	3: Design & Development	4: Analysis, Design, Research	5: Modern Tool Usage	6: Society & Culture	7: Environment & Sustainability	8: Ethics	9: Individual & Team Work	10: Communication	11: Project Mgt. & Finance	12: Life Long Learning	13: PSO - 1	14: PSO - 2	15: PSO - 3
CLO-1 :	*Identify the basic concepts of OOPS*	2	75	75	H	-	-	-	-	-	-	-	-	-	-	-	M	M	-
CLO-2 :	*Classify and utilize the concepts of C++*	3	75	75	H	M	M	L	M	-	-	-	-	-	-	-	M	M	-
CLO-3 :	*Develop potential applications from the advancements in C++*	3	75	75	H	H	H	M	M	-	-	-	-	-	-	-	M	M	-
CLO-4 :	*Discover the basics of JAVA*	3	75	75	H	L	L	L	M	-	-	-	-	-	-	-	M	M	-
CLO-5 :	*Apply and analyze the advanced features of JAVA*	3	75	75	H	H	H	H	M	-	-	-	-	-	-	-	M	M	-
CLO-6 :	*Design and develop applications based on C++ and JAVA*	3	75	75	H	H	M	M	M	-	-	-	-	-	-	-	M	M	-

Duration (hour)		9	9	9	9	9
S-1	SLO-1	*Need of Object-Oriented Programming*	*Introduction to Classes*	*Pointers*	*Java platform features-Data types, Key words, Scoping rules*	*finalize() method*
	SLO-2	*Characteristics of Object-Oriented Languages*	*Introduction to Objects*	*Pointers with arrays and functions*	*Automatic Type Conversion, Type Casting and Arrays*	*finalize() method: Implementation*
S-2	SLO-1	*Introduction to the principles of object-oriented programming*	*Class fundamentals*	*Virtual Functions*	*Java platform features*	*Overloading methods*
	SLO-2	*Data Types, Variables*	*Structure of class*	*Friend Functions*	*Data types, Key words, Scoping rules*	*Constructors*
S-3	SLO-1	*Constants - Type Conversion*	*Declaring objects*	*Programs using pointers and arrays*	*Operators Precedence*	*Nested classes*
	SLO-2	*Basic Program Construction*	*Simple object creation*	*Programs using functions*	*Associativity, Expression*	*Inner classes*
S-4	SLO-1	*Operators*	*Objects and messages*	*Introduction to STL: Containers, Algorithms*	*Enhanced for loop, switch statements*	*Potential problems with methods and classes*
	SLO-2	*Constants , Strings, Expressions and Data types*	*Constructors and its types*	*Introduction to STL: Iterators*	*Handling Strings*	*Potential problems with constructors and classes*
S-5	SLO-1	*Library Functions*	*Destructors*	*Potential problems with STL: Containers, Algorithms*	*Declaring objects*	*Packages*
	SLO-2	*Loops and Decisions*	*Passing arguments to Functions*	*Potential problems with STL: Iterators*	*Assigning object reference variable*	*Interfaces*
S-6	SLO-1	*Structures*	*Passing Objects as Function arguments*	*Encapsulation*	*Methods & Method Signatures*	*Potential programs with packages*
	SLO-2	*Functions : Simple Functions*	*Returning values from Functions*	*Implementation of Encapsulation*	*Method retuning Values, Method with parameters*	*Potential programs with interfaces*
S-7	SLO-1	*Passing arguments, Returning values*	*Returning Objects from Functions*	*Polymorphism*	*Variable arguments in Java*	*Event handling*
	SLO-2	*Reference Arguments*	*Operator Overloading*	*Operator and method overloading*	*I/O Basics: Byte stream& Character Stream*	*Errors and Exception handling*

S-8	SLO-1	*Recursion, Inline Functions*	*Inheritance: Basics*	*Event handling*	*Getting user input: Reading console input & Writing console output,*	*Introduction to Threads*
	SLO-2	*Default Arguments*	*Inheritance: Method overriding from operator overriding*	*Errors and Exception handling*	*Reading and Writing files-new file system*	*Multithreaded programming*
S-9	SLO-1	*Storage Classes*	*Potential programming using functions, constructors and destructors*	*Potential programs using encapsulation, polymorphism*	*Constructors: Default Constructor,*	*Potential programs using threads*
	SLO-2	*Arrays – Strings*	*Potential programming using overloading and inheritance*	*Potential programs using exception handling*	*Parameterized constructor*	*Potential programs using multithreads*

Learning Resources	1. *D Deitel, C++ How to Program, 6th edition, PHI publication, 2008.* 2. *R. Subburaj, Object Oriented Programming With C++ , Vikas Publishing House, New Delhi, Revised Edition, 2013* 3. *Bjarne Stroustrup ,The C++ Programming Language, 4th Edition, Addison Wesley, 2015*	4. *Herbert Schildt, The Complete Reference (Fully updated for jdk7), Oracle press Ninth Edition,2014.* 5. *Deitel & Deitel, Java How to Program, Prentice Hall, 10th Edition, 2016.* 6. *Herbert Schildt ,Java: A Beginner's Guide, Sixth Edition, Oracle Press, 2014.* 7. *https://docs.oracle.com/javase/tutorial*

Learning Assessment

	Bloom's Level of Thinking	Continuous Learning Assessment (50% weightage)								Final Examination (50% weightage)	
		CLA – 1 (10%)		CLA – 2 (15%)		CLA – 3 (15%)		CLA – 4 (10%)#			
		Theory	Practice	Theory	Practice	Theory	Practice	Theory	Practice	Theory	Practice
Level 1	Remember Understand	40 %	-	30 %	-	30 %	-	30 %	-	30%	-
Level 2	Apply Analyze	40 %	-	40 %	-	40 %	-	40 %	-	40%	-
Level 3	Evaluate Create	20 %	-	30 %	-	30 %	-	30 %	-	30%	-
	Total	100 %		100 %		100 %		100 %		100 %	

CLA – 4 can be from any combination of these: Assignments, Seminars, Tech Talks, Mini-Projects, Case-Studies, Self-Study, MOOCs, Certifications, Conf. Paper etc.,

Course Designers		
Experts from Industry	Experts from Higher Technical Institutions	Internal Experts
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2.Mr.Ravikumar A R, PayPal,ravikumar.venkataramani@gmail.com	*2.Dr.N.Sripriya, SSN College of Engineering, sripriyan@ssn.edu.in*	*2.Dr. G. Niranjana, SRMIST*

Course Code	18EEE422T	Course Name	MODERN OPTIMIZATION TECHNIQUE	Course Category	E	Professional Elective	L	T	P	C
							3	0	0	3

Pre-requisite Courses	Nil	Co-requisite Courses	Nil	Progressive Courses	Nil
Course Offering Department	Electrical & Electronics Engineering	Data Book / Codes/Standards	Nil		

Course Learning Rationale (CLR):	*The purpose of learning this course is to:*
CLR-1 :	*Introduce and classify different conventional optimization techniques.*
CLR-2 :	*Understand the fundamentals of genetic algorithm and to apply appropriate algorithm for Engineering optimization problems*
CLR-3 :	*Outline the concept of particle swarm optimization and its hybrid approach to Engineering applications*
CLR-4 :	*Interpret other modern optimization algorithms for engineering applications*
CLR-5 :	*Extend optimization techniques to multi objective optimization*
CLR-6 :	*Introduce the concept of optimization design for Engineering problems*

Course Learning Outcomes (CLO):	*At the end of this course, learners will be able to:*	Learning 1: Level of Thinking (Bloom)	Learning 2: Expected Proficiency (%)	Learning 3: Expected Attainment (%)	1: Engineering Knowledge	2: Problem Analysis	3: Design & Development	4: Analysis, Design, Research	5: Modern Tool Usage	6: Society & Culture	7: Environment & Sustainability	8: Ethics	9: Individual & Team Work	10: Communication	11: Project Mgt. & Finance	12: Life Long Learning	13: PSO - 1	14: PSO - 2	15: PSO - 3
CLO-1 :	*Categorize optimization problems and its techniques based on constraints and variables*	*1*	*75*	*75*	*H*	-	-	-	-	-	-	-	-	-	-	-	-	-	-
CLO-2 :	*Apply Genetic algorithm for various Engineering application*	*2*	*75*	*75*	*H*	*H*	*M*	*M*	-	-	-	-	-	-	-	-	*H*	*H*	-
CLO-3 :	*Utilize Particle swarm optimization to Engineering applications*	*3*	*75*	*75*	*H*	*M*	*M*	*M*	-	-	-	-	-	-	-	-	*H*	*H*	-
CLO-4 :	*Gain knowledge about other modern optimization algorithms*	*3*	*75*	*75*	*H*	*H*	*H*	*H*	-	-	-	-	-	-	-	-	*H*	*H*	-
CLO-5 :	*Formulate multi objective optimization algorithm for various applications*	*3*	*75*	*75*	*H*	*H*	*H*	*H*	-	-	-	-	-	-	-	-	*H*	*H*	-
CLO-6 :	*Apply optimization techniques in modelling Engineering problems*	*3*	*75*	*75*	*H*	*H*	*H*	*H*	-	-	-	-	-	-	-	-	*H*	*H*	-

Program Learning Outcomes (PLO)

Duration (hour)		9	9	9	9	9
S-1	SLO-1	*Introduction to optimization*	*Introduction – Genetic Algorithm*	*Particle Swarm Optimization*	*Bacterial foraging-Chemotaxis, Swarming*	*Multiobjective optimization*
	SLO-2	*Classification of optimization problem*	*Encoding – Methods for GA*	*Fundamental principle*	*Operation of Bacterial foraging*	*General form of MOOP*
S-2	SLO-1	*Single variable optimization – optimalityconditions*	*Fitness function*	*Velocity updating in PSO*	*Bees colony algorithm-Behavior of Honey bee swarm*	*Pareto optimality*
	SLO-2	*Single variable (unconstrained optimization) – Exhaustive search method*	*Maximization & Minimization*	*Algorithm for PSO*	*Algorithm for Bee colony optimization*	*Dominance test*
S-3	SLO-1	*Successive quadratic estimation method*	*Genetic operators – Crossover*	*PSO – Parameter Selection*	*Differential evolution-Initialization, Mutation*	*Classical Methods – Weighted sum method, ε-constraint method*
	SLO-2	*Newton method*	*Single point crossover, Two-point crossover*	*Pseudocode*	*Recombination, Selection*	*Weighted metric methods, Benson method.*
S-4	SLO-1	*Multi variable optimization – optimality conditions*	*Uniform Crossover, Arithmetic Crossover*	*Implementation & Convergence issues in PSO*	*Ant colony optimization-Introduction*	*Multi objectiveGA*
	SLO-2	*Multi variable optimization (unconstrained) – Simplex search method*	*Mutation*	*Advanced operators of PSO*	*Algorithm for Ant colony optimization*	*Fitnessassignment*
S-5	SLO-1	*Cauchy's method*	*Parent SelectionMethods*	*Meta-Optimization-Behavioral parameters*	*Simulated Annealing optimization-Components and control parameters*	*Sharing function*
	SLO-2	*Steepest Descent Method*	*Rank selection, Roulette wheel selection, Stochastic universal selection, Tournament selection*	*Algorithm for Meta Optimization*	*Algorithm for Simulated Annealing*	*Convergence criterion*

S-6	SLO-1	*Multivariable optimization (Constrained) Kuhn – Tucker Conditions*	*Issues in GA implementation*	*Application of PSO*	*Firefly optimization-Working Principle*	*NSGA-II-Fitness assignment*
	SLO-2	*Transformation Method –Method of Multipliers*	*Applications of GA –Filter design*	*Harmonics Elimination*	*Algorithm for Firefly optimization*	*Sharing Function*
S-7	SLO-1	*Linearized search Technique*	*Automatic Load Frequency Control (ALFC)*	*Applications of PSO*	*Flower Pollination optimization-Introduction*	*Dynamic neighborhood PSO-Introduction*
	SLO-2	*Frank Wolfe method*	*Automatic Voltage Regulation (AVR)*	*Maximum Power Point Tracking*	*Algorithm for Flower pollination*	*Algorithm for Dynamic neighborhood PSO*
S-8	SLO-1	*Non-Linearized Search Technique*	*Evolutionary Algorithm*	*Application of PSO*	*Grey Wolfe optimization-Introduction*	*Vector evaluated PSO*
	SLO-2	*Reduced gradient method*	*Evolutionary Programming*	*Reactive power control using PSO*	*Algorithm for Grey Wolfe optimization*	*Applications – Economic load Dispatch*
S-9	SLO-1	*Quadraticprogramming-Objective Function*	*Evolutionary Strategy-Non-Recombinative strategy*	*HybridAlgorithm of GA and PSO*	*Comparison of various algorithms*	*Unit Commitment,*
	SLO-2	*Algorithm*	*Recombinative strategy*	*GAandPSO operators*	*Benchmark functions*	*Robot Path Planning*

Learning Resources	1. *SingiresuRaoS, EngineeringOptimization–TheoryandPracticebyJohn Wiley & Sons, Inc., New Jersey, 2009.* 2. *Kalyanmoy Deb, Muti-objective Optimization using Evolutionary Algorithms, WileyIndia Private Limited, 2010* 3. *Kalyanmoy Deb, Optimization of Engineering Design, Prentice Hall of India, second Edition, 2012.*	4. *Jizhong Zhou, Optimization of Power System Operation, IEEE Press, Second Edition, 2015.* 5. *Xin - She Yang, Nature Inspired Optimization algorithms, Elsevier, 2014.* 6. *Chee Peng Lim, Lakhmi C. Jain, Satchidananda Dehuri, Innovations in Swarm Intelligence, Springer, Berlin, Heidelberg, 2009.* 7. *https://engineering.purdue.edu/~sudhoff/ee630/Lecture09.pdf*

Learning Assessment

	Bloom's Level of Thinking	Continuous Learning Assessment (50% weightage)								Final Examination (50% weightage)	
		CLA – 1 (10%)		CLA – 2 (15%)		CLA – 3 (15%)		CLA – 4 (10%)			
		Theory	Practice	Theory	Practice	Theory	Practice	Theory	Practice	Theory	Practice
Level 1	Remember Understand	40%	-	30%	-	30%	-	30%	-	30%	-
Level 2	Apply Analyze	40%	-	40%	-	40%	-	40%	-	40%	-
Level 3	Evaluate Create	20%	-	30%	-	30%	-	30%	-	30%	-
	Total	100 %		100 %		100 %		100 %		100 %	

CLA – 4 can be from any combination of these: Assignments, Seminars, Tech Talks, Mini-Projects, Case-Studies, Self-Study, MOOCs, Certifications, Conf. Paper etc.,

Course Designers		
Experts from Industry	Experts from Higher Technical Institutions	Internal Experts
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Course Code	18EEE423T	Course Name	NEURO FUZZY AND GENETICS PROGRAMMING	Course Category	E	Professional Elective	L	T	P	C
							3	0	0	3

Pre-requisite Courses	Nil	Co-requisite Courses	Nil	Progressive Courses	Nil
Course Offering Department	Electrical and Electronics Engineering	Data Book / Codes/Standards	Nil		

Course Learning Rationale (CLR):	The purpose of learning this course is to:
CLR-1 :	*Acquire knowledge on neural network.*
CLR-2 :	*Understand the neural network algorithms for pattern classification and regression problems*
CLR-3 :	*Introduce the basics of fuzzy logic and its reasoning.*
CLR-4 :	*Study the architecture of Fuzzy logic controller and neuro-fuzzy based systems.*
CLR-5 :	*Develop the knowledge on genetic algorithm for optimization problems*
CLR-6 :	*Demonstrate the application of neural network, fuzzy logic and Genetic algorithm in real world*

Course Learning Outcomes (CLO):	At the end of this course, learners will be able to:	Learning 1: Level of Thinking (Bloom)	Learning 2: Expected Proficiency (%)	Learning 3: Expected Attainment (%)
CLO-1 :	*Illustrate the working of various learning algorithms of Neural network.*	3	75	75
CLO-2 :	*Develop and analyze neural networks for pattern classification and pattern association.*	3	75	75
CLO-3 :	*Apply fuzzy logic and reasoning to handle uncertainty and solve engineering problems*	3	75	75
CLO-4 :	*Develop the process of approximate reasoning using Fuzzy logic controller and Neuro-Fuzzy Modeling.*	3	75	75
CLO-5 :	*Formulate a mathematical background to carry out optimization using genetic algorithm.*	3	75	75
CLO-6 :	*Design and perform experiments on real life problems using Neural network, Fuzzy logic and Genetic algorithm*	3	75	75

Program Learning Outcomes (PLO)

	1 Engineering Knowledge	2 Problem Analysis	3 Design & Development	4 Analysis, Design, Research	5 Modern Tool Usage	6 Society & Culture	7 Environment & Sustainability	8 Ethics	9 Individual & Team Work	10 Communication	11 Project Mgt. & Finance	12 Life Long Learning	13 PSO - 1	14 PSO - 2	15 PSO - 3
CLO-1	H	H	M	-	-	-	-	-	-	-	-	-	M	M	-
CLO-2	H	H	M	L	H	-	-	-	-	-	-	-	M	M	-
CLO-3	H	H	M	-	-	-	-	-	-	-	-	-	M	M	-
CLO-4	H	H	M	L	H	-	-	-	-	-	-	-	M	M	-
CLO-5	H	H	M	L	H	-	-	-	L	L	-	-	M	M	-
CLO-6	H	H	M	L	H	-	-	-	L	L	-	-	M	M	-

Duration (hour)		9	9	9	9	9
S-1	SLO-1	*Biological Neurons and Their Artificial Models*	*Pattern Association-Hebb rule*	*Introduction to Fuzzy Logic, Uncertainty based Information*	*Introduction to Fuzzy Reasoning*	*Difference between Traditional optimization Algorithms and genetic algorithm*
	SLO-2	*Models of Artificial Neural Networks, Architectures*	*Delta Rule for pattern association*	*Chances / randomness versus Fuzziness*	*Fuzzy rule generation. Aggregation Operations*	*The basic operation of genetic algorithm*
S-2	SLO-1	*Setting Weights, Activation functions, Learning Processes*	*Hetero associative memories - Architecture-Algorithm*	*Classical/crisp set*	*Fuzzy Logic controller- Basic block*	*Pseudo code of GA*
	SLO-2	*Learning Paradigms-Supervised, Unsupervised and reinforcement Learning*	*Example Problem-Application*	*Properties and operations of classical set*	*Knowledge Base-Rule base-Inference system-Importance*	*Schema theorem*
S-3	SLO-1	*McCulloch-Pitt Neuron*	*Auto associative memories -Architecture-Algorithm*	*Fuzzy set- Representation of fuzzy sets*	*Fuzzification*	*Encoding operation*
	SLO-2	*Linear Separability*	*Example Problem-Application-Storage Capacity*	*Properties and Operations of Fuzzy Sets*	*Assignment of membership functions*	*Binary, Octal, Hexadecimal , Permutation and Tree encoding*
S-4	SLO-1	*ANN training Algorithms-Training rules*	*Iterative Associative Net- Discrete Hopfield Network -Energy Function*	*Measure of Fuzziness and Inaccuracy of fuzzy set*	*Defuzzification Methods-Weighted Average method*	*Importance of Selection and Reproduction operators of GA*
	SLO-2	*Hebb rule-Algorithm -Application*	*Continuous Hopfield Network-Energy Function*	*Cartesian Product- Fuzzy Relations-Composition of fuzzy Relations*	*Centroid method, Center of sums, Mean max method*	*Selection operators of GA-Roulette Wheel, Tournament selection, Boltzmann selection and Rank Selection*
S-5	SLO-1	*Perceptrons-Algorithm*	*Bidirectional associative memories-Architecture (BAM)*	*Fuzzy Max-Min Composition*	*Introduction to Architecture of Mamdani Type Fuzzy Control Systems*	*Crossover operators of GA-Single point*
	SLO-2	*Application of Perceptron algorithm*	*BAM Algorithm-Analysis*	*Fuzzy Max-Product Composition*	*Fuzzy Reasoning approach*	*Two point-multiple point-Uniform crossovers*

S-6	SLO-1	*Delta Rule*	*Competitive Learning Networks-Basics*	*Types of fuzzy sets-Terms of fuzzy sets*	*Takagi and Sugeno's approach*	*Mutation operators of GA*
	SLO-2	*Derivations--Adaline Algorithm*	*Kohonen Self organizing Maps-Algorithm*	*Types of Membership Function distributions*	*Introduction to Fuzzy Clustering*	*Sample Problem to demonstrate the working of GA*
S-7	SLO-1	*Back Propagation Algorithm-Derivation*	*Learning Vector Quantization (LVQ)*	*Classical Logic, Multivalued Logics*	*Fuzzy Knowledge Based Systems for real world applications.*	*GA convergence analysis*
	SLO-2	*Sample problem for BPN*	*LVQ-Architecture-Algorithm*	*Fuzzy Propositions*	*Design of controllers using Simulation Software*	*Application of Genetic Algorithm.*
S-8	SLO-1	*Radial Basis Function Networks-Basics*	*Basic architecture of Adaptive Resonance Theory (ART)*	*Fuzzy Qualifiers*	*Hybrid Model implementing Fuuzy and Neuro*	*Hybrid Algorithms using GA*
	SLO-2	*Algorithm of RBF*	*Basic Operation of ART*	*Linguistic Variables, Linguistic Hedges*	*Adaptive Neuro-Fuzzy Inference Systems*	*Basics of GA-Fuzzy Logic, GA-Neural Network*
S-9	SLO-1	*Multilayer Perceptron Model*	*Applications of Artificial Neural Networks .*	*Introduction to basic Fuzzy Arithmetic*	*Architecture of adaptive neuro fuzzy Hybrid Learning Algorithm*	*GA-Fuzzy-Neural Network*
	SLO-2	*Madaline*	*Design of controllers using Simulation Software*	*Extension Principle.*	*Learning Methods that Cross-fertilize ANFIS and RBFN*	*Case study on real time application using Neuro/Fuzzy/Genetics*

Learning Resources	1. *Laurene Fausett.,Fundamentals of Neural Networks-Architecture, Algorithms and Application, Prentice Hall International, First edition,1994.* 2. *Timothy J.Ross, Fuzzy Logic with Engineering Applications, John Wiley and sons Ltd. publication, Fourth edition,2016.* 3. *Kalyanmoy Deb, Optimization for Engineering Design: Algorithms and Examples, Prentice Hall of India, second edition, 2012.* 4. *David E. Goldberg, Genetic Algorithms in search, optimization and machine learning, Pearson Education Inc, First edition, 1989.*	5. *Anderson, James A., An Introduction to Neural Networks, Prentice Hall of India, ISBN: 978-81-203-13514,, 2008.* 6. *Zimmerman H.J, Fuzzy set Theory-and its applications, Kluwer Academic Publishers, second edition,1991.* 7. *Hertz J. Krogh, R.G. Palmer ,Introduction to the Theory of Neural Computation, Addison- Wesley, ISBN 9780201515602,1991.* 8. *G.J. Klir& B. Yuan,Fuzzy Sets & Fuzzy Logic, Prentice Hall of India, 2006,ISBN: 978-81-203-1136-7* 9. *http://www.myreaders.info/html/soft_computing.html*

Learning Assessment

	Bloom's Level of Thinking	Continuous Learning Assessment (50% weightage)								Final Examination (50% weightage)	
		CLA – 1 (10%)		CLA – 2 (15%)		CLA – 3 (15%)		CLA – 4 (10%)#			
		Theory	Practice	Theory	Practice	Theory	Practice	Theory	Practice	Theory	Practice
Level 1	Remember Understand	40 %	-	30 %	-	30 %	-	30 %	-	30%	-
Level 2	Apply Analyze	40 %	-	40 %	-	40 %	-	40 %	-	40%	-
Level 3	Evaluate Create	20 %	-	30 %	-	30 %	-	30 %	-	30%	-
	Total	100 %		100 %		100 %		100 %		100 %	

CLA – 4 can be from any combination of these: Assignments, Seminars, Tech Talks, Mini-Projects, Case-Studies, Self-Study, MOOCs, Certifications, Conf. Paper etc.,

Course Designers

Experts from Industry	Experts from Higher Technical Institutions	Internal Experts
1. Mr.Roosefart Mohan, Nelcast Limited, Chennai,roosefart@gmail.com	*1. Dr. R.Subha, Associate Prof. ,Sir MVIT, subha.mvit@gmail.com*	*1. Dr. D.Suchitra,, SRMIST*
2.Mr.Muralikrishna, National Instruments, emkkrishnan@gmail.com	*2. Dr. C.Nayanatara, Shri Sairam Engineering College, nayanatara.eee@sairam.edu.in*	*2. Dr.J.Preetha Roselyn, SRMIST*

Course Code	18EEE424T	Course Name	ARTIFICIAL INTELLIGENCE	Course Category	E	Professional Elective	L	T	P	C
							3	0	0	3

Pre-requisite Courses	Nil	Co-requisite Courses	Nil	Progressive Courses	Nil
Course Offering Department	Electrical and Electronics Engineering	Data Book / Codes/Standards	Nil		

Course Learning Rationale (CLR):	*The purpose of learning this course is to:*
CLR-1 :	*Impact the knowledge on AI and its different Heuristic solution strategies*
CLR-2 :	*Provide adequate knowledge on the technology of knowledge-based agents and Game Playing*
CLR-3 :	*Describe the different planning approaches*
CLR-4 :	*Discuss the different learning algorithms*
CLR-5 :	*Understand the basics of machine learning algorithm*
CLR-6 :	*Create an overall knowledge of different artificial intelligence approaches*

Course Learning Outcomes (CLO):	*At the end of this course, learners will be able to:*	Learning 1	Learning 2	Learning 3	Program Learning Outcomes (PLO) 1	2	3	4	5	6	7	8	9	10	11	12	13	14	15
		Level of Thinking (Bloom)	Expected Proficiency (%)	Expected Attainment (%)	Engineering Knowledge	Problem Analysis	Design & Development	Analysis, Design, Research	Modern Tool Usage	Society & Culture	Environment & Sustainability	Ethics	Individual & Team Work	Communication	Project Mgt. & Finance	Life Long Learning	PSO - 1	PSO - 2	PSO - 3
CLO-1 :	*Illustrate the concept of AI and different Heuristic methodologies*	*2*	*80*	*75*	*H*	*H*	-	-	-	-	-	-	-	-	-	-	*H*	*M*	-
CLO-2 :	*Recall different technologies in knowledge-based agents and Game Playing*	*2*	*80*	*75*	*H*	*H*	-	-	-	-	-	-	-	-	-	-	*M*	*M*	-
CLO-3 :	*Analyze the different planning approaches*	*2*	*80*	*75*	*H*	*H*	-	-	-	-	-	-	-	-	-	-	*H*	*M*	-
CLO-4 :	*Apply the different learning algorithms for real time systems*	*2*	*80*	*75*	*H*	*M*	-	-	-	-	-	-	-	-	-	-	*H*	*H*	-
CLO-5 :	*Implement the machine learning algorithm for clustering and regression*	*2*	*80*	*75*	*H*	*H*	-	-	-	-	-	-	-	-	-	-	*H*	*M*	-
CLO-6 :	*Utilize a perfect artificial intelligence approach for different applications*	*2*	*80*	*75*	*H*	*H*	-	-	-	-	-	-	-	-	-	-	*H*	*M*	-

Duration (hour)		9	9	9	9	9
S-1	SLO-1	*Introduction to Artificial Intelligence (AI)*	*Games as Search Problems*	*The Planning Problem*	*Representing Knowledge in an Uncertain Domain*	*Types of Machine Learning: Supervised Learning Reinforcement*
	SLO-2	*The Foundations of AI*	*Optimal Decisions in Games*	*Planning with State-Space Search*	*The Semantics of Bayesian Networks*	*Unsupervised Learning Reinforcement*
S-2	SLO-1	*The History of AI*	*Alpha-Beta Pruning*	*Partial-Order Planning, Planning Graphs*	*Efficient Representation of Conditional Distributions*	*Over fitting and linear regression*
	SLO-2	*The State of the Art*	*Imperfect Decisions, State-of-the-Art Game Programs*	*Planning with Propositional Logic*	*Exact Inference in Bayesian Networks*	*Learning Curve*
S-3	SLO-1	*Structure of Intelligent Agents*	*Knowledge-Based Agents*	*Analysis of Planning Approaches*	*Approximate Inference in Bayesian Networks*	*Parametric vs. non-parametric models*
	SLO-2	*Problem-Solving Agents*	*The Wumpus World*	*Hierarchical Task Network Planning*	*Relational and First-Order Probability Models*	*Linear models*
S-4	SLO-1	*Formulating Problems*	*Logic, Propositional Logic*	*Planning and Acting in Nondeterministic Domains*	*Forms of Learning*	*Bayesian hierarchical clustering*
	SLO-2	*Searching for Solutions*	*Reasoning Patterns in Propositional Logic*	*Conditional Planning*	*Supervised Learning*	*Clustering datapoints and features*
S-5	SLO-1	*Uninformed Search Strategies*	*Effective propositional inference*	*Execution Monitoring and Re-planning*	*Learning Decision Trees*	*K-Means clustering*
	SLO-2	*Informed (Heuristic) Search Strategies*	*Agents Based on Propositional Logic*	*Continuous Planning*	*Ensemble Learning*	*K-Medoids clustering*
S-6	SLO-1	*Heuristic Functions*	*Syntax and Semantics of First-Order Logic*	*Multi-Agent Planning*	*A Logical Formulation of Learning*	*Neural network Representation*
	SLO-2	*Local Search Algorithms*	*Unification and Lifting*	*Acting under Uncertainty*	*Knowledge in Learning*	*Perceptrons, Feed forward networks*
S-7	SLO-1	*Optimization Problems*	*Forward Chaining*	*Basic Probability Notation*	*Explanation-Based Learning*	*Back Propagation Algorithms*
	SLO-2	*Local Search in Continuous Spaces*	*Backward Chaining*	*The Axioms of Probability*	*Learning Using Relevance Information*	*Recurrent networks*
S-8	SLO-1	*Online Search Agents*	*Resolution, Ontological Engineering*	*Inference Using Full Joint Distributions*	*Inductive Logic Programming*	*Linear Regression*
	SLO-2	*Constraint Satisfaction Problems*	*Categories and Objects*	*Independence*	*Statistical Learning*	*Logistic Regression*
S-9	SLO-1	*Backtracking Search for CSPs*	*Mental Events and Mental Objects*	*Bayes' Rule and Its Use*	*Learning with Complete Data*	*Maximum Likelihood estimation (least squares)*

	SLO-2	*Local Search for Constraint*	*The Internet Shopping World*	*The Wumpus World Revisited*	*Learning with Hidden Variables: The EM Algorithm*	*Online learning and stochastic optimization*

Learning Resources	1. *Stuart Russell and Peter Norvig, Artificial Intelligence – A Modern Approach, Pearson Education Press, 2010.* 2. *Kevin Knight, Elaine Rich, B. Nair, Artificial Intelligence, McGraw Hill, 2008.* 3. *George F. Luger, Artificial Intelligence, Pearson Education, 2001.*	4. *Kevin P. Murphy, Machine Learning: A Probabilistic Perspective, MIT Press, 2012.* 5. *Stephen Marsland, Machine Learning –An Algorithmic Perspective, CRC Press, 2009.* 6. *https://www.youtube.com/playlist?list=PL6EE0CD02910E57B8.*

Learning Assessment

	Bloom's Level of Thinking	Continuous Learning Assessment (50% weightage)								Final Examination (50% weightage)	
		CLA – 1 (10%)		CLA – 2 (15%)		CLA – 3 (15%)		CLA – 4 (10%)#			
		Theory	Practice	Theory	Practice	Theory	Practice	Theory	Practice	Theory	Practice
Level 1	Remember Understand	40 %	-	30 %	-	30 %	-	30 %	-	30%	-
Level 2	Apply Analyze	40 %	-	40 %	-	40 %	-	40 %	-	40%	-
Level 3	Evaluate Create	20 %	-	30 %	-	30 %	-	30 %	-	30%	-
	Total	100 %		100 %		100 %		100 %		100 %	

CLA – 4 can be from any combination of these: Assignments, Seminars, Tech Talks, Mini-Projects, Case-Studies, Self-Study, MOOCs, Certifications, Conf. Paper etc.,

Course Designers

Experts from Industry	Experts from Higher Technical Institutions	Internal Experts
1.Mr. Tripathi patro,visam pvt ltd,btp@visom.co.in	*1.Dr.P.Ganesh Kumar, Anna University, ganesh23508@gmail.com*	*1.Dr.J.Preetha Roselin, SRMIST*
2.Mr.Balachandrasekar.K,CTS,dyaksha@gmail.com	*2.Dr. C.Nayanatara, Shri Sairam Engineering College, nayanatara.eee@sairam.edu.in*	*2.Mr.P.Kanakaraj, SRMIST*

Course Code	18EEE425T	Course Name	FUNDAMENTALS OF BIG DATA ANALYTICS	Course Category	E	Professional Elective	L	T	P	C
							3	0	0	3

Pre-requisite Courses	Nil	Co-requisite Courses	Nil	Progressive Courses	Nil
Course Offering Department	Electrical and Electronics Engineering	Data Book / Codes/Standards	Nil		

Course Learning Rationale (CLR):	*The purpose of learning this course is to:*
CLR-1 :	*Introduce big data and its role in various domains*
CLR-2 :	*Learn and analyze the big data analytical tools*
CLR-3 :	*Introduce Hadoop and its components*
CLR-4 :	*Implement Map Reduce technique*
CLR-5 :	*Study the security concerns of big-data*
CLR-6 :	*Create an overall knowledge in big data with different environment*

Course Learning Outcomes (CLO):	*At the end of this course, learners will be able to:*	Learning 1 Level of Thinking (Bloom)	2 Expected Proficiency (%)	3 Expected Attainment (%)	PLO 1 Engineering Knowledge	2 Problem Analysis	3 Design & Development	4 Analysis, Design, Research	5 Modern Tool Usage	6 Society & Culture	7 Environment & Sustainability	8 Ethics	9 Individual & Team Work	10 Communication	11 Project Mgt. & Finance	12 Life Long Learning	13 PSO - 1	14 PSO - 2	15 PSO - 3
CLO-1 :	*Familiarize with applications of Big Data Analytics in various domains*	1	80	75	H	-	-	-	-	-	-	M	-	-	-	-	H	M	M
CLO-2 :	*Practice open source big data analytical tools*	2	80	75	H	H	H	H	H	-	-	M	-	-	-	-	M	M	M
CLO-3 :	*Install and operate the open source Distributed File System Hadoop*	2	80	75	H	H	M	M	H	-	-	-	-	-	-	-	H	M	-
CLO-4 :	*Solve simple problems using Map Reduce Technique*	2	80	75	H	H	M	M	H	-	-	-	-	-	-	-	H	H	-
CLO-5 :	*Analyze the log file in security aspects*	2	80	75	H	H	M	M	-	-	-	H	-	-	-	-	H	M	H
CLO-6 :	*Design a big data platform for different applications*	2	80	75	H	H	M	M	M	-	-	M	-	-	-	-	H	M	M

Duration (hour)		9	9	9	9	9
S-1	SLO-1	*Introduction to Big Data Platform*	*Data Analytics Lifecycle*	*History of Hadoop*	*Developing a Map Reduce Application*	*Introduction to Security Analytics*
	SLO-2	*Challenges of Conventional Systems*	*Overview of Data Analytics Lifecycle*	*Hadoop Distributed File System*	*How MapReduce Works*	*Challenges in Security Analytics*
S-2	SLO-1	*Intelligent data analysis*	*Successful Analytics Project*	*Components of Hadoop*	*Unit Tests*	*Concepts in Data Analytics*
	SLO-2	*Nature of Data*	*Key Roles for a Successful Analytics Project*	*Analyzing the Data with Hadoop*	*Unit Tests with MapReduce Unit*	*Techniques in Data Analytics*
S-3	SLO-1	*Analytic Processes and Tools*	*Background of Data Analytics Lifecycle*	*Scaling Out, Hadoop Streaming*	*Test Data*	*Data for Security Analysis*
	SLO-2	*Industry Examples of Big Data*	*Global Innovation Network and Analysis*	*Design of HDFS*	*Local Tests*	*Analysis in Everyday Life*
S-4	SLO-1	*Web Analytics*	*Case Study: Global Innovation Network and Analysis*	*Java Interfaces to HDFS Basics*	*Anatomy of a Map Reduce Job Run*	*Scenarios in Intrusion*
	SLO-2	*Big Data and Marketing*	*Introduction to R*	*Data Flow, Hadoop I/O*	*Classic MapReduce*	*Challenges in Intrusion*
S-5	SLO-1	*Fraud and Big Data*	*Introduction to SQL*	*Data Integrity*	*YARN*	*Incident Identification*
	SLO-2	*Risk and Big Data*	*Charts*	*Compression, Serialization*	*Failures in Classic MapReduce*	*Analysis of Log File*
S-6	SLO-1	*Credit Risk Management*	*Graphs*	*Avro, File Based Data Structures*	*Failures in YARN*	*Loading the Data*
	SLO-2	*Big Data and Algorithmic Trading*	*Data tools*	*Pig, Hive*	*Job Scheduling*	*Simulation*
S-7	SLO-1	*Big Data and Healthcare*	*Statistical Methods*	*Hbase*	*Shuffle and Sort*	*Security Process*
	SLO-2	*Big Data in Medicine*	*Clustering*	*Data Model and Implementations*	*Task Execution*	*Access Analytics*
S-8	SLO-1	*Advertising and Big Data*	*Association Rules Regression*	*Hbase Clients, Hbase Examples*	*MapReduce Types*	*Security Analysis*
	SLO-2	*Different advertising in Big Data*	*Classification*	*Praxis, Cassandra*	*MapReduce Formats*	*Security Analysis with Text Mining Security Intelligence*
S-9	SLO-1	*Big Data Technologies*	*Time Series Analysis*	*Cassandra Data Model*	*MapReduce Features*	*Security Breaches*
	SLO-2	*Classification of different technologies in Big Data*	*Text Analysis*	*Cassandra Clients, Cassandra Examples*	*Hadoop environment*	*Security Breaches Examples*

Learning Resources		
Learning Resources	1. *David Dietrich, Barry Heller and Beibei Yang, Data Science and Big Data Analytics: Discovering, Analyzing, Visualizing and Presenting Data, Reprint 2015, EMC Education Services, Wiley, ISBN:9788126556533.* 2. *Tom White, Hadoop: The Definitive Guide, Third Edition, O'reilly Media, 2012.*	3. *https://www.tutorialspoint.com/big_data_analytics/index.htm* 4. *https://www.youtube.com/playlist?list=PLFW6lRTa1g813IyYHLRP_bWJEKQDeEcSP* 5. *Mark Allen Weiss, Data Structures and Algorithm Analysis in C++, Third Edition, 2009*

Learning Assessment

	Bloom's Level of Thinking	Continuous Learning Assessment (50% weightage)								Final Examination (50% weightage)	
		CLA – 1 (10%)		CLA – 2 (15%)		CLA – 3 (15%)		CLA – 4 (10%)#			
		Theory	Practice	Theory	Practice	Theory	Practice	Theory	Practice	Theory	Practice
Level 1	Remember Understand	40 %	-	30 %	-	30 %	-	30 %	-	30%	-
Level 2	Apply Analyze	40 %	-	40 %	-	40 %	-	40 %	-	40%	-
Level 3	Evaluate Create	20 %	-	30 %	-	30 %	-	30 %	-	30%	-
	Total	100 %		100 %		100 %		100 %		100 %	

CLA – 4 can be from any combination of these: Assignments, Seminars, Tech Talks, Mini-Projects, Case-Studies, Self-Study, MOOCs, Certifications, Conf. Paper etc.,

Course Designers

Experts from Industry	Experts from Higher Technical Institutions	Internal Experts
1.Mr. Tripathi patro,visam pvt ltd,btp@visom.co.in	*1.Dr.P.Ganesh Kumar, Anna University, ganesh23508@gmail.com*	*1. Dr.E.Poovammal, SRMIST*
2.Mr.Balachandrasekar.K,CTS,dyaksha@gmail.com	*2.Dr. C.Nayanatara, Shri Sairam Engineering College, nayanatara.eee@sairam.edu.in*	*2. Mr.P.Kanakaraj, SRMIST*

Course Code	18EEE426T	Course Name	FUNDAMENTALS OF CLOUD COMPUTING	Course Category	E	Professional Elective	L	T	P	C
							3	0	0	3

Pre-requisite Courses	Nil	Co-requisite Courses	Nil	Progressive Courses	Nil
Course Offering Department	Electrical and Electronics Engineering	Data Book / Codes/Standards	Nil		

Course Learning Rationale (CLR):	*The purpose of learning this course is to:*
CLR-1 :	*Outline cloud computing and its model*
CLR-2 :	*Explain the cloud-enabling technology and its applications*
CLR-3 :	*Educate on different cloud computing architectures*
CLR-4 :	*Understand the cost metrics and cloud management*
CLR-5 :	*Provide adequate knowledge in cloud security*
CLR-6 :	*Create application by utilizing cloud platforms*

Course Learning Outcomes (CLO):	*At the end of this course, learners will be able to:*	Learning 1: Level of Thinking (Bloom)	Learning 2: Expected Proficiency (%)	Learning 3: Expected Attainment (%)	PLO 1: Engineering Knowledge	PLO 2: Problem Analysis	PLO 3: Design & Development	PLO 4: Analysis, Design, Research	PLO 5: Modern Tool Usage	PLO 6: Society & Culture	PLO 7: Environment & Sustainability	PLO 8: Ethics	PLO 9: Individual & Team Work	PLO 10: Communication	PLO 11: Project Mgt. & Finance	PLO 12: Life Long Learning	PLO 13: PSO - 1	PLO 14: PSO - 2	PLO 15: PSO - 3
CLO-1 :	*Recall the basic concepts of cloud computing and its model*	1	80	75	H	-	-	-	-	-	-	-	-	-	-	-	H	M	-
CLO-2 :	*Acquire knowledge on the cloud enabling technologies and its applications*	2	80	75	H	H	M	M	M	-	-	L	-	-	-	-	M	M	L
CLO-3 :	*Illustrate the basic concepts of cloud computing architecture*	1	80	75	H	-	-	-	-	-	-	-	-	-	-	-	H	M	-
CLO-4 :	*Analyze the cost metrics and recall the concepts of cloud management*	2	80	75	H	H	M	M	-	-	-	M	-	-	-	-	H	H	M
CLO-5 :	*Realize the security threats in cloud*	2	80	75	H	H	H	M	-	-	-	M	-	-	-	-	H	M	M
CLO-6 :	*Design a perfect cloud platform for different applications*	2	80	75	H	H	M	M	M	-	-	M	-	-	-	-	H	M	M

Duration (hour)		9	9	9	9	9
S-1	SLO-1	*Cloud*	*Key Drivers to Adopting the Cloud*	*Requirements of Cloud computing architecture*	*Cost Metrics*	*Infrastructure Security*
	SLO-2	*Overview of Cloud*	*Examples of Key Drivers to Adopting the Cloud*	*Introduction to Cloud computing architecture*	*Pricing Models*	*The Network Level Infrastructure Security*
S-2	SLO-1	*Basic Concepts of Cloud*	*The Impact of Cloud Computing*	*Workload Distribution Architecture*	*Business Cost Metrics*	*The Host Level Infrastructure Security*
	SLO-2	*Basic Terminology of Cloud*	*The Impact of Cloud Computing on Users*	*Example*	*Cloud Usage Cost Metrics*	*The Application Level Infrastructure Security*
S-3	SLO-1	*Goals*	*Broadband Networks*	*Resource Pooling Architecture*	*Cost Management*	*Data Security and Storage*
	SLO-2	*Benefits*	*Internet Architecture*	*Example*	*Considerations of Cost Management*	*Aspects of Data Security*
S-4	SLO-1	*Risks*	*Data Center Technology*	*Dynamic Scalability Architecture*	*Service Quality Metrics*	*Data Security Mitigation*
	SLO-2	*Challenges*	*Virtualization Technology*	*Example*	*Different types of Service Quality Metrics*	*Provider Data*
S-5	SLO-1	*Cloud service provider*	*Web Technology*	*Elastic Resource Capacity Architecture*	*SLA*	*Provider Data Security*
	SLO-2	*Cloud service consumer*	*Multitenant Technology*	*Example*	*SLA Guidelines*	*Encryption*
S-6	SLO-1	*Cloud Characteristics*	*Service Technology*	*Service Load Balancing Architecture*	*Identity and Access Management*	*Hashing*
	SLO-2	*Issues in Cloud Computing*	*Different Applications of Cloud Computing*	*Example*	*Trust Boundaries*	*Digital Signature*
S-7	SLO-1	*Cloud Computing*	*Healthcare*	*Cloud Bursting Architecture*	*IAM*	*Public Key Infrastructure (PKI)*
	SLO-2	*Grid Computing*	*Energy systems*	*Example*	*IAM Challenges*	*Example*
S-8	SLO-1	*Comparative study of Cloud Computing and Grid Computing*	*Transportation systems*	*Elastic Disk Provisioning Architecture*	*Relevant IAM Standards for Cloud Services*	*Single Sign On (SSO)*
	SLO-2	*Cloud Service Models*	*Manufacturing industry*	*Example*	*Relevant IAM Protocols for Cloud Services*	*Kerberos authentication - One-time password*
S-9	SLO-1	*IaaS, PaaS and SaaS*	*Education*	*Redundant Storage Architecture*	*IAM Practices in the Cloud*	*Example*
	SLO-2	*Cloud Deployment Models*	*Mobile Communication*	*Example*	*Cloud Authorization Management*	*Cloud Based Security Groups*

Learning Resources	1. *Thomas Erl, Zaigham Mahmood, Richardo Puttini, Cloud Computing: Concepts, Technology & Architecture, Fourth Printing, Prentice Hall/PearsonPTR, 2014, ISBN: 9780133387520.* 2. *Tim Mather, Subra Kumaraswamy, Shahed Latif, Cloud Security and Privacy: An Enterprise Perspective on Risks and Compliance, O'Reilly Media, Inc.", Computers - 338 pages.* 3. *https://www.youtube.com/channel/UCK73enkjfQNDwdBqMyaMtRg/videos* 4. *ArshdeepBahga, Vijay Madisetti, Cloud Computing: A Hands-On Approach, University Press, 2016, ISBN: 9780996025508.* 5. *K.Chandrasekaran, Essentials of Cloud Computing, Chapman and Hall/CRC Press, 2014, ISBN 9781482205435.* 6. *Thomas Erl, Robert Cope, Amin Naserpour, Cloud Computing Design Patterns, Prentice Hall/Service Tech Press, Pearson, 2015, ISBN: 978-0133858563.*

Learning Assessment

	Bloom's Level of Thinking	Continuous Learning Assessment (50% weightage)								Final Examination (50% weightage)	
		CLA – 1 (10%)		CLA – 2 (15%)		CLA – 3 (15%)		CLA – 4 (10%)#			
		Theory	Practice	Theory	Practice	Theory	Practice	Theory	Practice	Theory	Practice
Level 1	Remember Understand	40 %	-	30 %	-	30 %	-	30 %	-	30%	-
Level 2	Apply Analyze	40 %	-	40 %	-	40 %	-	40 %	-	40%	-
Level 3	Evaluate Create	20 %	-	30 %	-	30 %	-	30 %	-	30%	-
	Total	100 %		100 %		100 %		100 %		100 %	

CLA – 4 can be from any combination of these: Assignments, Seminars, Tech Talks, Mini-Projects, Case-Studies, Self-Study, MOOCs, Certifications, Conf. Paper etc.,

Course Designers

Experts from Industry	Experts from Higher Technical Institutions	Internal Experts
1.Mr. Tripathi patro,visam pvt ltd,btp@visom.co.in	*1.Dr.P.Ganesh Kumar, Anna University, ganesh23508@gmail.com*	*1. Mrs.P.Akilandeswari, SRMIST*
2.Mr.Balachandrasekar.K,CTS,dyaksha@gmail.com	*2.Dr. C.Nayanatara, Shri Sairam Engineering College, nayanatara.eee@sairam.edu.in*	*2. Mr.P.Kanakaraj, SRMIST*

ACADEMIC CURRICULA

Professional Elective Courses

ELECTRONICS AND COMMUNICATION ENGINEERING

Regulations - 2018

SRM INSTITUTE OF SCIENCE AND TECHNOLOGY

(Deemed to be University u/s 3 of UGC Act, 1956)

Kattankulathur, Kancheepuram, Tamil Nadu, India

Course Code	18ECE201J	Course Name	PYTHON AND SCIENTIFIC PYTHON	Course Category	E	Professional Elective	L	T	P	C
							2	0	2	3

Pre-requisite Courses	Nil	Co-requisite Courses	Nil	Progressive Courses	Nil
Course Offering Department	Electronics and Communication Engineering	Data Book / Codes/Standards	Nil		

Course Learning Rationale (CLR):	*The purpose of learning this course is to:*
CLR-1 :	*Understanding the python language construct and apply them for scientific computation*
CLR-2 :	*Apply python vector ,list and plot concept to solve curve fitting*
CLR-3 :	*Applying Dictionary concept to model Polynomials*
CLR-4 :	*Create insights to difference equation based system model and solving them with python*
CLR-5 :	*Analyze Monte Carlo Simulation for computing Probabilities*
CLR-6 :	*Create insights to the concepts and programming of SciPy, numpy, matplotlib to solve scientific problem*

Course Learning Outcomes (CLO):	*At the end of this course, learners will be able to:*	Learning 1	Learning 2	Learning 3	PLO 1	PLO 2	PLO 3	PLO 4	PLO 5	PLO 6	PLO 7	PLO 8	PLO 9	PLO 10	PLO 11	PLO 12	PLO 13	PLO 14	PLO 15
		Level of Thinking (Bloom)	Expected Proficiency (%)	Expected Attainment (%)	Engineering Knowledge	Problem Analysis	Design & Development	Analysis, Design, Research	Modern Tool Usage	Society & Culture	Environment & Sustainability	Ethics	Individual & Team Work	Communication	Project Mgt. & Finance	Life Long Learning	PSO - 1	PSO - 2	PSO - 3
CLO-1 :	*Apply python language construct to compute formula and scientific problem*	*2*	*80*	*70*	*H*	*H*	-	-	-	-	-	-	-	-	-	-	-	-	*H*
CLO-2 :	*Analyze Mathematical Models system using f Difference Equations and solving*	*2*	*85*	*75*	*H*	*H*	-	-	-	-	-	-	-	-	-	-	-	-	*H*
CLO-3 :	*Apply time sequence concept for generation and processing of audio signal by python*	*2*	*75*	*70*	*H*	-	-	*H*	-	-	-	-	-	-	-	-	*H*	-	-
CLO-4 :	*Apply python language construct to solve Polynomials*	*2*	*85*	*80*	*H*	*H*	-	-	-	-	-	-	-	-	-	-	-	-	*H*
CLO-5 :	*Apply python language construct to compute probability by Monte Carlo Simulation ,game design and dynamic random motion creation*	*2*	*85*	*75*	*H*	-	*H*	-	-	-	-	-	-	-	-	-	-	-	*H*
CLO-6 :	*Apply SciPy, numpy, matplotlib to statistical analysis , correlation coefficient analysis , Solving equations- Linear least squares solutions and signal processing*	*2*	*80*	*70*	-	-	-	-	-	-	-	-	-	-	-	-	-	-	*H*

Duration (hour)		Solving Simple Formula And Scientific Problem	Plots, Array and Difference Equation Modelling	File I/O, Polynomials and Web Programming	Random Process and Game Programming	SciPy ,Numpy and Signal Processing
		12	12	12	12	12
S-1	SLO-1	*Computing with Formulas- Using a Program as a Calculator*	*Vectors, Mathematical Operations on Vectors, Vector Arithmetics and Vector Function*	*Reading Data from File- Line by Line, Reading a Mixture of Text and Numbers*	*Drawing Random Numbers- Uniformly Distributed Random Numbers*	*SciPy, numpy, matplotlib*
	SLO-2	*Using Variables, Formatting Text and Numbers*	*Arrays in Python Programs-Using Lists for Collecting Function Data*	*Making Dictionaries*	*Computing the Mean and Standard Deviation*	*Basic array methods in numpy, Changing the shape of an array*
S-2	SLO-1	*Celsius-Fahrenheit Conversion,*	*Curve Plotting-The SciTools and Easyviz Packages*	*Dictionary Operations*	*The Gaussian or Normal Distribution-Drawing a Random Element from a List*	*Maximum and minimum values*
	SLO-2	*Evaluating Standard Mathematical Functions, Type Conversion*	*Plotting a Single Curve, Decorating the Plot, Plotting Multiple Curves, Controlling Line Styles*	*Polynomials as Dictionaries, File Data in Dictionaries, File Data in Nested Dictionaries*	*Drawing random interger*	*Reading and writing an array to a fle*
S 3-4	SLO-1 SLO-2	*Lab 1:programming on formula and Standard Mathematical Functions- Evaluate a Gaussian function, Compute the air resistance on a football*	*Lab 4: Curve Plotting*	*Lab 7: reading student marks file into a dictionary data with the student name as key and computing the average grades*	*Lab 10: real card games*	*Lab 13: numpy file reading and data analysis*
S-5	SLO-1	*Complex Numbers, Complex Arithmetic's in Python*	*Numerical Python Arrays manipulations*	*Strings- Common Operations on Strings*	*Computing Probabilities- Principles of Monte Carlo Simulation*	*Statistical methods in numpy*
	SLO-2	*Input Data-Reading Keyboard Input-Reading from the Command Line*	*Higher-Dimensional Arrays- Two-Dimensional Numerical Python Arrays*	*Reading Coordinates*	*Throwing Dice, Rolling Two Dice game*	*Statistical methods in numpy*

S-6	SLO-1	*Making Modules, Collecting Functions in a Module File*	*Matrix Objects*	*Reading Data from Web Pages- About Web Pages*	*Drawing Balls from a Hat*	*Histograms*
	SLO-2	*Using Modules*	*Mathematical Models Based on Difference Equations- Interest Rates*	*Access Web Pages in Programs- Reading Pure Text Files,*	*Simple Games- Guessing a Number*	*Solving equations- Linear least squares solutions- Beer-Lambert Law*
S 7-8	SLO-1	*Lab 2: program on Making Modules and using them*	*Lab 5: Animating a Function-temperature on earth*	*Lab 8:reading web temperature text file into Dictionaries and computing average Temperature*	*Lab 11: Simple Games*	*Lab 14: the correlation coefficient between pressure and temperature*
	SLO-2					
S-9	SLO-1	*while loops and for loops*	*the Factorial as a Difference Equation*	*Extracting Data from an HTML Page*	*Random Walk in One Space Dimension*	*One-Dimensional Fast Fourier Transforms*
	SLO-2	*Lists and list manipulation*	*Growth of a Population, Payback of a Loan, Making a Living from a Fortune*	*Writing a Table to File, Reading and Writing Spreadsheet Files*	*Basic Implementation, visualization and Computing Statistics of the Particle Positions*	*Matplotlib basics- Plotting on a single axes object, scatter plot, Bar charts and pie charts*
S-10	SLO-1	*Loops with List Indices, Nested Lists*	*Logistic Growth, Programming with Sound Writing Sound to File, Reading Sound from File,*	*Representing a Function as a Class and manipulation*	*Random Walk in Two Space Dimensions*	*Choosing the Length of the DFT*
	SLO-2	*Tuples, Functions, Lambda Functions, If Tests*	*Playing Many Notes*	*Bank Accounts as class, A Class for Solving ODEs*	*Basic Implementation, visualization and Computing Statistics of the Particle Positions*	*Filters in Signal Processing*
S 11-12	SLO-1	*Lab 3: Programming on list and loops*	*Lab 6: Sound generated by formula and difference equation*	*Lab 9: Programming on class*	*Lab 12: Random Walk in One Space Dimension or Two Space Dimensions*	*Lab 15: Numpy signal processing*
	SLO-2					

Learning Resources	*1. Hans Petter Langtangen," A Primer on Scientific Programming with Python", Springer, 2000.* *2. Christian Hill, "Learning Scientific Programming with Python", Cambridge University Press, 2015.*	*3. Juan Nunez-Iglesias, Stéfan van der Walt, and Harriet Dashnow Elegant SciPy Te Art of Scientific Python, O'Reilly Media, 2017.*

Learning Assessment

	Bloom's Level of Thinking	Continuous Learning Assessment (50% weightage)								Final Examination (50% weightage)	
		CLA – 1 (10%)		CLA – 2 (15%)		CLA – 3 (15%)		CLA – 4 (10%)#			
		Theory	Practice	Theory	Practice	Theory	Practice	Theory	Practice	Theory	Practice
Level 1	Remember Understand	20%	20%	15%	15%	15%	15%	15%	15%	15%	15%
Level 2	Apply Analyze	20%	20%	20%	20%	20%	20%	20%	20%	20%	20%
Level 3	Evaluate Create	10%	10%	15%	15%	15%	15%	15%	15%	15%	15%
	Total	100 %		100 %		100 %		100 %		100 %	

CLA – 4 can be from any combination of these: Assignments, Seminars, Tech Talks, Mini-Projects, Case-Studies, Self-Study, MOOCs, Certifications, Conf. Paper etc.,

Course Designers

Experts from Industry	Experts from Higher Technical Institutions	Internal Experts
1. Mr. Anuj Kumar, Bombardier Transportation, Ahmedabad, kumaranuj.anii@gmail.com	*1. Dr. Meenakshi, Professor of ECE, CEG, Anna University, meena68@annauniv.edu*	*1. Dr. P. Vijayakumar , SRMIST*
2. Mr. Hariharasudhan - Johnson Controls, Pune, hariharasudhan.v@jci.com	*2. Dr. Venkatesan, Sr. Scientist, NIOT, Chennai, venkat@niot.res.in*	

Course Code	18ECE202T	Course Name	MICRO- AND NANO-FABRICATION TECHNOLOGIES	Course Category	E	Professional Elective	L	T	P	C
							3	0	0	3

Pre-requisite Courses	Nil	Co-requisite Courses	Nil	Progressive Courses	Nil
Course Offering Department	Electronics and Communication Engineering	Data Book / Codes/Standards	Nil		

Course Learning Rationale (CLR):	*The purpose of learning this course is to:*
CLR-1 :	*Provide learners a systematic overview of micro and nano fabrication processes*
CLR-2 :	*Gain understanding of lithography, etching and ion implantation methods to fabricate, structure and modify the layer*
CLR-3 :	*Understand thin film fabrication techniques including PVD and CVD and to apply the knowledge to film formation*
CLR-4 :	*Apply the knowledge of microfabrication technology to the fields of general microelectronics systems*
CLR-5 :	*Learn the significant advances in molecular engineering*
CLR-6 :	*Embark on building micro/ nano structures applicable to their needs.*

Course Learning Outcomes (CLO):	*At the end of this course, learners will be able to:*	Learning 1: Level of Thinking (Bloom)	Learning 2: Expected Proficiency (%)	Learning 3: Expected Attainment (%)	PLO 1: Engineering Knowledge	PLO 2: Problem Analysis0	PLO 3: Design & Development	PLO 4: Analysis, Design, Research	PLO 5: Modern Tool Usage	PLO 6: Society & Culture	PLO 7: Environment & Sustainability	PLO 8: Ethics	PLO 9: Individual & Team Work	PLO 10: Communication	PLO 11: Project Mgt. & Finance	PLO 12: Life Long Learning	PLO 13: PSO - 1	PLO 14: PSO - 2	PLO 15: PSO - 3
CLO-1 :	*Understand the various layering Technologies*	2	80	70	H	-	-	-	-	-	-	-	-	-	-	-	M	-	
CLO-2 :	*Realize how the pattern generation is done using Lithography Techniques*	2	85	75	H	-	M	-	-	-	-	-	-	-	-	-	M	-	
CLO-3 :	*Gain knowledge on particle sources, Optics and Interaction*	2	75	70	H	-	M	-	-	-	-	-	-	-	-	-	-	-	H
CLO-4 :	*Learn the device and circuit fabrication Techniques*	2	85	80	H		M	-	-	-	-	-	-	-	-	-	-	-	H
CLO-5 :	*Learn about new and advances in fabrication Technologies*	2	85	75	H	-		H	-	-	-	M	-	-	-	M	-	-	H
CLO-6 :	*Know the limitations and tools of micro, nanofabrication.*	2	80	70	H	M	-	-	M	-	-	-	-	-	-	L	M	-	H

Duration (hour)		Crystal Growth, Epitaxy, Oxidation	Lithographic Processes	Deposition, Diffusion, Ion implantation	Device Circuit Fabrication	Molecular Nanotechnology
		9	9	9	9	9
S-1	SLO-1	*Starting Materials*	*Photoreactive Materials*	*Vaccum Evaporation*	*Isolation*	*Directed Self Assembly*
	SLO-2	*Growth from Melt (Czochralski Technique)*	*Image Reversal*	*Sputter Deposition*	*Self Alignment*	*Device Assembly*
S-2	SLO-1	*Considerations for Paper Crystal Growth*	*Pattern Generation*	*Chemical Vapour Deposition*	*Local Oxidation-Trench Technique*	*Electrostatic*
	SLO-2	*Cystal Orientation, Crystal hardening Techniques*	*Mask Making*	*Growth Habit*	*Planarization*	*Templated self assembly*
S-3	SLO-1	*Doping, Dislocation*	*Pattern Transfer*	*Fims for protection & Masks*	*Metalization*	*Colloids & Nanoparticles*
	SLO-2	*Molecular Beam Epitaxy*	*Optical Printing*	*Self-aligned Masks*	*Gettering*	*Block Copolymers*
S-4	SLO-1	*Gas Source MBE*	*Advanced Techniques*	*Films for Doping*	*NIOS-based Micro Circuits*	*DNA Nanostructures*
	SLO-2	*Vapour Phase Epitaxy*	*Short Wave lengths*	*Dopart Sources*	*P,n Channel Transistors*	*Scanning probe lithography Techniques*
S-5 5-6	SLO-1	*VPE Process to Silicon*	*Multilayer Resists*	*Films for Ohmic contacts*	*Complementary Transistors*	*Local Anodic Oxidation*

	SLO-2	*VPE Process for GaAs*	*Phase Shifting Masks*	*Wet Chemical etching*	*Memory Devices*	*Scribing*
S-7	SLO-1	*Liquid Phase Epitaxy*	*Electron Beam Techniques*	*Anisotropic Effects*	*SOI Devices*	*Atomic Manipulation*
	SLO-2	*LPE System*	*Lon-Beam Techniques*	*Dry Physical Etching*	*BJT based Silicon Micro Circuits*	*SPM Scanning Probe Microscopy*
S-8	SLO-1	*Thermal Oxidation of Silicon*	*X Ray Printing*	*Dry Chemical Etching*	*The buried layer*	*Erasable Electrostatic Lithography*
	SLO-2	*Kinetics of Oxide Growth*	*Problem areas- defects*	*Reactive Lon Etching*	*p-n-p Transistor*	*Limits to Nano Fabrication*
S-9	SLO-1	*Oxidation System*	*Feature size control & anisotropic Etch Mechanism*	*Penetration range &Transverse effects*	*Field Effect Transistor*	*Limits to MSO Devices*
	SLO-2	*Halogenic Oxidation*	*Lift off Techniques*	*Annealing*	*BICMOS Integrated Circuits*	*Limits for Pattern Generation*
	SLO-2	*Anodix Oxidation* *Plasma Processes*	*Plasma reactor* *Relative Plasma etching Technique*	*Ion Implantation systems* *High energy, high current Inplants*	*Self Aligned Technology* *The Hetero junction Bipolar Transistor*	*Nanofabrication Tools*

Learning Resources	1. *Sorab. K. Gandhi, "VLSI Fabrication and Principles", McGraw Hill, 2005* 2. *Sami Franssila, "Introduction to Microfabrication", Wiley Publications, 2010* 3. *Richard C.Jaeger, "Introduction to Microelectronic Fabrication", Prentice hall, 2002* 4. *Ivor Brodie & Julius J. Muray,"The Physics of Micro/ Nano- Fabrication" Springer, 1992*	5. *Bo Cui, "Recent advances in Nanofabrication Techniques and Applications", InTech Publisher, 2011* 6. *A G Davies and J M T Thompson, "Advances in Nanoengineering Electronics, Materials and Assembly",Imperial College Press, 2007* 7. *Michael Pycraft Hughes , "Nanoelectromechanics in Engineering and Biology", by CRC Press LLC, 2003*

Learning Assessment

	Bloom's Level of Thinking	Continuous Learning Assessment (50% weightage)								Final Examination (50% weightage)	
		CLA – 1 (10%)		CLA – 2 (15%)		CLA – 3 (15%)		CLA – 4 (10%)#			
		Theory	Practice	Theory	Practice	Theory	Practice	Theory	Practice	Theory	Practice
Level 1	Remember Understand	40%	-	40%	-	40%	-	40%	-	40%	-
Level 2	Apply Analyze	40%	-	40%	-	40%	-	40%	-	40%	-
Level 3	Evaluate Create	20%	-	20%	-	20%	-	20%	-	20%	-
	Total	100 %		100 %		100 %		100 %		100 %	

CLA – 4 can be from any combination of these: Assignments, Seminars, Tech Talks, Mini-Projects, Case-Studies, Self-Study, MOOCs, Certifications, Conf. Paper etc.,

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Experts from Industry	Experts from Higher Technical Institutions	Internal Experts
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Course Code	18ECE204J	Course Name	ARM-BASED EMBEDDED SYSTEM DESIGN	Course Category	E	Professional Elective	L	T	P	C
							2	0	2	3

Pre-requisite Courses	18ECC203J	Co-requisite Courses	Nil	Progressive Courses	18ECE305J, 18ECE306J
Course Offering Department	Electronics and Communication Engineering	Data Book / Codes/ Standards	Nil		

Course Learning Rationale (CLR):	*The purpose of learning this course is to:*	Learning			Program Learning Outcomes (PLO)														
		1	2	3	1	2	3	4	5	6	7	8	9	10	11	12	13	14	15
CLR-1 :	*Understand fast software development tools of ARM processor*	Level of Thinking (Bloom)	Expected Proficiency (%)	Expected Attainment (%)	Engineering Knowledge	Problem Analysis	Design & Development	Analysis, Design, Research	Modern Tool Usage	Society & Culture	Environment & Sustainability	Ethics	Individual & Team Work	Communication	Project Mgt. & Finance	Life Long Learning	PSO - 1	PSO - 2	PSO - 3
CLR-2 :	*Understand I/O programming for ARM chip; A/D, PWM etc.*																		
CLR-3 :	*Understand the usage of timers and serial interfacing.*																		
CLR-4 :	*Know effective use of memory; and network interfacing, Ethernet and wireless protocol supports*																		
CLR-5 :	*Make application for audio signal processing.*																		
CLR-6 :	*Develop ARM Cortex-M based embedded systems for networking and signal processing applications.*																		
Course Learning Outcomes (CLO):	*At the end of this course, learners will be able to:*																		
CLO-1 :	*Learns about "mbed" software and C language application for ARM Cortex-M processors.*	*2*	*80*	*70*	*L*												*H*		
CLO-2 :	*Learns using mbed software to use A/D converter, PWM generation and digital input / output.*	*2*	*80*	*70*	*L*	*M*	*M*		*M*								*H*		
CLO-3 :	*Learns to program System timer and interval timers; use serial interface and use LCD display.*	*2*	*80*	*70*													*H*		
CLO-4 :	*Learns to use memory effectively and program network interface.*	*3*	*80*	*60*		*M*	*M*										*M*		
CLO-5 :	*Learns to do audio signal processing on embedded platform.*	*3*	*80*	*60*		*M*	*M*	*M*	*M*								*M*		
CLO-6 :	*Use of "mbed" software pack on ARM Cortex-M processor for networking and simple signal processing.*	*3*	*80*	*60*	*L*	*M*	*M*	*M*	*M*								*M*		

Duration (hour)		Cortex-M processor	Peripheral Interfacing-I	Peripheral Interfacing-II	Network Interfacing	Audio Signal Processing
		15	15	15	15	15
S-1	SLO-1	*Introducing embedded systems and mbed*	*Starting to Program Digital Input and Output*	*Introducing Synchronous Serial Communication*	*Memory organization*	*An Introduction to Digital Audio*
	SLO-2	*Introducing embedded systems and mbed*	*Voltages as Logic Values*	*I2C bus*	*Memory organization*	*USB MIDI on the mbed*
S-2	SLO-1	*ARM Cortex assembly language basics.*	*Introducing Analog output Data Conversion*	*Communicating With I2C-Enabled Sensors*	*Using Data Files With the mbed*	*Digital Audio Processing*
	SLO-2	*ARM Cortex assembly language basics.*	*Digital Output on the mbed*	*Asynchronous Serial Data Communication*	*Example mbed Data File Access*	*Digital Audio Filtering Example*
S 3-4	SLO-1 SLO-2	*Lab-1:Assembly language program, simulation -1*	*Lab 4: A/D conversion program*	*Lab 8: Multinode I2C Bus*	*Lab 10: Data logging*	*Lab 13: Audio signal generation*
S-5	SLO-1	*Cortex-M processor architecture and Basics : Programming exercises*	*Digital Input and Output.*	*LCD interfacing*	*Using External SD Card Memory With the mbed*	*Delay/Echo Effect*
	SLO-2	*Cortex-M processor architecture and Basics : Programming exercises*	*Digital Input and Output.*	*Using the mbed TextLCD Library*	*Using External USB Flash Memory With the mbed*	*Working With Wave Audio Files*
S-6	SLO-1	*Development Environment using the mbed*	*Switching Larger DC Loads*	*Time and Tasks in Embedded Systems*	*Introduction to Internet Communication*	*High-Fidelity Digital Audio With the mbed*

	SLO-2	*Development Environment using the mbed*	*Switching Larger DC Loads*	*Responding to External Events*	*The Ethernet Communication Protocol*	*High-Fidelity Digital Audio With the mbed*
S 7-8	SLO-1	*Lab 2: Assembly language program, simulation-2*	*Lab 5: Mini Project: Letter Counter*	*Lab 8: A/D output on LCD*	*Lab 11: Ethernet Communication*	*Lab 14: Model lab examination*
	SLO-2					
S-9	SLO-1	*Keil IDE and Debugging tools*	*Another Form of Analog Output: Pulse Width Modulation*	*An Introduction to Timers*	*Introducing Wireless Data Communication*	*Summary on Digital Audio and Digital Signal Processing*
	SLO-2	*Keil IDE and Debugging tools*	*Pulse Width Modulation on the mbed*	*Using the mbed Timer*	*Wireless Data Communication : Bluetooth and Zigbee*	*Summary on Digital Audio and Digital Signal Processing*
S-10	SLO-1	*C- language review*	*Design of PWM problem*	*Using the mbed Timeout and Ticker*	*Local Area Network Communications With the mbed*	*Review and discussions*
	SLO-2	*Embedded C , introduction*	*Design of PWM problem*	*The Real-Time Clock*	*Using RPC*	*Review and discussions*
S 11-12	SLO-1	*Lab 3: Parallel port programming, simulation*	*Lab 6: PWM waveform generation*	*Lab 9: Experimenting Interrupts, Timers*	*Lab 12: RPC Communication through ethernet*	*Lab 15: Final lab examination*
	SLO-2					

Learning Resources	*1. Tim Wilmshurst, "Fast and effective embedded system design, Applying the ARM mbed", ARM Education Media, 2018.* *2. Andrew Sloss, Dominic Symes, Chris Wright, "ARM System Designers Guide: Designing and optimizing System Software", The Morgan Kaufmann Series in Computer Architecture and Design, 2004.*	*3. Theory/Lab teaching materials, "Efficient embedded system design kit", ARM Education media.*

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Level 1	Remember Understand	20%	20%	15%	15%	15%	15%	15%	15%	15%	15%
Level 2	Apply Analyze	20%	20%	20%	20%	20%	20%	20%	20%	20%	20%
Level 3	Evaluate Create	10%	10%	15%	15%	15%	15%	15%	15%	15%	15%
	Total	100 %		100 %		100 %		100 %		-	

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Course Code	18ECE205J	Course Name	FPGA-BASED EMBEDDED SYSTEM DESIGN	Course Category	E	Professional Elective	L	T	P	C
							2	0	2	3

Pre-requisite Courses	18ECC203J	Co-requisite Courses	Nil	Progressive Courses	Nil
Course Offering Department	Electronics and Communication Engineering	Data Book / Codes/Standards	Nil		

Course Learning Rationale (CLR):	*The purpose of learning this course is to:*	Learning			Program Learning Outcomes (PLO)														
		1	2	3	1	2	3	4	5	6	7	8	9	10	11	12	13	14	15
		Level of Thinking (Bloom)	Expected Proficiency (%)	Expected Attainment (%)	Engineering Knowledge	Problem Analysis	Design & Development	Analysis, Design, Research	Modern Tool Usage	Society & Culture	Environment & Sustainability	Ethics	Individual & Team Work	Communication	Project Mgt. & Finance	Life Long Learning	PSO - 1	PSO - 2	PSO - 3
CLR-1 :	*Know why many high volume embedded systems need to be function specific*																		
CLR-2 :	*Design circuits using FPGA knowledge of using its resources like, clock, cells, device modules, etc.*																		
CLR-3 :	*study Xilinx FPGA IDE and design practice*																		
CLR-4 :	*Understand platform FPGAs*																		
CLR-5 :	*Understand FPGA system design and practical issues*																		
CLR-6 :	*Develop designs using FPGAs/PSoCs for specific embedded modules and low-power designs*																		
Course Learning Outcomes (CLO):	*At the end of this course, learners will be able to:*																		
CLO-1 :	*Explain Micro controller subsystems*	*2*	*80*	*70*	*M*												*H*		
CLO-2 :	*Make system design with PSoCs*	*3*	*80*	*70*	*L*	*H*	*H*		*M*								*H*		
CLO-3 :	*Understanding of Platform FPGAs*	*2*	*80*	*70*													*H*		
CLO-4 :	*Understanding of FPGA architecture design*	*3*	*80*	*60*		*H*	*H*										*H*		
CLO-5 :	*Designing with Platform FPGAs (examples)*	*3*	*80*	*60*		*H*	*H*	*M*	*M*								*H*		
CLO-6 :	*Design simple FPGA based systems*	*3*	*80*	*60*	*L*	*H*	*H*	*M*	*M*								*H*		

Duration (hour)		Basics of Peripherals	PSoC Design	Xilinx Virtex 5 IDE	Platform FPGA Designs	Designing Simple FPGA based Systems
		15	15	15	15	15
S-1	SLO-1	*Embedded systems performance criteria - Interrupts*	*PSoC3/5 architecture overview*	*Design challenges, life cycle*	*Design quality: correctness, reliability, resilience.*	*Communication: Coprocessor model*
	SLO-2	*Embedded systems performance criteria - Interrupts*	*PSoC3 architecture details and 8051 instructions*	*Metrics: measures of success*	*Modules and interfaces*	*Network on chip model*
S-2	SLO-1	*Embedded systems performance criteria - DMA*	*Interrupts and interrupt lines*	*Spectrometer example using Xilinx IDE*	*Abstraction and state,*	*Transfer of state*
	SLO-2	*Latency and its problems*	*Interrupt priority and nesting*	*Spectrometer example using Xilinx IDE*	*Cohesion and coupling and control flow graph*	*Practical issues: profiling issues*
S 3-4	SLO-1 SLO-2	*Lab 1: Embedded sensors and sensing -1*	*Lab 4: PSoC Design -1*	*Lab 7: VHDL, Verilog Practice session - 1*	*Lab 10: Sample design implementation*	*Lab 13: On-chip memory access, FIFOs*
S-5	SLO-1	*Embedded system subsystems: A/D conversion*	*The concept of memory and its connectivity to CPU*	*Xilinx Virtex 5 IDE*	*Origin of Platform FPGA Designs*	*Spatial design: Principles of parallelism*
	SLO-2	*Digital ports & its current capacity*	*Different DMA modes*	*Xilinx Virtex 5 IDE*	*Platform FPGA components*	*Granularity, degree of parallelism*
S-6	SLO-1	*Introduction to other digital interfaces*	*Clocking system: Internal master oscillator*	*PLD basics*	*Adding to platform FPGA systems*	*Spatial organizations*

	SLO-2	*Introduction to other digital interfaces*	*IMO, and sleep/wake up modes*	*FPGA configurations*	*Assembling custom compute cores*	*Spatial organizations*
S 7-8	SLO-1	*Lab 2: Embedded sensors and sensing - 2*	*Lab 5: PSoC Design -2*	*Lab 8: VHDL, Verilog Practice session - 2*	*Lab 11: Building base systems*	*Lab 14: Model lab examination*
	SLO-2					
S-9	SLO-1	*Sensors and sensing principles. Optical, capacitive sensors*	*Clock distribution*	*Various slices in Virtex 5*	*Software design :root file system, cross-developmental tools*	*Managing bandwidth: Balancing*
	SLO-2	*Magnetic, RF sensors*	*Power management: Internal regulators*	*Various slices in Virtex 5*	*Monitors and boot loaders*	*Khan process network*
S-10	SLO-1	*Processing: Mathematical views.*	*Types of reset*	*Bit stream*	*Overview of partitioning platform*	*Platform FPGA bandwidth techniques*
	SLO-2	*Programmable logic and mixed signal design fundamentals*	*Intro to PSoC creator IDE*	*Programming FPGA*	*Analytical solution to partitioning*	*On-chip, off-chip memory*
S 11-12	SLO-1	*Lab 3: Programmable logic design*	*Lab 6: PSoC Design - 3*	*Lab 9: Sample design implementation*	*Lab 12: Creating IP core*	*Lab 15: Final lab examination*
	SLO-2					

Learning Resources	1. *Robert Ashby, "Designers guide to the Cypress PSoC", Cypress Semiconductors, 2005.* 2. *Edward H. Currie and David Van Ess, " PSoC3/5 Reference Book", Cypress Semiconductor, 2010.*	3. *Sass and Shmidt, "Embedded system design with Platform FPGAs", Morgan Kaufmann, 2010.* 4. *Theory/Lab Session Teaching Materials, ARM Educational Media.*

Learning Assessment											
	Bloom'sLevel of Thinking	Continuous Learning Assessment (50% weightage)								Final Examination (50% weightage)	
		CLA – 1 (10%)		CLA – 2 (15%)		CLA – 3 (15%)		CLA – 4 (10%)#			
		Theory	Practice	Theory	Practice	Theory	Practice	Theory	Practice	Theory	Practice
Level 1	Remember Understand	20%	20%	15%	15%	15%	15%	15%	15%	15%	15%
Level 2	Apply Analyze	20%	20%	20%	20%	20%	20%	20%	20%	20%	20%
Level 3	Evaluate Create	10%	10%	15%	15%	15%	15%	15%	15%	15%	15%
	Total	100 %		100 %		100 %		100 %		-	

CLA – 4 can be from any combination of these: Assignments, Seminars, Tech Talks, Mini-Projects, Case-Studies, Self-Study, MOOCs, Certifications, Conf. Paper etc.,

Course Designers		
Experts from Industry	Experts from Higher Technical Institutions	Internal Experts
1. Mr. Anuj Kumar, Bombardier Transportation, Ahmedabad, kumaranuj.anii@gmail.com	*1. Dr. Meenakshi, Professor of ECE, CEG, Anna University, meena68@annauniv.edu*	*1. Prof. V. Natarajan, SRMIST*
2. Mr. Hariharasudhan - Johnson Controls, Pune, hariharasudhan.v@jci.com	*2. Dr. Venkatesan, Sr. Scientist, NIOT, Chennai, venkat@niot.res.in*	*2.*

Course Code	18ECE207J	Course Name	REAL TIME OPERATING SYSTEMS	Course Category	E	Professional Elective	L	T	P	C
							2	0	2	3

Pre-requisite Courses	18CSS101J	Co-requisite Courses	Nil	Progressive Courses	Nil
Course Offering Department	Electronics and Communication Engineering			Data Book / Codes/Standards	Nil

Course Learning Rationale (CLR):	*The purpose of learning this course is to:*
CLR-1 :	*Develop application program in ARM based hardware, we need to know, C and assembly programming and IDE.*
CLR-2 :	*Interface pheripherals, and hence gain the knowledge of programming, need to be known.*
CLR-3 :	*Study RTOS principles*
CLR-4 :	*Study RTOS principles of various types*
CLR-5 :	*Develop application programming of sample projects*
CLR-6 :	*Study and understand, how OS on ARM processor can be implemented and used.*

Course Learning Outcomes (CLO):	*At the end of this course, learners will be able to:*	Learning 1: Level of Thinking (Bloom)	2: Expected Proficiency (%)	3: Expected Attainment (%)	PLO 1: Engineering Knowledge	2: Problem Analysis	3: Design & Development	4: Analysis, Design, Research	5: Modern Tool Usage	6: Society & Culture	7: Environment & Sustainability	8: Ethics	9: Individual & Team Work	10: Communication	11: Project Mgt. & Finance	12: Life Long Learning	13: PSO - 1	14: PSO - 2	15: PSO - 3
CLO-1 :	*Read and understand many microprocessor instruction sets and their use.*	2	80	50	M												H		
CLO-2 :	*Implement and write code in assembly and C for embedded applications.*	3	99	70		H	H		M				M				H		
CLO-3 :	*Understand the concepts and requirements of RTOS, in general basic OS principles.*	2	80	70					M								H		
CLO-4 :	*Implement and use RTOS for embedded programs*	3	90	70			H	M	M				M				H		
CLO-5 :	*Apply the knowledge in related sample use cases.*	2	90	85	L	L			L										M
CLO-6 :	*Design processor based embedded systems along with OS implementation. (Specifically RTOS)*	2	90	70	L	M	H	M	M				M				H		L

Duration (hour)		Cortex-M processor & 'C'	Peripheral Programming in 'C'	Concepts of RTOS	RTOS Implementation	RTOS Applications
		15	15	15	15	15
S-1	SLO-1	*Cortex-M processor architecture*	*Parallel I/O programming*	*Introduction to RTOS*	*Process management*	*Real time systems: Data acquisition system*
	SLO-2	*Cortex-M processor architecture*	*Sample programs*	*Introduction to RTOS*	*Dynamic linking and loading*	*Real time systems: Data acquisition system*
S-2	SLO-1	*ARM Cortex assembly language – part1*	*Interrupt processing basics*	*Concurrent programming*	*Spin-lock semaphore, cooperative scheduling*	*Performance metrics*
	SLO-2	*ARM Cortex assembly language – part2*	*System tick; periodic interrupts*	*Thread fundamentals*	*Thread rendezvous*	*Examples and discussions*
S 3-4	SLO-1 SLO-2	*Lab 1: Arm Assembly language programming*	*Lab 4: Interrupts and timers in C and assembly*	*Lab 7: Simple thread programming in RTOS – Wave form simulation*	*Lab 10: Semaphore implementation experiment in RTOS*	*Lab 13: Any application program using RTOS.*
S-5	SLO-1	*ARM Cortex microcontroller interface standards*	*UART programming*	*Shared resources and Critical sections*	*FIFO & Little's theorem*	*Solid state disk*
	SLO-2	*IDE software tools*	*UART programming*	*Consumer producer problem*	*Three semaphore implementation*	*Flash device driver*
S-6	SLO-1	*Pointers in C*	*Digital signal time measurement*	*Switching threads*	*Thread sleeping*	*SD card interface*
	SLO-2	*Arrays, structures and unions, Linked lists*	*Use of timers and compare, capture registers.*	*Profiling the OS*	*Deadlocks, monitors*	*Communication systems with Ethernet*
S	SLO-1					*Lab 14: Model lab examination*

7-8	SLO-2	*Lab 2: C & assembly programming using Keil IDE and kit*	*Lab 5: Debugging hardware with target board – UART interface programming*	*Lab 8: Multi threaded application in RTOS – LED blinking with multi threads*	*Lab 11: Multi threaded application with Communication -1*	
S-9	SLO-1	*Embedded debugging tools in Keil IDE*	*SSI interface*	*Semaphores and implementation*	*Fixed scheduling*	*Application layer protocols for embedded systems*
	SLO-2	*Embedded debugging example with simulation*	*SSI programming with interrupt*	*Operations on semaphores*	*Fixed scheduling*	*CoAP, MQTT*
S-10	SLO-1	*Memory management -1*	*Analog I/O; A/D converter interfacing*	*Resource sharing*	*Kahn process networks*	*Discussions & Reviews*
	SLO-2	*Memory management -2*	*OS considerations of I/O devices*	*Thread Communications*	*Review*	*Discussions & Reviews*
S 11-12	SLO-1 SLO-2	*Lab 3: Practice: C & assembly programming using Keil IDE and kit*	*Lab 6: Debugging hardware with target board – Analog I/O programming*	*Lab 9 : Multi threaded application in RTOS, with semaphores*	*Lab 12: Multi threaded application with Communication -2*	*Lab 15: Final Lab Examination*

Learning Resources	1. *Jonathan Valvano, "Real time operating systems for ARM Cortex-M Microcontrollers, Embedded systems - Volume 3", ARM Educational Media, 2017.* 2. *Andrew Slosset all, "ARM system developers guide", Elsevier, 2004.*	3. *Quing Li, "Real time techniques for embedded systems", CMP Books, 2003.* 4. *K.C. Wang, "Embedded and Real time operating systems", Springer, 2017.* 5. *Theory/Lab Session teaching materials, " RTOS kit", ARM Educational media*

Learning Assessment

	Bloom's Level of Thinking	Continuous Learning Assessment (50% weightage)								Final Examination (50% weightage)	
		CLA – 1 (10%)		CLA – 2 (15%)		CLA – 3 (15%)		CLA – 4 (10%)#			
		Theory	Practice	Theory	Practice	Theory	Practice	Theory	Practice	Theory	Practice
Level 1	Remember Understand	20%	20%	15%	15%	15%	15%	15%	15%	15%	15%
Level 2	Apply Analyze	20%	20%	20%	20%	20%	20%	20%	20%	20%	20%
Level 3	Evaluate Create	10%	10%	15%	15%	15%	15%	15%	15%	15%	15%
	Total	100 %		100 %		100 %		100 %		-	

CLA – 4 can be from any combination of these: Assignments, Seminars, Tech Talks, Mini-Projects, Case-Studies, Self-Study, MOOCs, Certifications, Conf. Paper etc.,

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2. Mr. Hariharasudhan - Johnson Controls, Pune, hariharasudhan.v@jci.com	*2. Dr. Venkatesan, Sr. Scientist, NIOT, Chennai, venkat@niot.res.in*	

Course Code	18ECE301J	Course Name	CMOS ANALOG IC DESIGN	Course Category	E	Professional Elective	L	T	P	C
							2	0	2	3

Pre-requisite Courses	18ECC206J	Co-requisite Courses	Nil	Progressive Courses	Nil
Course Offering Department	Electronics and Communication Engineering			Data Book / Codes/Standards	Nil

Course Learning Rationale (CLR):	*The purpose of learning this course is to:*	Learning			Program Learning Outcomes (PLO)														
CLR-1 :	*Identify Analog IC Design process flow and IC biasing*	1	2	3	1	2	3	4	5	6	7	8	9	10	11	12	13	14	15
CLR-2 :	*Analyze the operation and frequency response of CMOS single stage amplifiers*																		
CLR-3 :	*Analyze operation and frequency response of the Differential amplifiers and Op-amp*																		
CLR-4 :	*Create insights to the concepts of noises in amplifiers*																		
CLR-5 :	*Utilize the concepts of oscillators and switched capacitor circuits*																		
Course Learning Outcomes (CLO):	*At the end of this course, learners will be able to:*	Level of Thinking (Bloom)	Expected Proficiency (%)	Expected Attainment (%)	Engineering Knowledge	Problem Analysis	Design & Development	Analysis, Design, Research	Modern Tool Usage	Society & Culture	Environment & Sustainability	Ethics	Individual & Team Work	Communication	Project Mgt. & Finance	Life Long Learning	PSO - 1	PSO - 2	PSO - 3
CLO-1 :	*Identify IC Biasing concepts*	*2*	*80*	*70*	*H*	*H*	-	-	*H*	-	-	-	-	-	-	-	-	-	-
CLO-2 :	*Analyze Single stage amplifiers*	*2*	*85*	*75*	*H*	*H*	-	-	*H*	-	-	-	-	-	-	-	-	-	-
CLO-3 :	*Analyze Differential Amplifiers and Op-amp*	*2*	*75*	*70*	*H*	-	-	*H*	*H*	-	-	-	-	-	-	-	-	-	-
CLO-4 :	*Identify the noises in Amplifiers*	*2*	*85*	*80*	*H*	*H*	-	-	*H*	-	-	-	-	-	-	-	-	-	-
CLO-5 :	*Identify oscillators and switched capacitors circuits*	*2*	*85*	*75*	*H*	-	*H*	-	*H*	-	-	-	-	-	-	-	-	-	-

Duration (hour)		12	12	12	12	12
S-1	SLO-1	*IC Design Philosophy : Introduction to MOSFET scaling*	*CMOS Single stage Amplifiers: Analog Design Octagon*	*Differential Amplifier: MOS Differential Pair- Operation with Common mode input*	*Noise in Amplifiers: Statistical characteristics of noise*	*Oscillators: General Considerations*
	SLO-2	*Analog IC design process flow, Typical values of IC MOSFET parameters*	*Common Source stage with resistive load*	*Operation with differential input*	*Statistical characteristics of noise-contn*	*Ring oscillators*
S-2	SLO-1	*IC Biasing: MOSFET current source*	*CS stage with diode connected load*	*Small signal operation of MOS differential pair- Differential gain*	*Types of Noises- Thermal Noise, flicker noise*	*LC oscillators*
	SLO-2	*Effect of the output resistance of the current source load*	*CS stage with current source load*	*Common mode gain, CMRR*	*Noise Model- MOSFET, Resistor*	*Cross coupled oscillators*
S 3-4	SLO-1 SLO-2	*Lab 1: Basic MOS Circuits: MOSFET as a switch & Inverter using HSPICE*	*Lab 4: Common source amplifier with resistive load and diode connect load*	*Lab 7: Differential amplifier*	*Lab 10: Noise analysis and a measure of noise figure in CS, CG and CD amplifier*	*Lab 13: Switched capacitor circuits*
S-5	SLO-1	*Basic MOSFET current mirror-operation*	*CS stage with triode load*	*Differential amplifier with current source load*	*Representation of noise in circuits*	*One port oscillators*
	SLO-2	*Study on the effects which deviates performance of the current mirror*	*CS stage with source degeneration*	*Cascode Differential amplifier*	*Representation of noise in circuits-Contn*	*Colpitt oscillator*
S-6	SLO-1	*Cascode Current mirror*	*Source Follower*	*Frequency response of the differential amplifier*	*Noise Analysis of CS stage*	*Voltage Controlled oscillators*
	SLO-2	*Cascode Current mirror- contn. and problem solving*	*Common gate stage*	*Frequency response of the differential amplifier- contn..*	*Noise Analysis of CD stage*	*Voltage Controlled oscillators-contn*

S 7-8	SLO-1	*Lab 2: Basic MOS current mirror, Current mirror circuit to overcome the channel length modulation effect*	*Lab 5: Common gate amplifier and Source follower*	*Lab 8: One stage op-amp*	*Lab 11: Ring oscillator*	*Lab 14: Pre and Post layout simulation of CMOS inverter using Cadence EDA (Virtuoso tool)*
	SLO-2					
S-9	SLO-1	*Wilson MOS current mirror*	*Cascode Amplifier*	*Multistage Amplifiers: Performance parameters of Op-Amp*	*Noise Analysis of CG stage*	*Switched Capacitors circuits: Basic principles*
	SLO-2	*MOS current steering circuits*	*Folded Cascode amplifier*	*One stage op-amp*	*Noise Analysis of Cascode stage*	*Sampling switches*
S-10	SLO-1	*Band gap reference circuits*	*Frequency response of CS amplifier*	*Two stage op-amp*	*Noise Analysis of Differential amplifier*	*Switched capacitor amplifier*
	SLO-2	*Band gap reference circuits-contn.*	*Frequency response of CS amplifier - Contn*	*Two stage op-amp with gain boosting*	*Noise Bandwidth, Noise Figure Concepts*	*Switched capacitor integrator*
S 11-12	SLO-1	*Lab 3: Cascode current mirror, Wilson current mirror*	*Lab 6: Cascode amplifier*	*Lab 9: Two stage op-amp*	*Lab 12: Voltage Controlled oscillators*	*Lab 15: Pre and Post layout simulation of CMOS Amplifier using Cadence EDA (Virtuoso tool)*
	SLO-2					

Learning Resources	1. *Adel S. Sedra, Kenneth C.Smith, "Microelectronic Circuits-Theory and Applications "– 6th Edition, Oxford University Press, 2011.* 2. *Behzad Razavi, "Design of Analog CMOS Integrated Circuits", Mc Graw Hill, 2001*	3. *Allen Holberg, "CMOS Analog Circuit Design", Oxford University Press, 2004* 4. *Gray, Meyer, Lewis, Hurst, "Analysis and Design of Analog Integrated Circuits", 4th edition, Willey International, 2002.*

Learning Assessment

	Bloom's Level of Thinking	Continuous Learning Assessment (50% weightage)								Final Examination (50% weightage)	
		CLA – 1 (10%)		CLA – 2 (15%)		CLA – 3 (15%)		CLA – 4 (10%)#			
		Theory	Practice	Theory	Practice	Theory	Practice	Theory	Practice	Theory	Practice
Level 1	Remember Understand	20%	20%	15%	15%	15%	15%	15%	15%	15%	15%
Level 2	Apply Analyze	20%	20%	20%	20%	20%	20%	20%	20%	20%	20%
Level 3	Evaluate Create	10%	10%	15%	15%	15%	15%	15%	15%	15%	15%
	Total	100 %		100 %		100 %		100 %		100 %	

CLA – 4 can be from any combination of these: Assignments, Seminars, Tech Talks, Mini-Projects, Case-Studies, Self-Study, MOOCs, Certifications, Conf. Paper etc.,

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Course Code	18ECE302T	Course Name	MEMS TECHNOLOGIES	Course Category	E	Professional Elective	L	T	P	C
							3	0	0	3

Pre-requisite Courses	Nil	Co-requisite Courses	Nil	Progressive Courses	Nil
Course Offering Department	Electronics and Communication Engineering			Data Book / Codes/Standards	Nil

Course Learning Rationale (CLR):	*The purpose of learning this course is to:*
CLR-1 :	*Identify the characteristics and various technology adopted in MEMS fabrication*
CLR-2 :	*Understand the electrical and mechanical phenomenon used in MEMS design*
CLR-3 :	*Analyze how to apply electrostatic and thermal principles in MEMS components design*
CLR-4 :	*Study the application of piezoresistive, piezoelectric principle and the design of microfluidic devices*
CLR-5 :	*Classify the application of polymer in MEMS application, also to explore the principle and application of optical, and RF MEMS devices*
CLR-6 :	*Study the mechanics of miniaturization, learning various micro fabrication technologies and the application of mechanisms used in MEMS sensor and Actuators design.*

Course Learning Outcomes (CLO):	*At the end of this course, learners will be able to:*	Learning 1: Level of Thinking (Bloom)	Learning 2: Expected Proficiency (%)	Learning 3: Expected Attainment (%)	PLO 1: Engineering Knowledge	2: Problem Analysis	3: Design & Development	4: Analysis, Design, Research	5: Modern Tool Usage	6: Society & Culture	7: Environment & Sustainability	8: Ethics	9: Individual & Team Work	10: Communication	11: Project Mgt. & Finance	12: Life Long Learning	13: PSO - 1	14: PSO - 2	15: PSO - 3
CLO-1 :	*Acquire the knowledge of MEMS devices principles and microfabrication techniques*	2	75	60	H	-	-	-	-	-	-	-	-	-	-	-	M	L	H
CLO-2 :	*Understand` the essential electrical and mechanical concepts of MEMS.*	2	75	60	H	H	H	-	-	-	-	-	-	-	-	-	M	L	H
CLO-3 :	*Familiarize about electrostatic and thermal sensing principles and actuating technique.*	2	75	60	H	H	H	-	-	-	-	-	-	-	-	-	M	L	H
CLO-4 :	*Attain the knowledge of piezoresistive, piezoelectric and magnetic sensing and actuating technique and microfluidic devices*	2	75	60	H	H	-	-	-	-	-	-	-	-	-	-	M	L	H
CLO-5 :	*Be familiar with the polymers material used in MEMS, design and exposure on optical and RF MEMS.*	2	75	60	H	-	-	-	-	-	-	-	-	-	-	-	M	L	H
CLO-6 :	*Understand the mechanics of miniaturization, familiar with various micro fabrication technologies and able to design MEMS sensor and Actuators based on the required application.*	2	75	60	H	M	H										M	L	H

Duration (hour)		Introduction to mems and micro fabrication	Electrical and mechanical concepts of mems	Electrostatic and thermal principle sensing and actuation	Piezoresistive, piezoelectric and magnetic principle sensors and actuator	Polymer, optical, rf mems and its application
		9	9	9	9	9
S-1	SLO-1	*History of MEMS Development*	*Conductivity of semiconductors*	*Electrostatic sensing - Parallel plate capacitor*	*Piezoresistive sensors -piezoresistive sensor material*	*Polymers in MEMS- polymide,SU-8, Liquid crystal polymer (LCP)*
	SLO-2		*Problems on conductivity of semiconductors*	*Problems on electrostatic sensing*		
S-2	SLO-1	*Characteristics of MEMS – Miniaturization,*	*Crystal plane and orientation- Single crystal Si (FCC, Miller Indices and notation, crystal planes & characteristics, flats & wafer identification)*	*Electrostatic actuation Parallel plate capacitor*	*Stress in flexural cantilever and membrane*	*Polymers in MEMS- PDMS, PMMA , Parylene, Fluorocarbon*
	SLO-2	*Microelectronics integration - Mass fabrication with precision*		*Problems on electrostatic actuation*		
S-3	SLO-1	*Miniaturization and scaling*	*Stress and strain - definition , Relationship between tensile stress and strain*	*Electrostatic sensing and actuation-Application - Inertial, pressure and tactile sensor*	*Piezoelectric sensing and actuation-piezoelectric material properties*	*Optical MEMS-passive MEMS optical components-lenses-mirrors*
	SLO-2	*Sensors and Actuators- Energy domains and example devices for each*				
S-4	SLO-1	*Micro fabrication process - Bulk and Surface Micromachining*	*Stress and strain - definition , Relationship between tensile stress and strain*	*Electrostatic sensing and actuation-Application - parallel plate actuator comb drive*	*Quartz - PZT-*	*Actuation for active optical MEMS.*
	SLO-2				*PVDF -ZnO -Applications*	

S-5	SLO-1	Silicon based MEMS processes- processing anisotropic wet etching	Flexural beam bending analysis under single loading condition	Problems on electrostatic sensing and actuation	Magnetic actuation- Principles- Deposition of magnetic materials	RF MEMS: Switches
	SLO-2	Isotropic wet etching				
S-6	SLO-1	Dry etching (plasma etching, ion milling, RIE, DRIE)	Types of beam, longitudinal strain under pure bending	Thermal sensing and Actuations- sensors and actuators based on thermal expansion	Design and fabrication of magnetic coil	RF MEMS - Filters, oscillators
	SLO-2	Photolithography,				
S-7		Thin film deposition -sputtering, evaporation,	Deflection of beam- Spring constant	Thermocouples	Microfluidics – Concepts of fluid mechanics	MEMS Packaging
		Thin film deposition - LPCVD, PECVD	Problems: Deflection of beam- Spring constant	Thermal resistors		
S-8	SLO-1	Thin film deposition - sputtering, evaporation, LPCVD, PECVD	Torsional deflection, intrinsic stress	Application of thermal sensors – Inertial, Flow, Infrared.	Microfluidics –Application: Channels, valves	MEMS Testing
	SLO-2	Thin film deposition - plating, spin-on				
S-9	SLO-1	New material and fabrication processing techniques	Resonance and quality factor	Problems on thermal sensing and actuation	Microfluidics – Application valves	Reliability issues in MEMS packaging
	SLO-2	Points of consideration for processing structural and sacrificial material.				

Learning Resources	1. Chang Liu, "Foundations of MEMS", Second Edition, Pearson , 2017 2. Tai-Ran Hsu, MEMS & Microsystem Design and Manufacturing, McGraw Hill Education (India) 1st Edition , 2015. 3. Gaberiel M. Rebiz, "RF MEMS Theory,Design and Technology", John Wiley & Sons, 2010. 4. Microsystem Design - by S. Senturia; Publisher: Springer.,	5. Charles P. Poole and Frank J. Owens, "Introduction to Nanotechnology", John Wiley & Sons, 2009. 6. Julian W.Gardner and Vijay K Varadhan, "Microsensors, MEMS and Smart Devices", John Wiley & sons, 2013. 7. Fundamentals of Microfabrication - by M. Madou; Publisher: CRC Press; 2 edition.

Learning Assessment

	Bloom's Level of Thinking	Continuous Learning Assessment (50% weightage)								Final Examination (50% weightage)	
		CLA – 1 (10%)		CLA – 2 (15%)		CLA – 3 (15%)		CLA – 4 (10%)#			
		Theory	Practice	Theory	Practice	Theory	Practice	Theory	Practice	Theory	Practice
Level 1	Remember Understand	40 %	-	30 %	-	30 %	-	30 %	-	30%	-
Level 2	Apply Analyze	40 %	-	40 %	-	40 %	-	40 %	-	40%	-
Level 3	Evaluate Create	20 %	-	30 %	-	30 %	-	30 %	-	30%	-
	Total	100 %		100 %		100 %		100 %		100 %	

CLA – 4 can be from any combination of these: Assignments, Seminars, Tech Talks, Mini-Projects, Case-Studies, Self-Study, MOOCs, Certifications, Conf. Paper etc.,

Course Designers

Experts from Industry	Experts from Higher Technical Institutions	Internal Experts
1. Mr. Anuj Kumar, Bombardier Transportation, Ahmedabad, kumaranuj.anii@gmail.com	1. Dr. Meenakshi, Professor of ECE, CEG, Anna University, meena68@annauniv.edu	1. Dr. P. Eswaran, SRMIST
2. Mr. Hariharasudhan - Johnson Controls, Pune, hariharasudhan.v@jci.com	2. Dr. Venkatesan, Sr. Scientist, NIOT, Chennai, venkat@niot.res.in	

Course Code	18ECE303T	Course Name	NANOELECTRONIC DEVICES AND CIRCUITS	Course Category	E	Professional Elective	L	T	P	C
							3	0	0	3

Pre-requisite Courses	18ECC102J	Co-requisite Courses	Nil	Progressive Courses	Nil
Course Offering Department	Electronics and Communication Engineering		Data Book / Codes/Standards	Nil	

Course Learning Rationale (CLR):	*The purpose of learning this course is to:*
CLR-1 :	*Identify the need and effects of device miniaturization*
CLR-2 :	*Understand the principles of nano devices*
CLR-3 :	*Learn about new devices at nano scale*
CLR-4 :	*Create insights to the concepts of nano CMOS circuits*
CLR-5 :	*Analyze the design considerations of the circuits*
CLR-6 :	*Utilize the design procedure in circuits*

Course Learning Outcomes (CLO):	*At the end of this course, learners will be able to:*	Learning 1 Level of Thinking (Bloom)	2 Expected Proficiency (%)	3 Expected Attainment (%)	PLO 1 Engineering Knowledge	2 Problem Analysis	3 Design & Development	4 Analysis, Design, Research	5 Modern Tool Usage	6 Society & Culture	7 Environment & Sustainability	8 Ethics	9 Individual & Team Work	10 Communication	11 Project Mgt. & Finance	12 Life Long Learning	13 PSO - 1	14 PSO - 2	15 PSO - 3
CLO-1 :	*Realize the importance of scaling of devices.*	2	80	70	H	M	-	M	-	-	-	-	-	-	-	-	-	-	M
CLO-2 :	*Identify the difference of nano devices from conventional devices.*	2	85	75	H	-	-	M	-	-	-	-	-	-	-	-	M	-	
CLO-3 :	*Analyze the performance measures of various devices*	2	75	70	H	-	M	H	H	-	-	-	-	-	-	-	-	-	H
CLO-4 :	*Choose appropriate application of the device*	2	85	80	H	H	-	-	-	H	L	H	-	-	-	-	-	L	H
CLO-5 :	*Understand the design considerations of nano circuits*	2	85	75	H	-	H	H	M	-	-	-	-	-	-	-	-	-	M
CLO-6 :	*Apply the design concepts of nano circuits in real time applications*	2	80	70	H	M	-	-	-	H	L	H	-	-	-	-	M	-	M

Duration (hour)		Introduction to Nano Devices	Silicon MOSFETs- Novel Materials and Alternative Concepts	Nano Devices – Principles and Techniques	Nano- CMOS scaling Problems and Implications	Mixed Signal Circuit Design
		9	9	9	9	9
S-1	SLO-1	*MOS transistor- A First Glance at the Device*	*SOI MOSFET, partially depleted*	*Classical transport: classical resistance and conductance*	*Design Methodology in the Nano-CMOS Era*	*Design Considerations – Device Modeling*
	SLO-2	*The MOS Transistor under Static Condition*	*fully depleted SOI*	*Quantum ballistic transport: quantum Resistance and conductance*	*Innovations needed to continue performance scaling -*	*Passive Components*
S-2	SLO-1	*MOS Transistor Capacitances- Channel Capacitance*	*Strained channel MOSFET,*	*Coulomb blockade effect*	*Sub-100-nm Scaling Challenges- Back-End-of-Line Challenges (Metallization)-*	*Design Using Thin Oxide Devices – Design Using Thick Oxide Devices*
	SLO-2	*Junction Capacitance*	*Hi-k gate dielectric, Metal gate electrode*	*Single Electron Transistor*	*Interconnect scaling-copper wire technology*	*Low-Voltage Techniques*
S-3	SLO-1	*The Actual MOS Transistor—Some Secondary Effect*	*Double gate MOSFET*	*Performance of the single-electron transistor*	*Low –k dielectric challenges-future global interconnect technologies*	*Design Procedures*
	SLO-2	*Challenges in Nanoscale MOSFETs*	*FinFET*	*SET technology and Field effect transistors*	*Front-End-of-Line Challenges (Transistors)-Quantum effects model*	*Electrostatic Discharge Protection*
S-4	SLO-1	*Scaling of transistor dimensions*	*Tunnel Effect*	*Carbon Nano Tube(CNT)*	*Polysilicon gate , Metal gate electrodes,*	*Multiple-Supply Concerns*
	SLO-2	*Moore's law*	*Tunneling through a potential barrier*	*Electronic properties of CNT*	*Direct tunneling gate leakage-Parasitic capacitance*	*Noise Isolation*
S	SLO-1				*Reliability concerns*	

5-6	SLO-2	*Short Channel Effects (SCE) : Sub-threshold Conduction,*	*Potential energy profiles for material interfaces*	*Geometrical structure, Electronic structure of CNT Transport properties*		*Guard Ring Structures Isolated NMOS Devices*
S-7	SLO-1	*Drain Induced Barrier Lowering*	*Metal -insulator, metal -semiconductor*	*CNTFET, comparison of Si MOSFET with CNTFET*	*Process Control Reliability*	*Epitaxial Material versus Bulk Silicon –*
	SLO-2	*Velocity Saturation, Hot electrons*	*Metal –insulator -metal junctions*	*FeFET*	*Lithographic Issues*	*Decoupling*
S-8	SLO-1	*Emergence of new materials,*	*Tunneling Diode*	*Principle of Spintronics*	*Mask Data Explosion*	*Power Busing*
	SLO-2	*Hi-k materials and its issues*	*Resonant Tunneling diode*	*Spin valves, SpinFET*	*New Breed of Circuit*	*Integration Problems*
S-9	SLO-1	*metal gate, copper interconnect and*	*Three-terminal resonant tunneling devices*	*Magnetic Tunnel Junctions*	*– Physical Design – Modeling Challenges*	*Corner Regions*
	SLO-2	*low-k interlayer dielectric*	*inverter and logic OR gates based on RTD*	*MRAM*	*Need for Design Methodology Changes*	*Neighboring Circuitry*

Learning Resources	*1. Rainer Waser (Ed.), "Nanoelectronics and Information Technology",Wiley-VCH, Third, Completely Revised and Enlarged Edition, 2012.* *2. Jan M. Rabaey, Anantha Chandrakasan, and Borivoje Nikolic," Digital Integrated Circuits 2nd edition", Pearson, 2000.* *3. Ban P. Wong, Anurag Mittal, YuCao, Gren Starr, "Nano- CMOS Circuit and Physical Design", John Willey and sons Publication, 2005*	*4. George W. Hanson, "Fundamentals of Nanoelectronics", Prentice Hall, 20073.Karl Goser, Peter GlÖsekötter,Jan Dienstuhl, "Nanoelectronics and Nanosystems", Springer, 2004* *5. Vladimir V. Mitin, Viatcheslav A. Kochelap, Michael A. Stroscio, "Introduction to Nanoelectronics: Science, Nanotechnology, Engineering, and Applications", Cambridge University Press, 2012*

Learning Assessment											
	Bloom's Level of Thinking	Continuous Learning Assessment (50% weightage)								Final Examination (50% weightage)	
		CLA – 1 (10%)		CLA – 2 (15%)		CLA – 3 (15%)		CLA – 4 (10%)#			
		Theory	Practice	Theory	Practice	Theory	Practice	Theory	Practice	Theory	Practice
Level 1	Remember Understand	40%	-	40%	-	40%	-	40%	-	40%	-
Level 2	Apply Analyze	40%	-	40%	-	40%	-	40%	-	40%	-
Level 3	Evaluate Create	20%	-	20%	-	20%	-	20%	-	20%	-
	Total	100 %		100 %		100 %		100 %		100 %	

CLA – 4 can be from any combination of these: Assignments, Seminars, Tech Talks, Mini-Projects, Case-Studies, Self-Study, MOOCs, Certifications, Conf. Paper etc.,

Course Designers		
Experts from Industry	Experts from Higher Technical Institutions	Internal Experts
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2. Mr. Hariharasudhan - Johnson Controls, Pune, hariharasudhan.v@jci.com	*2. Dr. Venkatesan, Sr. Scientist, NIOT, Chennai, venkat@niot.res.in*	

Course Code	18ECE304T	Course Name	MICROWAVE INTEGRATED CIRCUITS	Course Category	E	Professional Elective	L	T	P	C
							3	0	0	3

Pre-requisite Courses	18ECC105T	Co-requisite Courses	Nil	Progressive Courses	Nil
Course Offering Department	Electronics and Communication Engineering			Data Book / Codes/Standards	Nil

Course Learning Rationale (CLR):	*The purpose of learning this course is to:*
CLR-1 :	*Create the insights of microwave circuits*
CLR-2 :	*Analyze matching networks and filter design*
CLR-3 :	*Identify and implement amplifiers and oscillators*
CLR-4 :	*Layout the types of mixers and control circuits*
CLR-5 :	*Utilize techniques to fabricate and measurement of MICs*
CLR-6 :	*Analyze and realize microwave circuits and its techniques*

Course Learning Outcomes (CLO):	*At the end of this course, learners will be able to:*	Learning 1: Level of Thinking (Bloom)	2: Expected Proficiency (%)	3: Expected Attainment (%)	PLO 1: Engineering Knowledge	2: Problem Analysis	3: Design & Development	4: Analysis, Design, Research	5: Modern Tool Usage	6: Society & Culture	7: Environment & Sustainability	8: Ethics	9: Individual & Team Work	10: Communication	11: Project Mgt. & Finance	12: Life Long Learning	13: PSO - 1	14: PSO - 2	15: PSO - 3
CLO-1 :	*Understand the different types of MICs, different MIC devices and parameters to be used in MICs*	2	75	60	H	-	-	-	-	-	-	-	-	-	-	-	-	-	M
CLO-2 :	*Explore concept of frequency parameters, ZY smith chart, its interpretation in the analysis and design of matching circuits*	2	75	60	H	H	H	M	-	-	-	-	-	-	-	-	-	-	M
CLO-3 :	*Understand the design of Amplifiers and Oscillators*	2	75	60	H	H	H	H	-	-	-	-	-	-	-	-	-	-	H
CLO-4 :	*Explore the different Mixer types and Microwave diodes*	2	75	60	H	H	-	M	-	-	-	-	-	-	-	-	-	-	M
CLO-5 :	*Understand Micro fabrication of MIC devices and measurement techniques of MICs*	2	75	60	H	-	-	M	-	-	-	-	-	-	-	M	-	-	H
CLO-6 :	*Comprehend the MICs, fabrication and measurement of MIC devices*	2	75	60	H	H	H	H	-	-	-	-	-	-	-	M	M	-	M

Duration (hour)		Introduction to MIC	Matching Circuits	Microwave Amplifiers and Oscillators	Mixers and Microwave Diodes	MIC Measurement Techniques
		9	9	9	9	9
S-1	SLO-1	*Introduction to MICs*	*Circuit Representation of two port RF/Microwave Networks*	*Introduction to amplifiers*	*Introduction to Mixers*	*Microwave Integrated Circuits : Introduction to SOC, SOP*
	SLO-2			*Stability considerations in active networks*		
S-2	SLO-1	*Frequency Bands*	*Low Frequency Parameters*	*Gain Consideration in Amplifiers*	*Mixer Types*	*MIC Materials.*
	SLO-2	*Lumped versus Distributed Circuits*	*High Frequency Parameters*			
S-3	SLO-1	*Behavior of finite length transmission lines*	*Transmission Matrix*	*Noise Consideration in active networks*	*Conversion Loss*	*Hybrid versus Monolithic MICs*
	SLO-2					
S-4	SLO-1	*General Characteristics of PC Boards*	*ZY Smith Chart*	*Broadband Amplifier design*	*SSB Mixers*	*Multichip Module Technology*
	SLO-2			*Low Noise Amplifier Design*	*DSB Mixers*	
S-5	SLO-1	*Transmission Lines on PC Boards*	*ZY Smith Chart*	*Introduction to oscillators*	*Design of Mixers: Single Ended Mixers*	*Fabrication Techniques*
	SLO-2					
S-6	SLO-1	*Passives made from Transmission Lines*	*Design of Matching Circuits using Lumped Elements*	*Oscillator versus Amplifier Design*	*Single Balanced Mixers*	*Miniaturization techniques*
	SLO-2					
S-7	SLO-1	*Resonators*	*Design of Matching Circuits using Lumped Elements*	*Oscillation conditions*	*Sub Harmonic Diode Mixers*	*Test fixture measurements*
	SLO-2		*Matching Network Design using Distributed Elements*			
S-8	SLO-1	*Combiners and Splitters*	*Matching Network Design using Distributed Elements*	*Design and stability considerations of Microwave Transistor Oscillators.*	*Microwave Diodes*	*probe station measurements*
	SLO-2					
S-9	SLO-1	*Couplers*	*Filter design*		*Phase Shifters and PIN*	*thermal and cryogenic measurements*

	SLO-2			*Design and stability considerations of Microwave Transistor Oscillators.*	*Diode Attenuators*	

Learning Resources	*1. Thomas H.Lee, "Planar Microwave Engineering", Cambridge University Press, 2004* *2. Matthew M. Radmanesh, "Radio Frequency and Microwave Electronics", Pearson Education, II Edition 2002* *3. Guillermo Gonzalez, "Microwave Transistor Amplifiers – Analysis and Design", II Edition, Prentice Hall, New Jersy.* *4. Ravender Goyal, "Monolithic MIC; Technology & Design", Artech House, 1989.* *5. Gupta K.C. and Amarjit Singh, "Microwave Integrated Circuits", John Wiley, New York, 1975.*	*6. Hoffman R.K. "Handbook of Microwave Integrated Circuits", Artech House, Boston, 1987.* *7. Ulrich L. Rohde and David P.N., " RF / Microwave Circuit Design for Wireless Applications", John Wiley, 2000.* *8. C. Gentili, "Microwave Amplifiers and Oscillators", North Oxford Academic, 1986.* *9. Samuel. Y. Liao, "Microwave Circuit Analysis and Amplifier Design", Prentice Hall. Inc., 1987.*

Learning Assessment

	Bloom's Level of Thinking	Continuous Learning Assessment (50% weightage)								Final Examination (50% weightage)	
		CLA – 1 (10%)		CLA – 2 (15%)		CLA – 3 (15%)		CLA – 4 (10%)#			
		Theory	Practice	Theory	Practice	Theory	Practice	Theory	Practice	Theory	Practice
Level 1	Remember Understand	40 %	-	30 %	-	30 %	-	30 %	-	30%	-
Level 2	Apply Analyze	40 %	-	40 %	-	40 %	-	40 %	-	40%	-
Level 3	Evaluate Create	20 %	-	30 %	-	30 %	-	30 %	-	30%	-
	Total	100 %		100 %		100 %		100 %		100 %	

CLA – 4 can be from any combination of these: Assignments, Seminars, Tech Talks, Mini-Projects, Case-Studies, Self-Study, MOOCs, Certifications, Conf. Paper etc.,

Course Designers

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2. Mr. Hariharasudhan - Johnson Controls, Pune, hariharasudhan.v@jci.com	*2. Dr. Venkatesan, Sr. Scientist, NIOT, Chennai, venkat@niot.res.in*	*2. Dr. T. Ramarao, SRMIST*

Course Code	18ECE305J	Course Name	INTRODUCTION TO ARM -SOC	Course Category	E	Professional Elective	L	T	P	C
							2	0	2	3

Pre-requisite Courses	18ECE204J	Co-requisite Courses	Nil	Progressive Courses	Nil
Course Offering Department	Electronics and Communication Engineering			Data Book / Codes/Standards	Nil

Course Learning Rationale (CLR):	The purpose of learning this course is to:
CLR-1 :	*Study the hardware architecture of ARM Cortex-M core*
CLR-2 :	*Study the AHB (high speed bus) and peripherals*
CLR-3 :	*Study the AHB (high speed bus) and peripherals*
CLR-4 :	*Program high speed peripherals*
CLR-5 :	*Study APB bus and peripherals. Designing applications with CMSIS*
CLR-6 :	*Understand and learn to use ARM Cortex-M processor architecture, and deice level programming.*

Course Learning Outcomes (CLO):	*At the end of this course, learners will be able to:*	Learning 1: Level of Thinking (Bloom)	2: Expected Proficiency (%)	3: Expected Attainment (%)	Program Learning Outcomes (PLO) 1: Engineering Knowledge	2: Problem Analysis	3: Design & Development	4: Analysis, Design, Research	5: Modern Tool Usage	6: Society & Culture	7: Environment & Sustainability	8: Ethics	9: Individual & Team Work	10: Communication	11: Project Mgt. & Finance	12: Life Long Learning	13: PSO - 1	14: PSO - 2	15: PSO - 3
CLO-1 :	*Explain hardware and register architecture of ARM Cortex-M based processors*	*2*	*80*	*70*													*H*		
CLO-2 :	*Explain AHB and its signals, and program high speed peripherals*	*3*	*80*	*70*		*M*	*H*	*L*	*H*								*H*		*M*
CLO-3 :	*Understand AHB and its signals and program high speed peripherals*	*3*	*80*	*70*		*H*	*H*	*L*	*H*								*H*		*M*
CLO-4 :	*Program high speed peripherals with case study.*	*3*	*80*	*60*		*M*	*H*		*H*								*M*		
CLO-5 :	*Program device driver and create libraries.*	*3*	*80*	*60*		*M*	*H*		*M*								*M*		
CLO-6 :	*Perform system programming of ARM Cortex-M based processor.*	*3*	*80*	*60*		*M*	*H*	*L*	*H*								*M*		

		ARM Cortex-M architecture	ARM Internal bus	ARM pheripherals	SOC programming	Case studies
Duration (hour)		12	12	12	12	12
S-1	SLO-1	*Introduction to Programmable SoC*	*AMBA 3 AHB Lite architecture*	*AHB UART peripheral*	*Programming an SOC using C language*	*Graphics LCD interfacing*
	SLO-2	*Introduction to Programmable SoC*	*AMBA 3 AHB Lite architecture*	*AHB UART peripheral*	*Programming an SOC using C language*	*Graphics LCD interfacing*
S-2	SLO-1	*ARM architecture*	*AMBA 3 AHB Lite architecture*	*AHB UART peripheral*	*APB Bus*	*Board support package*
	SLO-2	*ARM architecture*	*AMBA 3 AHB Lite architecture*	*AHB UART peripheral*	*APB Bus*	*Board support package*
S 3-4	SLO-1, SLO-2	*Lab-1:ARM Keil IDE usage – sample ARM program.*	*Lab 4: Study of AHB peripheral*	*Lab 7: Multinode I2C Bus*	*Lab 10: Making a device driver*	*Lab 13: Case study – 2*
S-5	SLO-1	*ARM Register architecture*	*AHB SRAM controller*	*AHB timer*	*ARM CMSIS*	*Ethernet interfacing*
	SLO-2	*ARM Register architecture*	*AHB SRAM controller*	*AHB timer*	*ARM CMSIS*	*Ethernet interfacing*
S-6	SLO-1	*ARM assembly language*	*AHB SRAM controller*	*AHB-APB bridge*	*Device drivers*	*Ethernet interfacing*
	SLO-2	*ARM assembly language*	*Review and discussions*	*AHB-APB bridge*	*Device drivers*	*Ethernet interfacing*
S 7-8	SLO-1, SLO-2	*Lab 2: Assembly language programming of ARM processor using Keil IDE*	*Lab 5: ARM memory management*	*Lab 8: Application of timers*	*Lab 11: Using CMSIS*	*Lab 14: Model lab examination*
S-9	SLO-1	*ARM Cortex-M Architecture -1*	*AHB VGA peripheral*	*Fast GPIO programming*	*Application programming*	*Student Seminar / discussions*
	SLO-2	*ARM Cortex-M Architecture -1*	*AHB VGA peripheral*	*Fast GPIO programming*	*Application programming*	*Student Seminar / discussions*
S-10	SLO-1	*ARM Cortex-M Architecture -2 (pipelines)*	*AHB VGA peripheral*	*Interrupt mechanism of ARM*	*Case study - 1*	*Student Seminar / discussions*
	SLO-2	*ARM Cortex-M Architecture -2*	*AHB VGA peripheral*	*Interrupt mechanism of ARM*	*Case study - 2*	*Student Seminar / discussions*
S 11-12	SLO-1, SLO-2	*Lab 3: Parallel port programming*	*Lab 6: Graphics application*	*Lab 9: Experimenting Interrupts, Timers*	*Lab 12: Study of USB interface*	*Lab 15: Final lab examination*

Learning Resources	1. Steve Furber, *"ARM System on a Chip Architecture – 2nd Edition", Pearson Education, 2000.* 2. *"AMBA -3 APB Protocol", ARM Limited, 2003.* 3. *"AMBA -3 AHB Lite Protocol", ARM Limited, 2003.*	4. *Theory/Lab teaching materials, "Introduction to SoC kit", ARM Education media, 2018.*

Learning Assessment

	Bloom's Level of Thinking	Continuous Learning Assessment (50% weightage)								Final Examination (50% weightage)	
		CLA – 1 (10%)		CLA – 2 (15%)		CLA – 3 (15%)		CLA – 4 (10%)#			
		Theory	Practice	Theory	Practice	Theory	Practice	Theory	Practice	Theory	Practice
Level 1	Remember Understand	20%	20%	15%	15%	15%	15%	15%	15%	15%	15%
Level 2	Apply Analyze	20%	20%	20%	20%	20%	20%	20%	20%	20%	20%
Level 3	Evaluate Create	10%	10%	15%	15%	15%	15%	15%	15%	15%	15%
	Total	100 %		100 %		100 %		100 %		-	

CLA – 4 can be from any combination of these: Assignments, Seminars, Tech Talks, Mini-Projects, Case-Studies, Self-Study, MOOCs, Certifications, Conf. Paper etc.,

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Course Code	18ECE306J	Course Name	ARM BASED DIGITAL SIGNALS PROCESSING	Course Category	E	Professional Elective	L	T	P	C
							2	0	2	3

Pre-requisite Courses	18ECE204J	Co-requisite Courses	Nil	Progressive Courses	Nil
Course Offering Department	Electronics and Communication Engineering			Data Book / Codes/Standards	Nil

Course Learning Rationale (CLR):	*The purpose of learning this course is to:*
CLR-1 :	*Understand the concepts of DSP, discrete time signals and its properties.*
CLR-2 :	*Understand applications of transforms in solving digital signal processing*
CLR-3 :	*Study FIR filters*
CLR-4 :	*Study IIT filters*
CLR-5 :	*Understand the usage of adaptive filter techniques*
CLR-6 :	*Understand the usage of DSP in embedded ARM Cortex-M processor platform*

Course Learning Outcomes (CLO):	*At the end of this course, learners will be able to:*	Learning			Program Learning Outcomes (PLO)														
		1	2	3	1	2	3	4	5	6	7	8	9	10	11	12	13	14	15
		Level of Thinking (Bloom)	Expected Proficiency (%)	Expected Attainment (%)	Engineering Knowledge	Problem Analysis	Design & Development	Analysis, Design, Research	Modern Tool Usage	Society & Culture	Environment & Sustainability	Ethics	Individual & Team Work	Communication	Project Mgt. & Finance	Life Long Learning	PSO - 1	PSO - 2	PSO - 3
CLO-1 :	*Apply theory and application of discrete time signals*	*3*	*80*	*70*		*M*	-	-	*M*	-	-	-	-	-	-	-	*H*	-	*L*
CLO-2 :	*Apply theory and implementing methods of Z-transforms, DFT and FFT.*	*3*	*80*	*70*		*H*	-	-	*M*	-	-	-	-	-	-	-	*H*	-	*L*
CLO-3 :	*Apply FiR filter theory and processor implementation in C.*	*3*	*80*	*70*		*H*	-	-	*M*	-	-	-	-	-	-	-	*H*	-	*L*
CLO-4 :	*Apply IIR filter theory and processor implementation in C*	*3*	*80*	*60*		*H*	-	-	*M*	-	-	-	-	-	-	-	*H*	-	*L*
CLO-5 :	*Implement adaptive filter design theory, methods and its uses.*	*2*	*80*	*60*		*H*	-	-	*L*	-	-	-	-	-	-	-	*H*	-	*L*
CLO-6 :	*Apply the theory and implementation aspects of DSP in ARM Cortex-M based processor platform.*	*3*	*80*	*60*		*H*	-	-	*M*	-	-	-	-	-	-	-	*H*	-	*L*

Duration (hour)		Basics of digital signals	Transforms for DSP	FIR filters	IIR filters	DSP applications
		12	12	12	12	12
S-1	SLO-1	*DT Signals-basics properties &Operations on DT signals*	*Z-Transform Properties*	*Design of Finite Impulse Response Filters-Symmetric and Antisymmetric FIR filters*	*Frequency Response and Characteristics of Analog Filters*	*Introduction-Steepest Descent Method-Least Mean Squares Method*
	SLO-2	*DT Signals-basics properties &Operations on DT signals*	*Z-Transform Properties*	*Design of Finite Impulse Response Filters-Symmetric and Antisymmetric FIR filters*	*Frequency Response and Characteristics of Analog Filters*	*Introduction-Steepest Descent Method-Least Mean Squares Method*
S-2	SLO-1	*DT systems-Properties of DT Systems – LTI system*	*Inverse Z-Transform-solving Difference Equation*	*Design of Linear- Phase FIR filters Using window methods*	*IIR Filter Design by Impulse Invariance*	*Adaptive Filters: Prediction and System Identification*
	SLO-2	*DT systems-Properties of DT Systems – LTI system*	*Inverse Z-Transform-solving Difference Equation*	*Design of Linear- Phase FIR filters Using window methods*	*IIR Filter Design by Impulse Invariance*	*Adaptive Filters: Prediction and System Identification*
S 3-4	SLO-1 SLO-2	*Lab 1: Introduction- Keil MDK-ARM application development Environment.*	*Lab 4: LTI System Implementation*	*Lab 7: Filter Structures in the CMSIS-DSP Library*	*Lab 10: IIR Filter Structures in the CMSIS-DSP Library*	*Lab 13: CMSIS Implementation of the LMS and Normalized LMS methods*
S-5	SLO-1	*Convolution and Correlation*	*DFT-review; problems*	*Design of Linear- Phase FIR filters Using window methods*	*Design of Butterworth filter using Bilinear Transformation*	*Adaptive Filters: Equalization and Noise Cancellation*
	SLO-2	*Convolution and Correlation*	*DFT-review; problems*	*Design of Linear- Phase FIR filters Using window methods*	*Design of Butterworth filter using Bilinear Transformation*	*Adaptive Filters: Equalization and Noise Cancellation*
S-6	SLO-1	*CT-to DT Conversion Sampling Theorem in the Time Domain*	*DIT-FFT Radix 2 butterfly derivation - problems*	*Design of Optimum Equiripple Linear-Phase FIR filters*	*Chebyshev Filter Designs based on the Bilinear Transformation*	*Adaptive Filters: Adaptive FIR Filter*
	SLO-2	*CT-to DT Conversion Sampling Theorem in the Time Domain*	*DIT-FFT Radix 2 butterfly derivation - problems*	*Design of Optimum Equiripple Linear-Phase FIR filters*	*Chebyshev Filter Designs based on the Bilinear Transformation*	*Adaptive Filters: Adaptive FIR Filter*
S 7-8	SLO-1 SLO-2	*Lab 2: Digital Signals-operations on Digital Signals*	*Lab 5: Calculating the DFT-FFT*	*Lab 8: FIR Filter Design*	*Lab 11: IIR Filter Design*	*Lab 14: Model Practicals*

S-9	SLO-1	*Sampling Theorem in the Frequency Domain-Aliasing*	*Filtering in the FD-Circular & Convolution*	*Design of Optimum Equiripple Linear-Phase FIR filters*	*Chebyshev Filter Designs based on the Impulse Invariance*	*Review, Problems and Discussions*
	SLO-2	*Sampling Theorem in the Frequency Domain-Aliasing*	*Filtering in the FD-Circular & Convolution*	*Design of Optimum Equiripple Linear-Phase FIR filters*	*Chebyshev Filter Designs based on the Impulse Invariance*	*Review, Problems and Discussions*
S-10	SLO-1	*Reconstruction in the Frequency Domain & time Domain*	*Filtering in the FD-Linear Convolution*	*Filter Design using Software*	*Filter Design using Software*	*Review, Problems and Discussions*
	SLO-2	*Reconstruction in the Frequency Domain & time Domain*	*Filtering in the FD-Linear Convolution*	*Filter Design using Software*	*Filter Design using Software*	*Review, Problems and Discussions*
S 11-12	SLO-1 SLO-2	*Lab 3: A-D & D-A conversion-Changing the Sampling Frequency*	*Lab 6: Filtering in the Frequency Domain*	*Lab 9: Implementing a FIR Filter using Different Structures*	*Lab 12: Implementing a Filter using Different Structures*	*Lab 15: University practicals*

Learning Resources	*1. Cem Unsalan, M. Yerkin Yuccel, H. Deniz Gurham, "Digital Signal Processing Using ARM Cortex-M based microcontrollers, Theory and Practice", ARM Education Media, 2018.*	*2. Theory/Lab teaching materials, ARM Educational Media.*

Learning Assessment

	Bloom's Level of Thinking	Continuous Learning Assessment (50% weightage)								Final Examination (50% weightage)	
		CLA – 1 (10%)		CLA – 2 (15%)		CLA – 3 (15%)		CLA – 4 (10%)#			
		Theory	Practice	Theory	Practice	Theory	Practice	Theory	Practice	Theory	Practice
Level 1	Remember Understand	20%	20%	15%	15%	15%	15%	15%	15%	15%	15%
Level 2	Apply Analyze	20%	20%	20%	20%	20%	20%	20%	20%	20%	20%
Level 3	Evaluate Create	10%	10%	15%	15%	15%	15%	15%	15%	15%	15%
	Total	100 %		100 %		100 %		100 %		-	

CLA – 4 can be from any combination of these: Assignments, Seminars, Tech Talks, Mini-Projects, Case-Studies, Self-Study, MOOCs, Certifications, Conf. Paper etc.,

Course Designers

Experts from Industry	Experts from Higher Technical Institutions	Internal Experts
1. Mr. Anuj Kumar, Bombardier Transportation, Ahmedabad, kumaranuj.anii@gmail.com	*1. Dr. Meenakshi, Professor of ECE, CEG, Anna University, meena68@annauniv.edu*	*1. Prof. V. Natarajan, SRMIST*
2. Mr. Hariharasudhan - Johnson Controls, Pune, hariharasudhan.v@jci.com	*2. Dr. Venkatesan, Sr. Scientist, NIOT, Chennai, venkat@niot.res.in*	*2. Mr. U. Hari, SRMIST*

Course Code	18ECE307J	Course Name	APPLIED MACHINE LEARNING	Course Category	E	Professional Elective	L	T	P	C
							2	0	2	3

Pre-requisite Courses	Nil	Co-requisite Courses	Nil	Progressive Courses	Nil
Course Offering Department	Electronics and Communication Engineering		Data Book / Codes/Standards	Nil	

Course Learning Rationale (CLR):	*The purpose of learning this course is to:*
CLR-1 :	*Understanding the Machine Learning concept and types*
CLR-2 :	*Analyze the ML algorithm performance by Learning Curve and error*
CLR-3 :	*Applying ML algorithm for solving practical problems*
CLR-4 :	*Create insights to the concepts and programming of supervised and unsupervised ML methods*
CLR-5 :	*Analyze and understand the working principle and model development of Evolutionary Learning*
CLR-6 :	*Create insights to the concepts and programming of Reinforcement learning*

Course Learning Outcomes (CLO):	*At the end of this course, learners will be able to:*	Learning 1: Level of Thinking (Bloom)	2: Expected Proficiency (%)	3: Expected Attainment (%)	PLO 1: Engineering Knowledge	2: Problem Analysis	3: Design & Development	4: Analysis, Design, Research	5: Modern Tool Usage	6: Society & Culture	7: Environment & Sustainability	8: Ethics	9: Individual & Team Work	10: Communication	11: Project Mgt. & Finance	12: Life Long Learning	13: PSO - 1	14: PSO - 2	15: PSO - 3
CLO-1 :	*Apply Genetic Algorithm for evalualionary learning*	2	80	70	H	H	H	-	-	-	-	-	-	-	-	-	-	-	H
CLO-2 :	*Analyze Reinforcement learning*	2	85	75	H	H	-	H	H	-	-	-	-	-	-	-	-	-	H
CLO-3 :	*Apply linear model of linear regression and SVM for classification problem*	2	75	70	H	H	H	H	-	-	-	-	-	-	-	-	H	-	H
CLO-4 :	*Apply neural network and CNN for classification problem*	2	85	80	H	H	H	H	H	-	-	-	-	-	-	-	H	-	H
CLO-5 :	*Apply Decision Trees , clustering For classification problem*	2	85	75	H	H	H	H	H	-	-	-	-	-	-	-	H	-	H
CLO-6 :	*Apply probability model of Bayesian decision theory and HMM for classification problem*	2	80	70	H	H	H	H	H	-	-	-	-	-	-	-	H	-	H

Duration (hour)		Introduction to Machine Learning and Linear Model	Multiplayer Perceptrons and Decision Tree	Clustering, SOM and HMM	Bayes Network, Reinforcement Learning and CNN	Genetic Algorithm and Application of ML
		12	12	12	12	12
S-1	SLO-1	*Introduction to Machine learning: Types of Machine Learning - Supervised Learning – Unsupervised, Learning*	*Multiplayer, Perceptrons*	*Clustering*	*Bayesian decision theory*	*The Genetic Algorithm*
	SLO-2	*reinforcement learning , The Curse of dimensionality*	*Multiplayer, Perceptrons*	*K-Means clustering*	*Bayesian decision theory*	*The Genetic Algorithm*
S-2	SLO-1	*Bias and Variance, Learning Curve*	*Multiplayer, Perceptrons*	*Hierarchical clustering*	*Bayesian estimation*	*Facial Expression Recognition*
	SLO-2	*Classification, Error and noise, linear regression*	*Multiplayer, Perceptrons*	*Agglomerative clustering*	*Bayes network*	*Human Emotion Research*
S-3,4	SLO-1 SLO-2	*Lab 1: Linear Regression*	*Lab 4: Multiplayer, Perceptrons*	*Lab 7: K-Means clustering*	*Lab 10: Bayes Network*	*Lab 13: Genetic Algorithm*
S-5	SLO-1	*Support Vector Machines*	*example of using MLP*	*Vector Quantization*	*Reinforcement learning*	*Facial Expression Recognition System*
	SLO-2	*Support Vector Machines*	*example of using MLP*	*Vector Quantization*	*Reinforcement learning*	*Facial Expression Recognition System*
S-6	SLO-1	*Support Vector Machines*	*example of using MLP*	*The Self-Organizing Feature Map*	*Reinforcement learning*	*Speech Emotion Recognition*
	SLO-2	*Support Vector Machines*	*example of using MLP*	*The Self-Organizing Feature Map*	*Reinforcement learning*	*Speech Emotion Recognition*
S-7,8	SLO-1 SLO-2	*Lab 2: Support Vector Machines*	*Lab 5: MLP application*	*Lab 8: SOFM*	*Lab 11: Reinforcement learning*	*Lab 14: Speech Emotion Recognition Basic classification*

S-9	SLO-1	*basics of neural network*	*Decision Trees- classification*	*HMM*	*Understanding Convolutions*	*Neural Network Multi-Layer Perceptron Modeling For Surface Quality Prediction in Laser Machining*
	SLO-2	*Perceptrons*	*regression tree,*	*HMM*	*Understanding Convolutions*	
S-10	SLO-1	*LINEAR SEPARABILITY*	*pruning, rule from tree and data*	*HMM*	*CNN Building Blocks*	*Machine Learning in Cybersecurity-Supervised Learning for Misuse/Signature Detection*
	SLO-2	*Perceptrons and introduction to Multiplayer, Perceptrons*	*multivariate tree*	*HMM*	*CNN Building Blocks*	*Machine Learning in Cybersecurity-Supervised Learning for Misuse/Signature Detection*
S-11,12	SLO-1	*Lab 3: Perceptrons*	*Lab 6: Decision Trees*	*Lab 9: HMM*	*Lab 12: CNN*	*Lab 15: Mini project*
	SLO-2					

Learning Resources	1. *Ethem Alpaydin, "Introduction to Machine Learning", 3rd edition, MIT Press, 2014.* 2. *Stephen Marsland, "Machine Learning –An Algorithmic Perspective", 2nd edition, CRC Press, 2015.* 3. *Sumeet Dua and Xian Du , "Data Mining and Machine Learning in Cybersecurity", CRC Press, 2011.* 4. *Aurélien Géron Hands-On Machine Learning with Scikit-Learn and TensorFlow: Concepts, Tools, and Techniques to Build Intelligent Systems. O'Reilly Media, 2017.*	5. *Yagang Zhang, "Application of Machine Learning", Published by In-Tech, 2010.* 6. *Starter Bundle, "Deep Learning: A Practitioner's Approach", O'Reilly Media, 2017.* 7. *Dr. Adrian Rosebrock, "Deep Learning for Computer Vision with Python", Packt Publisher, 2018.* 8. *Ankur A Patel, "Hands-On Unsupervised Learning Using Python: How to Build Applied Machine Learning Solutions from Unlabeled Data", O'Reilly media, 2019.*

Learning Assessment"											
	Bloom's Level of Thinking	Continuous Learning Assessment (50% weightage)								Final Examination (50% weightage)	
		CLA – 1 (10%)		CLA – 2 (15%)		CLA – 3 (15%)		CLA – 4 (10%)#			
		Theory	Practice	Theory	Practice	Theory	Practice	Theory	Practice	Theory	Practice
Level 1	Remember Understand	20%	20%	15%	15%	15%	15%	15%	15%	15%	15%
Level 2	Apply Analyze	20%	20%	20%	20%	20%	20%	20%	20%	20%	20%
Level 3	Evaluate Create	10%	10%	15%	15%	15%	15%	15%	15%	15%	15%
	Total	100 %		100 %		100 %		100 %		100 %	

CLA – 4 can be from any combination of these: Assignments, Seminars, Tech Talks, Mini-Projects, Case-Studies, Self-Study, MOOCs, Certifications, Conf. Paper etc.,

Course Designers		
Experts from Industry	Experts from Higher Technical Institutions	Internal Experts
1. Mr. Anuj Kumar, Bombardier Transportation, Ahmedabad, kumaranuj.anii@gmail.com	*1. Dr. Meenakshi, Professor of ECE, CEG, Anna University, meena68@annauniv.edu*	*1. Dr. P. Vijayakumar, SRMIST*
2. Mr. Hariharasudhan - Johnson Controls, Pune, hariharasudhan.v@jci.com	*2. Dr. Venkatesan, Sr. Scientist, NIOT, Chennai, venkat@niot.res.in*	

Course Code	18ECE220T	Course Name	ADVANCED MOBILE COMMUNICATION SYSTEMS	Course Category	E	Professional Elective	L	T	P	C
							3	0	0	3

Pre-requisite Courses	18ECC301T	Co-requisite Courses	Nil	Progressive Courses	Nil
Course Offering Department	Electronics and Communication Engineering			Data Book / Codes/Standards	Nil

Course Learning Rationale (CLR):	*The purpose of learning this course is to:*
CLR-1 :	*Gain knowledge about the latest Standards from 3G to 5G systems.*
CLR-2 :	*Introduce the concepts of OFDM systems and standards.*
CLR-3 :	*Study the basics of MIMO system and the impact of different channel models on it.*
CLR-4 :	*Understand the techniques of cognitive radio spectrum sensing and sharing*
CLR-5 :	*Study the techniques of Millimeter wave Communication*
CLR-6 :	*Apply the knowledge gained to various Advanced Mobile Communication Systems*

Course Learning Outcomes (CLO):	*At the end of this course, learners will be able to:*	Learning			Program Learning Outcomes (PLO)														
		1	2	3	1	2	3	4	5	6	7	8	9	10	11	12	13	14	15
		Level of Thinking (Bloom)	Expected Proficiency (%)	Expected Attainment (%)	Engineering Knowledge	Problem Analysis	Design & Development	Analysis, Design, Research	Modern Tool Usage	Society & Culture	Environment & Sustainability	Ethics	Individual & Team Work	Communication	Project Mgt. & Finance	Life Long Learning	PSO - 1	PSO - 2	PSO - 3
CLO-1 :	*Apply the architecture and functionalities of 3G and 4G systems*	*2,3*	*85*	*80*	*H*	-	*M*	*M*	-	-	-	-	-	-	-	-	*H*	-	*M*
CLO-2 :	*Understand the concepts of OFDM and it issues*	*2,3*	*80*	*85*	*M*	-	*H*	*M*	-	-	-	-	-	-	-	-	*M*	-	*H*
CLO-3 :	*Understand the MIMO Communication systems*	*2,3*	*85*	*80*	*H*	-	*M*	*H*	-	-	-	-	-	-	-	-	*M*	-	*H*
CLO-4 :	*Understand the principle of Cognitive Radio Techniques*	*2,3*	*80*	*75*	*M*	-	-	*M*	-	-	-	-	-	-	-	-	*M*	-	*H*
CLO-5 :	*Acquire the concept of millimeter wave Communication*	*2,3*	*85*	*80*	*M*	-	*M*	*H*	-	-	-	-	-	-	-	-	*M*	-	*H*
CLO-6 :	*Able to analyze the Advance Mobile Communication systems*	*2,3*	*85*	*80*	*M*	-	*M*	*H*	-	-	-	-	-	-	-	-	*M*	-	*H*

Duration (hour)		Advanced cellular mobile Communication systems	Multicarrier modulation technique-OFDM	MIMO systems	Cognitive Spectrum management	Millimeter wave Communication
		9	9	9	9	9
S-1	SLO-1	*Overview of the legacy 3GPP cellular systems*	*Introduction to OFDM*	*Introduction to MIMO*	*Cognitive transceiver Introduction*	*Millimeter Wave Characteristics*
	SLO-2	*Overview of the legacy 3GPP cellular systems*	*Multicarrier Modulation Introduction*	*Introduction to MIMO Channel Capacity*	*Cognitive transceiver architecture*	*Introduction to Channel Performance at Mm wave Communication*
S-2	SLO-1	*WiMAX systems: Introduction*	*Multicarrier Modulation*	*MIMO Channel Estimation*	*Interweaving*	*Channel Performance at Mm wave Communication*
	SLO-2	*WiMAX systems: Architecture*	*Cyclic Prefix*	*MIMO Channel Estimation*	*Principle of interweaving*	*Modulation for Millimeter Wave Communication*
S-3	SLO-1	*WiMAX systems: Architecture*	*Channel model*	*MIMO Spatial Multiplexing*	*Principle of interweaving*	*Modulation for Millimeter Wave Communication*
	SLO-2	*WiMAX systems : Frame structure*	*SNR*	*MIMO Spatial Multiplexing*	*Introduction to Spectrums*	*Millimeter wave transmitter*
S-4	SLO-1	*WiMAX systems : Frame structure*	*SNR Performance*	*V- BLAST 2*	*Types of Spectrum*	*Millimeter wave Receiver*
	SLO-2	*WiMAX systems : Applications*	*SNR Problems*	*V- BLAST 2*	*Spectrum sensing*	*Millimeter wave Antenna*
S 5-6	SLO-1 SLO-2	*LTE systems: Introduction*	*OFDM Introduction*	*MIMO Diversity*	*Advantages of Spectrum sensing*	*Introduction Mm wave Communications*

S-7	SLO-1	*LTE systems: Architecture*	*OFDM Issues*	*MIMO Diversity*	*Disadvantages of Spectrum sensing*	*Emerging applications of Mm wave Communications*
	SLO-2	*LTE systems: Architecture*	*OFDM Issues*	*Alamouti*	*Disadvantages of Spectrum sensing*	*Emerging applications of Mm wave Communications*
S-8	SLO-1	*LTE systems: Frame structure*	*PAPR*	*Alamouti*	*Spectrum Management*	*Millimeter Wave Standards.*
	SLO-2	*LTE systems: Frame structure*	*Frequency and timing*	*OSTBC*	*Spectrum Management*	*Introduction to Millimeter Wave Standards.*
S-9	SLO-1	*LTE systems: applications*	*Frequency offset issues.*	*MIMO :OFDM system Introduction*	*Spectrum Management*	*Development of Millimeter Wave Standards.*
	SLO-2	*LTE systems: applications*	*Timing offset issues.*	*MIMO :OFDM system*	*Spectrum Management*	*Development of Millimeter Wave Standards.*

Learning Resources	1. *Andrea Molisch, "Wireless Communication", Cambridge University Press, 2nd edition, 2013.* 2. *Theodre Rappaport, "Wireless Communication: Principle and Practice", Prentice Hall, 2nd edition, 2014.* 3. *Kao-Cheng Huang, Zhaocheng Wang, "Millimeter Wave Communication System", Wiley-IEEE Press, 2nd edition, 2011.* 4. *EzioBigleri, "MIMO Wireless Communications", Cambridge University Press, 1st edition, 2007.*	5. *Arslan, Hüseyin, ed. Cognitive radio, software defined radio, and adaptive wireless systems. Springer Science & Business Media, 2007.(263-284)* 6. *Thomas W.Rondeau, Charles W. Bostain, "Artificial Intelligence in Wireless Communication", ARTECH HOUSE .2009 {pp1-51]* 7. *Andrew Goldsmith, Wireless Communications, Cambridge University Press, 2005.* 8. *Mischa Dohler, Jose F. Monserrat Afif Osseiran " 5G Mobile and Wireless Communication Technology", Cambridge University Press 2016.*

Learning Assessment

	Bloom's Level of Thinking	Continuous Learning Assessment (50% weightage)								Final Examination (50% weightage)	
		CLA – 1 (10%)		CLA – 2 (15%)		CLA – 3 (15%)		CLA – 4 (10%)#			
		Theory	Practice	Theory	Practice	Theory	Practice	Theory	Practice	Theory	Practice
Level 1	Remember / Understand	40 %	-	30 %	-	30 %	-	30 %	-	30%	-
Level 2	Apply / Analyze	40 %	-	40 %	-	40 %	-	40 %	-	40%	-
Level 3	Evaluate / Create	20 %	-	30 %	-	30 %	-	30 %	-	30%	-
	Total	100 %		100 %		100 %		100 %		100 %	

CLA – 4 can be from any combination of these: Assignments, Seminars, Tech Talks, Mini-Projects, Case-Studies, Self-Study, MOOCs, Certifications, Conf. Paper etc.,

Course Designers

Experts from Industry	Experts from Higher Technical Institutions	Internal Experts
1. Mr. Anuj Kumar, Bombardier Transportation, Ahmedabad, kumaranuj.anii@gmail.com	*1. Dr. Meenakshi, Professor of ECE, CEG, Anna University, meena68@annauniv.edu*	*1. Dr. Sabitha Gauni, SRMIST*
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Course Code	18ECE221T	Course Name	RADAR AND NAVIGATIONAL AIDS	Course Category	E	Professional Elective	L	T	P	C
							3	0	0	3

Pre-requisite Courses	18ECC205J	Co-requisite Courses	Nil	Progressive Courses	Nil
Course Offering Department	Electronics and Communication Engineering		Data Book / Codes/Standards	Nil	

Course Learning Rationale (CLR):	*The purpose of learning this course is to:*
CLR-1 :	*Get introduced to basics of Radar System*
CLR-2 :	*Impart the knowledge of different types of Radar*
CLR-3 :	*Analyze the various detection schemes*
CLR-4 :	*Understand the Radar transmitters and Receivers*
CLR-5 :	*Understand the fundamentals of navigation system*
CLR-6 :	*Acquire knowledge on theoretical concepts and analysis techniques related to different types of Radar and various navigational aids*

Course Learning Outcomes (CLO):	*At the end of this course, learners will be able to:*	Learning 1: Level of Thinking (Bloom)	Learning 2: Expected Proficiency (%)	Learning 3: Expected Attainment (%)	PLO 1: Engineering Knowledge	PLO 2: Problem Analysis	PLO 3: Design & Development	PLO 4: Analysis, Design, Research	PLO 5: Modern Tool Usage	PLO 6: Society & Culture	PLO 7: Environment & Sustainability	PLO 8: Ethics	PLO 9: Individual & Team Work	PLO 10: Communication	PLO 11: Project Mgt. & Finance	PLO 12: Life Long Learning	PLO 13: PSO - 1	PLO 14: PSO - 2	PLO 15: PSO - 3
CLO-1 :	*Gain knowledge about Radar theory and Range equation*	2	80	70	H	M	-	-	-	-	-	-	-	-	-	-	-	-	-
CLO-2 :	*Apply Doppler principle to Radars and hence understand the working principle of different types of Radar*	2	85	75	-	-	-	-	-	-	-	-	-	H	-	-	M	-	-
CLO-3 :	*Gain knowledge on Radar signal detection methods and propagation as related to Radars*	2	75	70	-	H	-	-	-	-	-	-	-	-	-	-	M	-	-
CLO-4 :	*Acquire information about Radar transmitters and Radars*	2	85	80	H	H	-	-	-	-	-	-	-	-	-	-	-	-	H
CLO-5 :	*Understand principles of navigation , in addition to approach and landing aids as related to navigation*	2	85	75	H	M	-	-	-	-	-	-	-	M	-	-	M	-	-
CLO-6 :	*Understand the principle of operation of Radar in the detection of different types of targets and various navigational aids*	2	85	75	H	H	-	-	-	-	-	-	-	H	-	-	-	-	H

Duration (hour)		Introduction To Radar Equation	MTI And Pulse Doppler Radar	Detection Of Signals In Noise	Radar Transmitter And Receiver	Radio Navigation
		9	9	9	9	9
S-1	SLO-1	*Introduction-Basic Radar*	*Introduction to Doppler Radar*	*Detection of Signals in Noise -Detection Criteria*	*Radar Transmitters and Receivers.*	*Introduction - Four methods of Navigation .- Positioning- Errors in Direction Finding*
	SLO-2	*Radar Frequencies -Applications of Radar*	*Introduction to MTI Radar*	*Probabilities of Detection and False Alarm*	*Linear Beam Power Tubes-Reflex Klystron*	*Line of sight Distance measurement*
S-2	SLO-1	*The Simple form of Radar Equation*	*Delay –Line Cancellers*	*Matched Filter Receiver*	*Linear Beam Power Tubes-TWT*	*Terrestrial Radio Navigation systems*
	SLO-2	*Tutorials*	*Delay –Line Cancellers*	*Derivation of Matched filter frequency response*	*Solid State RF Power Sources*	*Radio transmission and Reception*
S-3	SLO-1	*Radar Block Diagram*	*Doppler Filter Banks*	*Automatic Detector*	*Magnetron - Crossed Field Amplifiers*	*System design considerations-System Performance Parameters*
	SLO-2	*Receiver Noise*	*Digital MTI Processing*	*Constant-False-Alarm Rate Receivers*	*Magnetron - Crossed Field Amplifiers*	*The Loop Antenna - Adcock Direction Finders*
S-4	SLO-1	*Signal-to-Noise Ratio*	*Block Diagram of Digital MTI Doppler Signal Processor*	*Signal Management*	*Other RF Power Sources*	*Direction Finding at Very High Frequencies - Automatic Direction Finders*
	SLO-2	*Integration of Radar Pulses*	*Moving Target Detector - Limitations to MTI Performance*	*Propagation Radar Waves- Atmospheric Refraction*	*Other aspects of Radar Transmitter*	*VHF Omni Directional Range(VOR) - VOR Receiving Equipment - Range and Accuracy of VOR*
S-5	SLO-1	*Radar Cross Section of Targets-Simple Targets*	*Pulse Doppler Radar*	*Standard propagation*	*The Radar Receiver*	*Hyperbolic Systems of Navigation-Loran*

	SLO-2	*Radar Cross Section of Targets-Complex Targets Transmitter Power*	*High, Medium and Low prf Doppler*	*Nonstandard Propagation*	*Receiver noise Figure*	*Loran-C*
S-6	SLO-1	*Radar cross Section Fluctuations*	*Other Doppler Radar Topics*	*Ambiguity Diagram*	*Receiver noise Figure*	*The Decca Navigation System -Decca Receivers*
	SLO-2	*Swerling Target Model*	*Tracking with Radar*	*Ambiguity Diagram*	*Super heterodyne Receiver*	*Range and Accuracy of Decca*
S-7	SLO-1	*Transmitter Power*	*Mono pulse Tracking*	*Pulse compression*	*LNA and Mixers*	*TACAN*
	SLO-2	*Pulse Repetition Frequency*	*Two Coordinate amplitude comparison monopulse tracking*	*Linear FM pulse compression*	*Duplexers*	*TACAN Equipment*
S-8	SLO-1	*Antenna Parameters*	*Conical Scan and Sequential Lobing*	*Binary Phase Coded pulse compression*	*Receiver Protectors*	*Case study on Airborne Tactial networks-Instrument Landing System*
	SLO-2	*System losses-Microwave plumbing loss, Antenna loss, Signal Processing loss*	*Limitations to Tracking Accuracy*	*Questionnaire*	*Receiver Protectors*	*Case study on Airborne Tactial networks-Instrument Landing System*
S-9	SLO-1	*System losses-Doppler processing, Collapsing, Operator loss, propagation Effects*	*Case study on weather radars*	*Introduction to clutter*	*Radar Displays*	*Introduction to satellite Radio Navigation-*
	SLO-2	*Other Radar Equation Considerations*	*Case study on weather radars*	*Surface Clutter Radar equation*	*Surprise Test*	*Navstar Global Positioning System (GPS)*

Learning Resources	1. *Merrill I. Skolnik," Introduction to Radar Systems", 3rd Edition Tata Mc Graw-Hill 2008* 2. *R.B. Underdown and David Cockburn, "Ground Studies for Pilots: Radio Aids", sixth Edition, Blackwell Publishing, 2011.* 3. *Myron Kayton, Walter R.Fried, "Avionics Navigation Systems", second Edition, Wiley- India Edition, 2010.* 4. *N.S.Nagaraja, "Elements of Electronic Navigation Systems", 2nd Edition, TMH, 2000.*	5. *Mark, Richards.A, "Fundamentals of radar signal processing", Mc-Graw Hill, Electronic Engineering, 1st Edition, 2005.* 6. *Jenny L. Reed, Aaron D. Lanterman, John M. Trostel," Tutorial: Weather Radar: Operation and Phenomenology", IEEE Aerospace and Electronic Systems Magazine, Vol: 32, 7, 2017.* 7. *Bow-Nan Cheng, Frederick J. Block, B. Russ Hamilton, David Ripplinger, Chayil Timmerman, Leonid Veytser, and Aradhana Narula-Tam," Design Considerations for Next-Generation Airborne Tactical Networks, IEEE Communications Magazine , May 2014.*

Learning Assessment

	Bloom's Level of Thinking	Continuous Learning Assessment (50% weightage)								Final Examination (50% weightage)	
		CLA – 1 (10%)		CLA – 2 (15%)		CLA – 3 (15%)		CLA – 4 (10%)#			
		Theory	Practice	Theory	Practice	Theory	Practice	Theory	Practice	Theory	Practice
Level 1	Remember Understand	40 %	-	30 %	-	30 %	-	30 %	-	30%	-
Level 2	Apply Analyze	40 %	-	40 %	-	40 %	-	40 %	-	40%	-
Level 3	Evaluate Create	20 %	-	30 %	-	30 %	-	30 %	-	30%	-
	Total	100 %		100 %		100 %		100 %		100 %	

CLA – 4 can be from any combination of these: Assignments, Seminars, Tech Talks, Mini-Projects, Case-Studies, Self-Study, MOOCs, Certifications, Conf. Paper etc.,

Course Designers

Experts from Industry	Experts from Higher Technical Institutions	Internal Experts
1. Mr. Anuj Kumar, Bombardier Transportation, Ahmedabad, kumaranuj.anii@gmail.com	*1. Dr. Meenakshi, Professor of ECE, CEG, Anna University, meena68@annauniv.edu*	*1. Mrs. S. Vasanthadev Suryakala, SRMIST*
2. Mr. Hariharasudhan - Johnson Controls, Pune, hariharasudhan.v@jci.com	*2. Dr. Venkatesan, Sr. Scientist, NIOT, Chennai, venkat@niot.res.in*	

Course Code	18ECE223T	Course Name	SATELLITE COMMUNICATION AND BROADCASTING	Course Category	E	Professional Elective	L	T	P	C
							3	0	0	3

Pre-requisite Courses	18ECC205J	Co-requisite Courses	Nil	Progressive Courses	Nil
Course Offering Department	Electronics and Communication Engineering			Data Book / Codes/Standards	Nil

Course Learning Rationale (CLR):	*The purpose of learning this course is to:*
CLR-1 :	*Understand the orbital and functional principles of satellite Communication systems*
CLR-2 :	*Architect, interpret, and select appropriate technologies for implementation of specified satellite Communication systems*
CLR-3 :	*Analyze and evaluate a satellite link and suggest enhancements to improve the link performance*
CLR-4 :	*Select appropriate modulation, multiplexing, coding and multiple access schemes for a given satellite Communication link*
CLR-5 :	*Specify, design, prototype and test analog and digital satellite Communication systems as per given specifications*
CLR-6 :	*Utilize the concepts in optical Communication for the understanding of engineering and technology*

Course Learning Outcomes (CLO):	*At the end of this course, learners will be able to:*	Learning 1: Level of Thinking (Bloom)	Learning 2: Expected Proficiency (%)	Learning 3: Expected Attainment (%)	PLO 1: Engineering Knowledge	PLO 2: Problem Analysis	PLO 3: Design & Development	PLO 4: Analysis, Design, Research	PLO 5: Modern Tool Usage	PLO 6: Society & Culture	PLO 7: Environment & Sustainability	PLO 8: Ethics	PLO 9: Individual & Team Work	PLO 10: Communication	PLO 11: Project Mgt. & Finance	PLO 12: Life Long Learning	PLO 13: PSO - 1	PLO 14: PSO - 2	PLO 15: PSO - 3
CLO-1 :	*Understand the principles, concepts and operation of satellite Communication systems*	2	80	70	H	H	M	H	H	L	L	L	M	H	L	M	H	-	-
CLO-2 :	*Gain the knowledge of Satellite orbits and launching, link design, link availability and perform interference calculations*	2	85	75	H	H	M	H	H	L	L	L	M	H	L	M	H	-	-
CLO-3 :	*Analyze the concepts of Satellite systems in relation to other terrestrial systems*	2	75	70	H	H	M	H	H	L	L	L	L	H	L	M	H	-	-
CLO-4 :	*Evaluate the performance of various channel access schemes*	2	85	80	H	H	M	H	H	L	L	L	L	H	L	M	H	-	-
CLO-5 :	*Familiarize with applications of satellites and compression standards*	2	85	75	H	H	M	H	H	L	L	L	L	H	L	M	H	-	-
CLO-6 :	*Apply their idea in Satellite Communication module*	2	80	70	H	H	M	H	H	L	L	L	M	H	L	M	H	-	-

Duration (hour)		Satellite Orbit	Link Design	Space and Earth Segment	Multiple Access Techniques for Satellite Communication	Broadcast and Services
		9	9	9	9	9
S-1	SLO-1	*Satellite Orbit*	*Link Design*	*Space Segment*	*Concepts of Multiple Access techniques, types*	*Concept of Broadcasting satellites*
	SLO-2	*Kepler's law*	*EIRP*	*Basic concept of space segmen*	*Single Access*	*Direct Broadcasting Satellite*
S-2	SLO-1	*Earth - Orbiting satellites terms*	*Transmission Losses*	*Power Supply*	*Pre assigned FDMA*	*Orbital Spacing*
	SLO-2	*Types of satellites*	*Link Power Budget equation*	*Altitude control*	*Demand Assigned FDMA*	*Power ratings*
S-3	SLO-1	*Orbital elements*	*System Noise*	*Station keeping*	*SPADE system*	*Frequency and polarization*
	SLO-2	*Orbit Perturbations*	*Carrier to noise ratio*	*Thermal Control*	*TWT amplifier operation*	*Transponder Capacity*
S-4	SLO-1	*Inclined Orbits*	*Types of FEC*	*TT&C Subsystems*	*Downlink analysis*	*Bit rate*
	SLO-2	*Sun synchronous orbits*	*Computer-Aided Design*	*Antenna subsystem*	*TDMA*	*MPEG*
S-5	SLO-1	*Constellation:Geo stationary satellites*	*Uplink*	*Transponders*	*Reference bursts*	*Forward Error Correction*
	SLO-2	*Non geostationary constellation*	*saturation flux density, input backoff*	*Wideband Receiver*	*Preamble, Postamble*	*Outdoor Unit*
S-6	SLO-1	*Launching of Geostationary satellites*	*Down Link*	*Earth Segment*	*Carrier recovery*	*Indoor Unit*
	SLO-2	*Launch vehicle Types*	*output backoff, TWTA output*	*Basic concept of Earth segment*	*Network synchronization*	*Downlink Analysis*
S-7	SLO-1	*Antenna Look angles*	*Effects of rain*	*Receive only home TV system*	*Pre assigned TDMA*	*Uplink Analysis*
	SLO-2	*Sun transit outage*	*Inter modulation Noise*	*Community antenna TV system*	*Demand assigned TDMA*	*Satellite Mobile services*
S-8	SLO-1	*Solving Problems*	*Solving Problems*	*Solving Problems*	*CDMA*	*VSAT*
	SLO-2	*Solving Problems*	*Solving Problems*	*Solving Problems*	*Direct Sequence Spread Spectrum , CDMA throughput*	*GPS*
S-9	SLO-1	*Solving Problems*	*Solving Problems*	*Solving Problems*	*Solving Problems*	*Solving Problems*
	SLO-2	*Solving Problems*	*Solving Problems*	*Solving Problems*	*Solving Problems*	*Solving Problems*

Learning Resources	1. *Dennis Roddy, "Satellite Communications", Tata Mc-Graw Hill Publications, 4th Edition, 13th Reprint, 2014* 2. *TIMOTHY PRATT, CHARLES BOSTIAN JERMEY ALLNUTT, Satellite Communications, John Wiley, Singapore, 2nd Edition, reprint 2013.*	3. *MadhavendraRichharia, Leslie David, "Satellite Systems for Personal Applications Concepts and Technology", Wiley-Blackwell, 1st Edition, 2010.* 4. *Louis J. IppolitoJr, "Satellite Communications Systems Engineering", John Wiley and Sons , Ltd, Publication, 1st Edition, 2008*

Learning Assessment											
	Bloom's Level of Thinking	Continuous Learning Assessment (50% weightage)								Final Examination (50% weightage)	
		CLA – 1 (10%)		CLA – 2 (15%)		CLA – 3 (15%)		CLA – 4 (10%)#			
		Theory	Practice	Theory	Practice	Theory	Practice	Theory	Practice	Theory	Practice
Level 1	Remember Understand	40 %	-	30 %	-	30 %	-	30 %	-	30%	-
Level 2	Apply Analyze	40 %	-	40 %	-	40 %	-	40 %	-	40%	-
Level 3	Evaluate Create	20 %	-	30 %	-	30 %	-	30 %	-	30%	-
	Total	100 %		100 %		100 %		100 %		100 %	

CLA – 4 can be from any combination of these: Assignments, Seminars, Tech Talks, Mini-Projects, Case-Studies, Self-Study, MOOCs, Certifications, Conf. Paper etc.,

Course Designers		
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2. Mr. Hariharasudhan - Johnson Controls, Pune, hariharasudhan.v@jci.com	*2. Dr. Venkatesan, Sr. Scientist, NIOT, Chennai, venkat@niot.res.in*	

Course Code	18ECE225T	Course Name	INFORMATION THEORY AND CODING	Course Category	E	Professional Elective	L	T	P	C
							3	0	0	3

Pre-requisite Courses	18MAB203T	Co-requisite Courses	Nil	Progressive Courses	Nil
Course Offering Department	Electronics and Communication Engineering	Data Book / Codes/ Standards	Nil		

Course Learning Rationale (CLR):	*The purpose of learning this course is to:*
CLR-1 :	*Introduce source coding in information theory*
CLR-2 :	*Impart the fundamentals of error control coding techniques and their applications*
CLR-3 :	*Address the noisy channel coding problem*
CLR-4 :	*Assess the performance of both block and convolutional coding schemes in different practical situations*
CLR-5 :	*Derive Shannon's fundamental channel capacity results*
CLR-6 :	*Know about channel and impairments channel and how to mitigate them*

Course Learning Outcomes (CLO):	*At the end of this course, learners will be able to:*	Learning 1: Level of Thinking (Bloom)	Learning 2: Expected Proficiency (%)	Learning 3: Expected Attainment (%)	PLO 1: Engineering Knowledge	PLO 2: Problem Analysis	PLO 3: Design & Development	PLO 4: Analysis, Design, Research	PLO 5: Modern Tool Usage	PLO 6: Society & Culture	PLO 7: Environment & Sustainability	PLO 8: Ethics	PLO 9: Individual & Team Work	PLO 10: Communication	PLO 11: Project Mgt. & Finance	PLO 12: Life Long Learning	PLO 13: PSO - 1	PLO 14: PSO - 2	PLO 15: PSO - 3
CLO-1 :	*Comprehend various source coding schemes*	2	80	70	-	H	-	-	-	-	-	-	-	-	-	-	-	-	H
CLO-2 :	*Apply variable length codes for source coding*	2	85	75	-	H	-	-	-	-	-	-	-	-	-	-	-	-	H
CLO-3 :	*Apply linear block codes for error detection and correction*	2	75	70	-	H	-	-	-	-	-	-	-	-	-	-	-	H	-
CLO-4 :	*Apply convolution codes for performance analysis & cyclic codes for error detection and correction.*	2	85	80	-	H	-	-	-	-	-	-	-	-	-	-	-	H	-
CLO-5 :	*Design the channel performance using Information theory*	2	85	75	-	H	-	-	-	-	-	-	-	-	-	-	-	-	H
CLO-6 :	*Analyse any type of channel and select coding techniques to improve channel performance*	2	85	75	-	H	-	-	-	-	-	-	-	-	-	-	-	-	H

Duration (hour)		Source coding	Variable-Length Codes	Error Detecting and Error Correcting Codes	Convolutional Codes	Entropy and Channel Capacity
		9	9	9	9	9
S-1	SLO-1	*Introduction to Information theory*	*Unique decoding*	*Hamming codes Generation*	*Convolutional codes introduction*	*Entropy*
	SLO-2	*Model of signaling system*	*Rules and construction of Unique decoding*	*Hamming code checking*	*Convolutional codes generation*	*Mathematical properties*
S-2	SLO-1	*Block Diagram*	*Instantaneous codes*	*Hamming weight*	*Convolutional encoder*	*Entropy and coding*
	SLO-2	*Mathematical models for information sources*	*Construction of Instantaneous codes*	*Hamming distance*	*Encoder for different rates*	*System entropies*
S-3	SLO-1	*Encoding a source alphabet*	*The Kraft's inequality*	*Minimum distance decoding*	*code tree formation*	*Mutual information*
	SLO-2	*Source coding*	*Shortened block codes*	*Linear block codes Generator polynomial*	*code tree formation*	*Example Problem solving- Mutual information*
S-4	SLO-1	*ASCII code*	*The McMillan's Inequality*	*Linear block codes Generation*	*state diagram generation*	*Shannon-Fano coding*
	SLO-2	*Code Formation for an information*	*Huffman codes*	*Linear block codes Decoding*	*state diagram generation for different rates*	*Example Problem solving- Shannon-Fano coding*
S-5	SLO-1	*Radix r code*	*Huffman codes -special cases*	*Example Problem solving- Linear block codes*	*trellis diagram for decoding convolutional codes*	*Classification of channels*
	SLO-2	*Different examples for different 'r'*	*Extensions of a code*	*Cyclic codes Generator polynomial*	*trellis diagram for decoding convolutional codes*	*Channel Capacity*
S-6	SLO-1	*Simple parity checks – Generator*	*Huffman codes Radix r*	*Cyclic codes Generation*	*Maximum likelihood decoding of convolutional codes*	*Calculation of channel capacity*
	SLO-2	*Simple parity Checker*	*Example Problem solving in Huffman coding*	*Cyclic codes Decoding*	*Maximum likelihood decoding of convolutional codes*	*Types of channel*

S-7	SLO-1	*CRC codes-Generation*	*Example Problem solving in Huffman coding-special cases*	*Example Problem solving -Cyclic codes*	*Sequential decoding of convolutional codes-*	*Conditional mutual information*
	SLO-2	*CRC codes-Checking*	*Noise in Huffman coding probabilities*	*Example Problem solving- Syndrome calculation*	*Sequential decoding of convolutional codes*	*Random encoding*
S-8	SLO-1	*Single parity checks*	*Use of Huffman codes*	*Block encoders*	*Applications of Viterbi decoding*	*Average random code*
	SLO-2	*Double parity checks*	*Hamming coding*	*Block Decoders*	*Viterbi decoding*	*Fano bound*
S-9	SLO-1	*Miscellaneous codes*	*Example Problem solving in Hamming coding*	*Assignment Problems in Linear Block codes*	*Turbo codes*	*Converse of Shannon's theorem*
	SLO-2	*Problems in source coding with different radix and parity*	*Assignment Problems in Huffman and Hamming coding*	*Assignment Problems in Cyclic codes*	*Assignment Problems in Convolutional codes*	*Assignment Problems in Channel capacity and mutual information*

Learning Resources	1. *Kennedy, "Electronic Communication systems", McGraw Hill, 4th Ed., 1999* 2. *Daniel Costello, and Shu Lin, "Error Control coding fundamentals and applications", Prentice Hall Inc, 1983* 3. *Hamming, Richard W, "Coding and Information Theory", Prentice Hall Inc., NJ, 1986.*	4. *Proakis J. G., "Digital Communications", McGraw Hill Inc., 4th Edition, NY, 2001.* 5. *Simon Haykin, "Communication System", Wiley, 2008*

Learning Assessment

	Bloom's Level of Thinking	Continuous Learning Assessment (50% weightage)								Final Examination (50% weightage)	
		CLA – 1 (10%)		CLA – 2 (15%)		CLA – 3 (15%)		CLA – 4 (10%)#			
		Theory	Practice	Theory	Practice	Theory	Practice	Theory	Practice	Theory	Practice
Level 1	Remember Understand	40 %	-	30 %	-	30 %	-	30 %	-	30%	-
Level 2	Apply Analyze	40 %	-	40 %	-	40 %	-	40 %	-	40%	-
Level 3	Evaluate Create	20 %	-	30 %	-	30 %	-	30 %	-	30%	-
	Total	100 %		100 %		100 %		100 %		100 %	

CLA – 4 can be from any combination of these: Assignments, Seminars, Tech Talks, Mini-Projects, Case-Studies, Self-Study, MOOCs, Certifications, Conf. Paper etc.,

Course Designers

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Course Code	18ECE226T	Course Name	OPTICAL COMPONENTS, SYSTEMS AND NETWORKS	Course Category	E	Professional Elective	L	T	P	C
							3	0	0	3

Pre-requisite Courses	18ECC302J	Co-requisite Courses	Nil	Progressive Courses	Nil
Course Offering Department	Electronics and Communication Engineering	Data Book / Codes/Standards	Nil		

Course Learning Rationale (CLR):	*The purpose of learning this course is to:*
CLR-1 :	*Understand the basics working principle of optical fibers, fiber modes configurations and structures.*
CLR-2 :	*Learn the various optical source materials, LED structures, quantum efficiency, Laser diodes. To learn the fiber optical network components, switches, EDFA, SOA.*
CLR-3 :	*Acquire the basic knowledge of fiber optical receivers such as PIN APD diodes, noise performance in photo detector, receiver operation and configuration.*
CLR-4 :	*Get the knowledge on optical wave guides modulators and other signal degradation factors*
CLR-5 :	*Understand the basic working principle of WDM, DWDM etc..*
CLR-6 :	*Understand, the basic optical networks and their applications*

		Learning			Program Learning Outcomes (PLO)														
		1	2	3	1	2	3	4	5	6	7	8	9	10	11	12	13	14	15
Course Learning Outcomes (CLO):	*At the end of this course, learners will be able to:*	Level of Thinking (Bloom)	Expected Proficiency (%)	Expected Attainment (%)	Engineering Knowledge	Problem Analysis	Design & Development	Analysis, Design, Research	Modern Tool Usage	Society & Culture	Environment & Sustainability	Ethics	Individual & Team Work	Communication	Project Mgt. & Finance	Life Long Learning	PSO - 1	PSO - 2	PSO - 3
CLO-1 :	*Familiarize with the fundamentals of light transmission through fiber*	2	80	70	H	M	-	-	-	-	-	-	-	-	-	-	H	-	H
CLO-2 :	*Understand how signal degrades inside the fiber due to physical effects and externally due to various factors like alignment, splicing and connecterization*	2	85	75	H	M	-	-	-	-	-	-	-	-	-	-	H	-	H
CLO-3 :	*Understand the operation of optical sources, amplifiers and detectors and thereby build transmitter and receiver circuits*	2	75	70	H	-	-	H	-	-	-	-	-	-	-	-	H	-	H
CLO-4 :	*Familiarize with optical measurements for performance analysis*	2	85	80	H	M	-	-	-	M	M	-	-	-	-	-	H	-	-
CLO-5 :	*Design a basic optical Communication system*	2	85	75	H	-	H	-	-	-	-	-	-	-	-	-	H	-	M
CLO-6 :	*Acquire fundamental concepts on multichannel system and related components*	2	80	70	-	-	-	-	M	-	-	-	-	-	-	-	-	-	-

Duration (Hour)		Optical Fibers and transmission characteristics	Optical Sources, Amplifier and Transmitter	Optical Detectors and receivers	Optical modulators, switches and OEICs	Optical Communication systems
		9	9	9	9	9
S-1	SLO-1	*Elements of Optical fiber Communication, Optical spectral bands*	*Introduction to Luminescence: Photo, electro, cathodo, injection luminiscence*	*Photo detection principle*	*Electro optic modulators*	*Point to point links*
	SLO-2	*Optical fiber structure, Light Propagation in Optical fibers: Ray theory , Total Internal reflection, Skew rays, Fiber types: SI, GI, MM, SM*	*Plasma display, LCD*	*Photoconductor,*	*Acousto optic modulators*	*Digital and analog systems design considerations*
S-2	SLO-1	*Overview of Modes, Cutoff wavelength and V number,*	*LED: Choice of material,*	*Noise in photoconductors, SNR*	*Interferometry modulators*	*Digital link design,*
	SLO-2	*Problems on v-number*	*LED Structures; Surface and Edge emitters,*	*Response time*	*Semiconductor optical amplifiers*	*Links power budget*
S-3	SLO-1	*Wave Equations for Step index fiber, Modal equation, Modes in SI fibers*	*Quantum efficiency and power, LED Characteristics*	*Problems on response time and SNR*	*Optical switching and logic devices*	*Rise time budget*
	SLO-2	*Problems on V-number, modes*	*Problems on LED quantum efficiency*	*Problems on Photoconductor*	*Problems on modulators*	*Overview of analog links*
S-4	SLO-1	*Special Fibers introduction, Polarization Maintaining fibers,*	*Semiconductor Laser Diode, Operating principles,*	*Photodiode: PIN Photodiode*	*Optical switching*	*Radio over fibers*
	SLO-2	*Photonic Crystal fibers, Dispersion compensated fiber*	*Emission absorption and radiation*	*Avalanche photodiode*	*Logic devices*	*Key link parameters*
S-5	SLO-1	*Attenuation Introduction*	*Population inversion*	*Detector performance parameters*	*Hybrid integration*	*Multichannel systems*

	SLO-2	*Material Adsorption, Scattering, bending and core cladding losses*	*Optical feed- back, Threshold condition*	*Detectors for long wavelength operation*	*Monolithic integration*	*Need for multiplexing*
S-6	SLO-1	*Problems*	*External Quantum efficiency, LASER Characteristics*	*wavelength selective detection*	*Comparison of hybrid and monolithic*	*Operating principle of WDM*
	SLO-2	*Overview of Signal dispersion in fibers*	*Problems on LASER quantum efficiency*	*Fundamental receiver operation*	*Slab waveguides*	*Operating principle of DWDM*
S-7	SLO-1	*Dispersion limitations, Intermodal dispersion*	*Single mode Laser: VCSEL*	*Front end amplifier and decision circuit*	*Strip waveguides*	*WDM components*
	SLO-2	*Intra-Modal dispersion: Material dispersion,*	*Introduction to Fiber Amplifiers*	*Functional block diagram of receiver circuit*	*Guided wave devices*	*Couplers/splitters*
S-8	SLO-1	*Waveguide dispersion and PMD*	*EDFA*	*Measurement standards, basic test equipment*	*Active filters*	*Isolators and circulators*
	SLO-2	*Problems on Dispersion*	*SOA*	*Optical spectrum analyzer*	*Problems*	*Machzender interferometer*
S-9	SLO-1	*Non linear effects : Non linear scattering, Kerr effects*	*Modulation characteristics and Driver circuits*	*Oprtical power meter*	*Integrated Transmitter*	*Fabry perot filters*
	SLO-2	*Fiber alignment and Joint Loss, Fiber Splices Optical fiber connectors, Expanded Beam Connectors*	*Functional block diagram of a Transmitter module*	*OTDR*	*Integrated Receivers*	*Optical MEMS*

Learning Resources

1. *Gerd Keiser, "Optical Fiber Communication" McGraw –Hill International, Singapore, 3rd edition, 2000*
2. *J. Wilson and JF B Hawkes "Optoelectronics – An Introduction"' 3rd Edition PearsonEducation Taiwan Ltd 2010*
3. *Pallab Bhattachara "Semiconductors Optoelectronics Devices", 2nd Edition, Prentice Hall of India Pvt Ltd, New Delhi, 2009.*
4. *Jasprit Singh " Optoelectronics- An Introduction to Materials and Devices",Mc Graw HillEducation India 2014.*
5. *S C Gupta " Optoelectronics Devices and systems", 2nd Edition, Prentice Hall of India, 2015.*
6. *S O Kasap "Optoelectronics and Photonics: Principles and practices", 2nd Edition Person Education International, 2012.*
7. *Rajiv Ramaswami, Kumar N. Sivaranjan, "Optical Networks A practical perspective", 2nd edition, Elsevier, 2004*
8. *Djafar K. Mynbaev, Lowell L. Scheiner, "Fiber-Optic Communications Technology", 1st edition, Pearson Education, 2001.*
9. *John Powers, "An Introduction to Fiber optic Systems", 2nd edition, Irwin-McGraw Hill,1999.*
10. *J.Gowar, "Optical Communication System", 2nd edition, Prentice Hall of India, 2001.*

Learning Assessment

	Bloom's Level of Thinking	Continuous Learning Assessment (50% weightage)								Final Examination (50% weightage)	
		CLA – 1 (10%)		CLA – 2 (15%)		CLA – 3 (15%)		CLA – 4 (10%)#			
		Theory	Practice	Theory	Practice	Theory	Practice	Theory	Practice	Theory	Practice
Level 1	Remember Understand	40 %	-	30 %	-	30 %	-	30 %	-	30%	-
Level 2	Apply Analyze	40 %	-	40 %	-	40 %	-	40 %	-	40%	-
Level 3	Evaluate Create	20 %	-	30 %	-	30 %	-	30 %	-	30%	-
	Total	100 %		100 %		100 %		100 %		100 %	

CLA – 4 can be from any combination of these: Assignments, Seminars, Tech Talks, Mini-Projects, Case-Studies, Self-Study, MOOCs, Certifications, Conf. Paper etc.,

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Course Code	18ECE320T	Course Name	SOFTWARE DEFINED NETWORKS	Course Category	E	Professional Elective	L	T	P	C
							3	0	0	3

Pre-requisite Courses	18ECC303J	Co-requisite Courses	Nil	Progressive Courses	Nil
Course Offering Department	Electronics and Communication Engineering		Data Book / Codes/Standards	Nil	

Course Learning Rationale (CLR):	*The purpose of learning this course is to:*
CLR-1 :	*Understanding SDN- Evolution*
CLR-2 :	*Understanding The Control Plane, Data Plane of SDN*
CLR-3 :	*Analyze and understand various SDN controller*
CLR-4 :	*Create insights to the standard Open Flow for SDN*
CLR-5 :	*understand the Network Programmability for SDN and SDN Open Source*
CLR-6 :	*understand the Application of SDN and role of SDN in 5G*

Course Learning Outcomes (CLO):	*At the end of this course, learners will be able to:*	Learning 1 Level of Thinking (Bloom)	2 Expected Proficiency (%)	3 Expected Attainment (%)	PLO 1 Engineering Knowledge	2 Problem Analysis	3 Design & Development	4 Analysis, Design, Research	5 Modern Tool Usage	6 Society & Culture	7 Environment & Sustainability	8 Ethics	9 Individual & Team Work	10 Communication	11 Project Mgt. & Finance	12 Life Long Learning	13 PSO - 1	14 PSO - 2	15 PSO - 3
CLO-1 :	*understand the SDN architecture and benefit*	2	80	70	H	-	-	-	H	-	-	-	-	-	-	-	-	H	-
CLO-2 :	*Analyze and compare available SDN controller*	2	85	75	H	-		H	H	-	-	-	-	-	-	-	-	-	H
CLO-3 :	*Program the SDN elements*	2	75	70	H		H	H	-	-	-	-	-	-	-	-	H	-	-
CLO-4 :	*Apply NVF for next generation networks and 5G*	2	85	80	H	H	H	H	H	-	-	-	-	-	-	-	-	-	H
CLO-5 :	*Understand the possible application of SDN*	2	85	75	H	-		H	-	-	-	-	-	-	-	-	-	-	-
CLO-6 :	*Understand standard OpenFlow*	2	80	70	H	-	H	-	H	-	-	-	-	-	-	-	-	-	-

Duration (hour)		Basics of SDN	SDN Devices and Controller	OpenFlow, Programmability and Management Interface	SDN Application and Use Case	SDN Implementation and Mobile Networks
		9	9	9	9	9
S-1	SLO-1	*Introduction to SDN- Evolution of Switches and Control Planes , Cost*	*How SDN Works- Fundamental Characteristics of SDN*	*OpenFlow Overview- The OpenFlow Switch, The OpenFlow Controller,*	*SDN in the Data Center - Data Center Definition, Data Center Demands*	*SDN Open Source-Chapter-Specific Terminology ,Open Source Licensing Issues*
	SLO-2	*Introduction to SDN - SDN Implications for Research and Innovation*	*SDN Operation, SDN Devices*	*The OpenFlow Protocol, The OpenFlow Protocol*	*Tunneling Technologies for the Data Center.*	*Profiles of SDN Open Source Users ,OpenFlow Source Code,*
S-2	SLO-1	*need of SDN- Data Center Innovation,*	*SDN Controller*	*OpenFlow 1.0 and OpenFlow Basics- Ports and Port Queues, Flow Table, Packet Matching,*	*Path Technologies in the Data Cente Ethernet Fabrics in the Data Center*	*Switch Implementations , Controller Implementations SDN Applications*
	SLO-2	*need of SDN- Data Center Needs*	*SDN Applications ,Alternate SDN Methods*	*Actions and Packet Forwarding, Messaging Between Controller and Switch*	*SDN Use Cases in the Data Center*	*Simulation, Testing, and Tools, OpenStack, Example: Applying SDN Open Source .*
S-3	SLO-1	*Genesis of SDN- The Evolution of Networking Technology*	*General Concepts of SDN Controller*	*Example: Controller Programming Flow Table ,Example: Basic Packet Forwarding, Example: Switch Forwarding Packet to Controller*	*Open SDN versus Overlays in the Data Center*	*SDN Futures-Current State of Affairs*
	SLO-2	*the Genesis of SDN- forerunners of SDN*	*VMware*	*OpenFlow 1.3 Additions and OpenFlow Limitations*	*Real-World Data Center Implementations*	*Potential Novel Applications of Open SDN*
S-4	SLO-1	*the Genesis of SDN- software Defined Networking is Born, Sustaining SDN Interoperability*	*Nicira*	*Introduction to Network Programmability and The Management Interface*	*SDN in Other Environments - Wide Area Networks. Service Provider and Carrier Networks*	*role of SDN in 5G- Drawback of hardware-based network functions., Network Functions Virtualization (NFV) and Software Defined Networking (SDN) in 5G*
	SLO-2	*Open Source Contributions, Legacy Mechanisms Evolve Toward SDN , Network Virtualization*	*VMware/Nicira*	*The Application-Network Divide*	*Campus Networks, Hospitality Networks*	*optimization models that aim at finding the optimal design for a mobile core network based on SDN and NFV*

S-5	SLO-1	*The Control Plane, Data Plane*	*OpenFlow-Related*	*Modern Programmatic Interfaces- Publish and Subscribe Interfaces, XMPP*	*Mobile Networks. In-Line Network Functions,*	*SDN and NFV Mobile Network Architectures*
	SLO-2	*Moving Information Between Planes, Separation Importance*	*Mininet ,NOX/POX*	*Google's Protocol Buffers , Thrift ,JSON*	*Optical Networks*	*Dimensioning and Resource Allocation Problems*
S-6	SLO-1	*Distributed Control Planes- IP and MPLS, Creating IP Underlay, Convergence Time*	*Trema, Ryu*	*I2RS 143 Modern Orchestration- OpenStack*	*SDN vs. P2P/Overlay Networks*	*Mobile Core Network Architecture*
	SLO-2	*Load Balancing ,High Availability, Creating the MPLS Overlay, Replication*	*Big Switch Networks/Floodlight,*	*CloudStack, puppet*	*SDN Applications- reactive versus Proactive Applications ,Analyzing Simple SDN Applications ,*	*SDN Mobile Core Network Architecture*
S-7	SLO-1	*Centralized Control Planes- Logical Versus Literal*	*Layer 3 Centric, L3VPN*	*Introduction to Network Function Virtualization, Virtualization and Data Plane I/O*	*A Simple Reactive Java Application, Background on Controllers*	*NFV Mobile Core Network Architecture*
	SLO-2	*ATM/LANE ,Route Servers*	*Path Computation Element Server*	*Services Engineered Path*	*Using the Floodlight Controller, Using the OpenDaylight Controller, Using the Cisco XNC Controller, Using the Hewlett-Packard Controller.*	*Data Plane Function Chains Analysis*
S-8	SLO-1	*Introduction to OpenFlow- Wire Protocol*	*Path Computation Element Server*	*Service Locations and Chaining*	*witch Considerations, Creating Network Virtualization Tunnels, Offloading Flows in the Data Center, Access Control for the Campus, Traffc Engineering for Service Providers*	*Control Plane Function Chains Analysis*
	SLO-2	*Replication ,FAWG (Forwarding Abstraction Workgroup)*	*Plexxi Plexxi Affinity*	*Non-ETSI NFV Work- Middlebox Studie*	*SDN Use Cases- Use Cases for Bandwidth Scheduling*	*requirements & challenges of SDN and NVF In 5G*
S-9	SLO-1	*Configuration and Extensibility, Architecture*	*Cisco OnePK*	*Embrane/LineRate*	*Big Data and Application Hyper-Virtualization for Instant CSPF*	*Existing Solutions*
	SLO-2	*Hybrid Approaches , Ships in the Night ,Dual Function Switches*	*Relation to Idealized SDN Framework*	*Platform Virtualization*	*use Cases for Input Traffic Monitoring, Classification, and Triggered Action*	*future directions*

Learning Resources	1. *Software Defined Networks: A Comprehensive Approach by Paul Goransson and Chuck Black, Morgan Kaufmann Publications, 2014* 2. *SDN - Software Defined Networks by Thomas D. Nadeau & Ken Gray, O'Reilly, 2013* 3. *Cho, Hsin-Hung, et al. "Integration of SDR and SDN for 5G." IEEE Access 2 (2014): 1196-1204.*	4. *Bouras, Christos, Anastasia Kollia, and Andreas Papazois. "SDN & NFV in 5G: Advancements and challenges." Innovations in Clouds, Internet and Networks (ICIN), 2017 20th Conference on. IEEE, 2017.* 5. *Arsany Basta; Andreas Blenk; Klaus Hoffmann; Hans Jochen Morper; Marco Hoffmann; Wolfgang Kellerer, Towards a Cost Optimal Design for a 5G Mobile Core Network Based on SDN and NFV,,IEEE Transactions on Network and Service Management, 2017, Volume: 14, Issue: 4 ,Pages: 1061 - 1075*

Learning Assessment

	Bloom's Level of Thinking	Continuous Learning Assessment (50% weightage)								Final Examination (50% weightage)	
		CLA – 1 (10%)		CLA – 2 (15%)		CLA – 3 (15%)		CLA – 4 (10%)#			
		Theory	Practice	Theory	Practice	Theory	Practice	Theory	Practice	Theory	Practice
Level 1	Remember Understand	40 %	-	30 %	-	30 %	-	30 %	-	30%	-
Level 2	Apply Analyze	40 %	-	40 %	-	40 %	-	40 %	-	40%	-
Level 3	Evaluate Create	20 %	-	30 %	-	30 %	-	30 %	-	30%	-
	Total	100 %		100 %		100 %		100 %		100 %	

CLA – 4 can be from any combination of these: Assignments, Seminars, Tech Talks, Mini-Projects, Case-Studies, Self-Study, MOOCs, Certifications, Conf. Paper etc.,

Course Designers

Experts from Industry	Experts from Higher Technical Institutions	Internal Experts
1. Mr. Anuj Kumar, Bombardier Transportation, Ahmedabad, kumaranuj.anii@gmail.com	*1. Dr. Meenakshi, Professor of ECE, CEG, Anna University, meena68@annauniv.edu*	*1. Dr. P. Vijayakumar, SRMIST*
2. Mr. Hariharasudhan - Johnson Controls, Pune, hariharasudhan.v@jci.com	*2. Dr. Venkatesan, Sr. Scientist, NIOT, Chennai, venkat@niot.res.in*	

Course Code	18ECE322T	Course Name	OPTOELECTRONICS	Course Category	E	Professional Elective	L	T	P	C
							3	0	0	3

Pre-requisite Courses	18ECC102J	Co-requisite Courses	Nil	Progressive Courses	Nil
Course Offering Department	Electronics and Communication Engineering		Data Book / Codes/Standards	Nil	

Course Learning Rationale (CLR):	*The purpose of learning this course is to:*
CLR-1 :	*Identify the working and nature of optical wave*
CLR-2 :	*Identify the working and nature of optical semiconductors*
CLR-3 :	*Analyze the working principles of different photonic sources*
CLR-4 :	*Analyze the working principles of different photonic detectors*
CLR-5 :	*Create knowledge about various optoelectronic applications*
CLR-6 :	*Familiarize the concepts of optoelectronic integrated circuits*

		Learning			Program Learning Outcomes (PLO)														
		1	2	3	1	2	3	4	5	6	7	8	9	10	11	12	13	14	15
Course Learning Outcomes (CLO):	*At the end of this course, learners will be able to:*	Level of Thinking (Bloom)	Expected Proficiency (%)	Expected Attainment (%)	Engineering Knowledge	Problem Analysis	Design & Development	Analysis, Design, Research	Modern Tool Usage	Society & Culture	Environment & Sustainability	Ethics	Individual & Team Work	Communication	Project Mgt. & Finance	Life Long Learning	PSO - 1	PSO - 2	PSO - 3
CLO-1 :	*Review the basics of optics, optical semiconductors*	*2*	*85*	*80*	*H*	*H*	-	-	-	-	-	-	-	-	-	*M*	-	-	-
CLO-2 :	*Understand the working principle of different photonic sources*	*4*	*85*	*75*	*H*	*H*	*H*	*H*	-	-	-	-	-	-	-	*M*	*L*	-	*H*
CLO-3 :	*Familiarize the principle and operation of various detectors*	*4*	*85*	*75*	*H*	*H*	*H*	*H*	-	-	-	-	-	-	-	*M*	*L*	-	*H*
CLO-4 :	*Acquire knowledge of various optoelectronic modulators and switches*	*4*	*80*	*70*	*H*	*H*	-	-	-	-	-	-	-	-	-	*M*	-	-	-
CLO-5 :	*Explore the concepts of optoelectronic integrated circuits and components*	*4*	*80*	*70*	*H*	-	*H*	-	-	-	-	-	-	-	-	*M*	*L*	-	-
CLO-6 :	*Design and analyze the working of different components in optical system and use it for various applications.*	*4*	*80*	*70*	*H*	*H*	*H*	*H*	-	-	-	-	-	-	-	*M*	-	-	*H*

Duration (hour)		Wave nature of light and semiconductor optics	Semiconductor photon sources and display devices	Semiconductor photon detectors	Optoelectronic modulators, interconnects and switches	Optoelectronic integrated circuits (oeic) and applications
		9	9	9	9	9
S-1	SLO-1	*Light Waves In A Homogeneous Medium-Plane electromagnetic wave, Maxwell's wave equation*	*LED Principles- Homojunction LED, Heterostructure LED*	*Principle of Photo Detection*	*Electro-Optic Modulator: Principles, Electro optic effect*	*Introduction*
	SLO-2	*Refractive Index And Dispersion- Sellmeier equation and diamond, Cauchy equation and diamond*	*Quantum Well High Intensity LEDs*	*The PIN Photodiode*	*Single waveguide electro optic modulators*	*Need For Integration*
S-2	SLO-1	*Polarization Of Light*	*LED Materials and Structures*	*Avalanche Photodiode- Principles, Structures*	*Dual channel waveguide electro optic modulator*	*Slab and stripe waveguides*
	SLO-2	*Snell's law and Total internal reflection*	*LED Efficiencies and Luminous Flux*	*Responsivit, Efficiency*	*Electro optic modulator employing reflection or Diffraction*	*Basic IO structural elements*
S-3	SLO-1	*Reflection And Refraction*	*Manufacturing Process and Applications*	*Heterojunction Photodiodes*	*Integrated Optical Modulators: Phase and polarization modulation*	*IO devices: Optical disk read head*
	SLO-2	*Solving problems*	*Solving Problems*	*Schottky Junction Photodetectors*	*Mach Zehnder modulator, Coupled waveguide modulator*	*OIC temperature sensor*
S-4	SLO-1	*Superposition And Interference Of Waves*	*LASER: Threshold Condition*	*Solving problems*	*Acousto-Optic Modulator: Principles, Acousto optic effect, Raman nath and Bragg type modulators*	*IO high voltage sensor*

	SLO-2	*Diffraction Principles- Fraunhofer diffraction, Diffraction Grating*	*Emission and Absorption of Radiation*	*Solving problems*	*Performance characteristics, Acousto optic frequency shifters*	*IO chemical sensor*
S-5	SLO-1	*Overview Of Semiconductors*	*Population Inversion*	*Metal-Semiconductor, Metal Photodiode*	*Solving problems*	*IO wavelength meters and spectrum analyzers*
	SLO-2	*Interaction of Photons With Charge Carriers*	*Principle of the Laser Diode*	*Phototransistors*	*Solving problems*	*RF Spectrum Analyzer*
S-6	SLO-1	*Hole Pair Formation And Recombination*	*Heterostructure Laser Diodes*	*Array Detectors*	*Faraday Rotation*	*Monolithic Wavelength-Multiplexed Optical Source*
	SLO-2	*Absorption In Semiconductors*	*Device Fabrication*	*Photoconductive detectors*	*Optical Isolators*	*Analog-To-Digital Converter*
S-7	SLO-1	*Effect Of Electric Field On Absorption*	*Solving problems*	*Noise In Photodetectors*	*Nonlinear Optics*	*Integrated-Optic Doppler Velocimeter*
	SLO-2	*Absorption In Quantum Wells*	*Display Device: Photo Luminescence*	*Noise In Photodetectors*	*Second Harmonic Generation*	*Guided Wave Devices*
S-8	SLO-1	*Radiation In Semiconductors*	*Cathode Luminescence, Electro Luminescence*	*Solving problems*	*Optical Interconnects*	*Guided Wave Devices*
	SLO-2	*Solving Problems*	*Injection Luminescence*	*Solving problems*	*Optical gates*	*OEIC: Transmitter*
S-9	SLO-1	*Heterojunctions*	*Plasma Displays*	*Charge Coupled Devices (CCD)*	*Photonic Switches*	*OEIC: Receiver*
	SLO-2	*Heterojunctions*	*LCD, Numeric Displays*	*Charge Coupled Devices (CCD)*	*Solving problems*	*OEIC phased array antenna driver*

Learning Resources	1. *Kasap, "Optoelectronics & Photonics: Principles & Practices", 2nd edition, Pearson Education, 2013.* 2. *Pallab Bhattacharya "Semiconductor Optoelectronic Devices", 2nd Edition, Prentice Hall of India Pvt. Ltd, New Delhi, 2009.* 3. *B. E. A. Saleh and m.c. Teich, "Fundamentals Of Photonics," 2nd edition, John Wiley & Sons, Inc. 2007.*	4. *Robert G. Hunsperger, "Integrated Optics- Theory And Technology", Springer, 2009* 5. *J. Wilson and J F B Hawkes "Optoelectronics- An Introduction", 3rd edition, Pearson Education Taiwan Ltd, 2010.* 6. *A Ghatak and K Thyagarajan, "Introduction to Fiber Optics", Cambridge University Press 2006.*

Learning Assessment

	Bloom's Level of Thinking	Continuous Learning Assessment (50% weightage)								Final Examination (50% weightage)	
		CLA – 1 (10%)		CLA – 2 (15%)		CLA – 3 (15%)		CLA – 4 (10%)			
		Theory	Practice	Theory	Practice	Theory	Practice	Theory	Practice	Theory	Practice
Level 1	Remember Understand	40%	-	40%	-	35%	-	35%	-	40%	-
Level 2	Apply Analyze	40%	-	40%	-	35%	-	35%	-	40%	-
Level 3	Evaluate Create	20%	-	20%	-	30%	-	30%	-	20%	-
	Total	100 %		100 %		100 %		100 %		100 %	

CLA – 4 can be from any combination of these: Assignments, Seminars, Tech Talks, Mini-Projects, Case-Studies, Self-Study, MOOCs, Certifications, Conf. Paper etc.,

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2. Mr. Hariharasudhan - Johnson Controls, Pune, hariharasudhan.v@jci.com	*2. Dr. Venkatesan, Sr. Scientist, NIOT, Chennai, venkat@niot.res.in*	

Course Code	18ECE323T	Course Name	ADVANCED OPTICAL COMMUNICATION	Course Category	E	Professional Elective	L	T	P	C
							3	0	0	3

Pre-requisite Courses	18ECC302J	Co-requisite Courses	Nil	Progressive Courses	Nil
Course Offering Department	Electronics and Communication Engineering			Data Book / Codes/Standards	Nil

Course Learning Rationale (CLR):	*The purpose of learning this course is to:*
CLR-1 :	*Introduce the advanced features of Fibers and light wave system*
CLR-2 :	*Illustrate the basics of light wave system and multichannel system*
CLR-3 :	*Understand the various dispersion compensation techniques*
CLR-4 :	*Gain the information on advanced RoF Systems*
CLR-5 :	*Improve the knowledge about the characterization of the Visible Light Communication*
CLR-6 :	*Utilize the concepts in optical Communication for the understanding of engineering and technology*

		Learning			Program Learning Outcomes (PLO)														
		1	2	3	1	2	3	4	5	6	7	8	9	10	11	12	13	14	15
Course Learning Outcomes (CLO):	At the end of this course, learners will be able to:	Level of Thinking (Bloom)	Expected Proficiency (%)	Expected Attainment (%)	Engineering Knowledge	Problem Analysis	Design & Development	Analysis, Design, Research	Modern Tool Usage	Society & Culture	Environment & Sustainability	Ethics	Individual & Team Work	Communication	Project Mgt. & Finance	Life Long Learning	PSO - 1	PSO - 2	PSO - 3
CLO-1 :	*Explain the concept of wave propagation and dispersion in single-mode fibers, loss and nonlinear of fiber and fiber design and fabrication.*	*2*	*80*	*70*	*H*	*H*	*M*	*H*	*H*	-	*L*	-	-	*H*	-	-	*H*	*M*	*H*
CLO-2 :	*Apply the concept of optical transmitter and receiver in single-mode semiconductor lasers, light-emitting diodes, transmitter design and receiver design*	*2*	*85*	*75*	*H*	*H*	*M*	*H*	*H*	-	*L*	-	-	*H*	-	-	*H*	*M*	*H*
CLO-3 :	*Demonstrate the concept of long-haul systems, computer-aided design, WDM light wave systems, WDM Components, time-division, subcarrier and code division multiplexing*	*2*	*75*	*70*	*H*	*H*	*M*	*H*	*H*	-	*L*	-	-	*H*	-	-	*H*	*M*	*H*
CLO-4 :	*Explain the loss and dispersion managements in EDFA - Raman amplifiers, dispersion compensating fibers Fiber Bragg gratings, dispersion-equalizing filters and optical phase conjugation*	*2*	*85*	*80*	*H*	*H*	*M*	*H*	*H*	-	*L*	-	-	*H*	-	-	*H*	*M*	*H*
CLO-5 :	*Apply the concept of advanced light wave system in demodulation schemes sensitivity degradation mechanisms and impact of nonlinear effects*	*2*	*85*	*75*	*H*	*H*	*M*	*H*	*H*	-	*L*	-	-	*H*	-	-	*H*	*M*	*H*
CLO-6 :	*Apply their idea in Optical Communication module*	*2*	*80*	*70*	*H*	*H*	*M*	*H*	*H*	-	*L*	-	-	*H*	-	-	*H*	*M*	*H*

Duration (hour)		Optical fibers and lightwave systems	Lightwave systems and multichannel systems	Loss management and dispersion management	Radio over fiber systems	Optical wireless Communication
		9	9	9	9	9
S-1	SLO-1	*Geometrical-Optics Description*	*System Architectures*	*Compensation of Fiber Losses*	*Trends in Wireless Communications*	*Free-space optical wireless Communication*
	SLO-2	*Wave Propagation*	*Working Principles*	*Erbium-Doped Fiber Amplifiers les*	*Basic Transmission problems and solutions*	*Free-space optical OFDM Communication*
S-2	SLO-1	*Dispersion in Single-Mode Fibers*	*Design Guidelines*	*Raman Amplifiers*	*Regulation*	*Wireless optical CDMA Communication systems*
	SLO-2	*Dispersion Induced Limitations*	*Long-Haul Systems*	*Optical Signal-To-Noise Ratio*	*Standardization*	*Comparison of Free-space optical OFDM & CDMA Communication*
S-3	SLO-1	*Fiber Losses*	*Sources of Power Penalty*	*Electrical Signal-To-Noise Ratio*	*System concepts for the central processing of signals*	*Indoor wireless optical Communication*
	SLO-2	*Nonlinear Optical Effects*	*Forward Error Correction*	*Receiver Sensitivity and Q Factor*	*Wireless Trends*	*outdoor wireless optical Communication*
S-4	SLO-1	*Fiber Design and Fabrication*	*Types of FEC*	*role of Dispersive and Nonlinear Effects*	*Architecture options,*	*Heterogeneous optical networks (HONs)*

	SLO-2	*multicore fibers*	*Computer-Aided Design*	*Periodically Amplified Lightwave Systems*	*global centralized Architecture*	*System Performance*
S-5	SLO-1	*multiclad fibers*	*WDM*	*Dispersion Problem*	*FUTON scenarios*	*VLC System Model*
	SLO-2	*advantages and its applications*	*DWDM*	*Its Solution*	*Optical Infrastructure*	*Advantages and its applications*
S-6	SLO-1	*Advanced Modulation Formats*	*Light wave Systems*	*Dispersion-Compensating Fibers*	*Concepts of Radio over Fiber systems*	*(RF) sensor network system*
	SLO-2	*Demodulation Schemes*	*WDM Components*	*Fiber Bragg Gratings*	*Features of ROF*	*Advantages and its applications*
S-7	SLO-1	*Shot Noise*	*System Performance Issues*	*Dispersion Equalizing Filters*	*Categories RoF systems*	*(FSO) sensor network system*
	SLO-2	*Bit-Error Rate*	*Time-Division Multiplexing*	*Optical Phase Conjugation*	*Performances RoF systems*	*Advantages and its applications*
S-8	SLO-1	*Sensitivity Degradation Mechanisms*	*Subcarrier Multiplexing*	*Channels at High Bit Rates*	*Applications of RoF Technology*	*Recent Advancement in Optical Wireless Communication*
	SLO-2	*Impact of Nonlinear Effects*	*Code-Division Multiplexing*	*Electronic Dispersion Compensation*	*Advantages of RoF Technology*	*Advantages and its applications*
S-9	SLO-1	*Recent Progress*	*Solving Problems*	*Solving Problems*	*Solving Problems*	*Solving Problems*
	SLO-2	*Ultimate Channel Capacity*	*Solving Problems*	*Solving Problems*	*Solving Problems*	*Solving Problems*

Learning Resources	1. *Nathan J. Gomes, Paulo P. Monteiro and Atilio Gameiro "Next Generation wireless Communications using Radio over Fiber" John Wiley & Sons, Ltd, 2012* 2. *G.P. Agarwal, Fiber optic Communication systems, 4nd Ed, John Wiley & Sons, New York, 2010*	3. *ShlomiArnon, John R. Barry, George K. Karagiannidis, Robert Schober, Murat Uysal, "Advanced Optical Wireless Communication Systems" Cambridge University Press, 2012* 4. *Shlomi Arnon, "Visible light Communication", Cambridge University Press, 2015*

Learning Assessment

	Bloom's Level of Thinking	Continuous Learning Assessment (50% weightage)								Final Examination (50% weightage)	
		CLA – 1 (10%)		CLA – 2 (15%)		CLA – 3 (15%)		CLA – 4 (10%)#			
		Theory	Practice	Theory	Practice	Theory	Practice	Theory	Practice	Theory	Practice
Level 1	Remember Understand	40 %	-	30 %	-	30 %	-	30 %	-	30%	-
Level 2	Apply Analyze	40 %	-	40 %	-	40 %	-	40 %	-	40%	-
Level 3	Evaluate Create	20 %	-	30 %	-	30 %	-	30 %	-	30%	-
	Total	100 %		100 %		100 %		100 %		100 %	

CLA – 4 can be from any combination of these: Assignments, Seminars, Tech Talks, Mini-Projects, Case-Studies, Self-Study, MOOCs, Certifications, Conf. Paper etc.,

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Course Code	18ECE243J	Course Name	DIGITAL IMAGE AND VIDEO PROCESSING	Course Category	E	Professional Elective	L	T	P	C
							2	0	2	3

Pre-requisite Courses	18ECC204J	Co-requisite Courses	Nil	Progressive Courses	Nil
Course Offering Department	Electronics and Communication Engineering			Data Book / Codes/Standards	Nil

Course Learning Rationale (CLR):	*The purpose of learning this course is to:*
CLR-1 :	*Introduce the fundamentals of image processing and transforms*
CLR-2 :	*Understand the concepts of image enhancement and restoration*
CLR-3 :	*Acquire knowledge on image compression and segmentation methods*
CLR-4 :	*Gain knowledge on basics of video processing*
CLR-5 :	*Know about motion estimation methods in video processing*
CLR-6 :	*Utilize the concepts of image and video processing for practical applications*

Course Learning Outcomes (CLO):	*At the end of this course, learners will be able to:*	Learning 1	Learning 2	Learning 3	Program Learning Outcomes (PLO) 1	2	3	4	5	6	7	8	9	10	11	12	13	14	15
		Level of Thinking (Bloom)	Expected Proficiency (%)	Expected Attainment (%)	Engineering Knowledge	Problem Analysis	Design & Development	Analysis, Design, Research	Modern Tool Usage	Society & Culture	Environment & Sustainability	Ethics	Individual & Team Work	Communication	Project Mgt. & Finance	Life Long Learning	PSO - 1	PSO - 2	PSO - 3
CLO-1 :	*Understand the basics of digital image processing fundamentals and transforms*	*1,2*	*95*	*70*	*L*	-	-	-	-	-	-	-	-	-	-	*H*	*M*	-	-
CLO-2 :	*Design 2D filters and apply it for image enhancement and restoration*	*2*	*90*	*70*	*M*	*H*	-	*H*	*H*	-	-	-	-	-	-	*H*	*M*	-	*H*
CLO-3 :	*Apply image compression and segmentation methods on digital images*	*2*	*90*	*65*	*M*	*H*	-	*H*	*H*	-	-	-	-	-	-	*H*	-	-	*H*
CLO-4 :	*Analyze the video formation techniques*	*1*	*95*	*70*	*H*	*H*	-	*H*	*H*	-	-	-	-	-	-	*H*	-	-	*H*
CLO-5 :	*Learn about the techniques for applying motion estimation in video coding*	*1,2*	*90*	*65*	*M*	*H*	-	*H*	*H*	-	-	-	-	-	-	*H*	-	-	*H*
CLO-6 :	*Apply the concepts of digital image, video processing and their applications*	*1,2*	*90*	*70*	-	-	-	-	-	-	-	-	-	-	-	-	*M*	-	*H*

Duration (hour)		Digital Image Fundamentals and Image Transforms	Image Enhancement and Restoration	Image Compression and Segmentation	Basic Steps of Video Processing	2D Motion Estimation
		12	12	12	12	12
S-1	SLO-1	*Origin of digital image processing*	*Some basic intensity transformation functions – image negatives, log transformations*	*Fundamentals of image compression-coding redundancy, spatial and temporal redundancy*	*Analog video signals, standard*	*2D motion estimation – Optical flow – 2D motion vs. apparent motion*
	SLO-2	*Fundamental steps in digital image processing*	*Piecewise linear transformation functions*	*Irrelevant information, measuring image information*	*Digital video signal, standard, Digital video processing*	*Correspondence and optical flow*
S-2	SLO-1	*Components of an image processing system*	*Histogram equalization, Matching*	*Image compression model, Lossless compression, Huffman coding*	*Time varying image formation models – 3D motion models*	*Occlusion problem*
	SLO-2	*Structure of human eye, Image formation*	*Local Histogram Processing*	*Arithmetic Coding, Run length coding*	*Rigid motion in Cartesian, Homogenous coordinates*	*Aperture problem, 2D motion field models*
S- 3-4	SLO-1 SLO-2	*Lab 1: To learn MATLAB software and its basic commands for image processing*	*Lab 4: Histogram Modifications*	*Lab 7: Run length coding*	*Lab 10: Wavelet coding*	*Lab 13: Convert video into frames and process them*
S-5	SLO-1	*Brightness adaptation and discrimination*	*Using histogram statistics for image enhancement*	*Lossy compression - Transform coding*	*Deformable motion*	*Block motion models- translational block motion*

	SLO-2	Basic concepts in sampling and Quantization , Representing digital images	Smoothing linear filters	Wavelet coding	Geometric image formation	Generalized/ Deformable block motion
S-6	SLO-1	Neighbors of a pixel, Adjacency, Connectivity, Regions and Boundaries	Order statistics nonlinear filters	Image segmentation – detection of isolated points, line detection	Perspective projection	Block matching criteria, Matching procedures
	SLO-2	Distance Measures, A simple image formation model	Sharpening spatial filters	Edge models, Basic edge detection	Photometric image formation	Hierarchical motion estimation
S- 7-8	SLO-1	Lab 2: Fourier analysis of image	Lab 5: Image smoothing and sharpening	Lab 8: Basic edge detection operations	Lab 11: JPEG Compression	Lab 14:Filtering video signals
	SLO-2					
S-9	SLO-1	Fourier transform of sampled functions	Combined spatial enhancement methods	Region based segmentation – region growing	Photometric effects of 3D motion	Gradient based optimization
	SLO-2	Sampling theorem, Aliasing, Obtaining the DFT from the Continuous Transform of a Sampled Function	Homomorphic filtering, A model of image degradation/ restoration process	Region splitting and merging	Observation noise, Sampling structures of analog, digital video	Steepest Descent method
S-10	SLO-1	Properties of 2D DFT – Relationship between spatial and frequency interval, Translation and Rotation, Periodicity, symmetric properties	A model of image degradation/ restoration process, Noise models	Spatial, frequency domain techniques	2D fourier transform relations, Intra frame filtering- LMMSE filtering	Newton Raphson method, Transform coding , 3D waveform coding
	SLO-2	DWT, DCT	Singular value decomposition	Texture based segmentation	Median and weighted median filtering, Motion detection based filtering	Local vs. Global minima, Predictive coding
S- 11 - 12	SLO-1	Lab 3: Image filtering	Lab 6: Singular value decomposition	Lab 9: Repeat/Revision of experiments	Lab 12: Region based image segmentation	Lab 15: Mini project
	SLO-2					

Learning Resources	1. Rafael C Gonzalez, Richard E Woods, "Digital Image Processing"- 3rd Edition, Pearson Education 2008. 2. Yao wang, JoemOstarmann and Ya – quin Zhang, "Video processing and Communication ",1st edition , PHI 3. M. Tekalp ,"Digital video Processing", Prentice Hall International	4. A.K. Jain, "Fundamentals of Digital Image Processing". Pearson education 5. William K Pratt, "Digital Image Processing", John Willey (2001).

Learning Assessment											
	Bloom's Level of Thinking	Continuous Learning Assessment (50% weightage)								Final Examination (50% weightage)	
		CLA – 1 (10%)		CLA – 2 (15%)		CLA – 3 (15%)		CLA – 4 (10%)#			
		Theory	Practice	Theory	Practice	Theory	Practice	Theory	Practice	Theory	Practice
Level 1	Remember Understand	20%	20%	15%	15%	15%	15%	15%	15%	15%	15%
Level 2	Apply Analyze	20%	20%	20%	20%	20%	20%	20%	20%	20%	20%
Level 3	Evaluate Create	10%	10%	15%	15%	15%	15%	15%	15%	15%	15%
	Total	100 %		100 %		100 %		100 %		-	

CLA – 4 can be from any combination of these: Assignments, Seminars, Tech Talks, Mini-Projects, Case-Studies, Self-Study, MOOCs, Certifications, Conf. Paper etc.,

Course Designers		
Experts from Industry	Experts from Higher Technical Institutions	Internal Experts
1. Mr. Anuj Kumar, Bombardier Transportation, Ahmedabad, kumaranuj.anii@gmail.com	1. Dr. Meenakshi, Professor of ECE, CEG, Anna University, meena68@annauniv.edu	1. Dr. S. Dhanalakshmi, SRMIST
2. Mr. Hariharasudhan - Johnson Controls, Pune, hariharasudhan.v@jci.com	2. Dr. Venkatesan, Sr. Scientist, NIOT, Chennai, venkat@niot.res.in	2. Mrs. S. Latha, SRMIST

Course Code	18ECE244J	Course Name	DSP SYSTEM DESIGN	Course Category	E	Professional Elective	L	T	P	C
							2	0	2	3

Pre-requisite Courses	18ECC204J	Co-requisite Courses	Nil	Progressive Courses	Nil
Course Offering Department	Electronics and Communication Engineering	Data Book / Codes/Standards	IEEE 1641-2010, IEEE 754, IEEE Standard. 1149.1		

Course Learning Rationale (CLR):	*The purpose of learning this course is to:*
CLR-1 :	*Acquire knowledge on Floating and Fixed point Processor such as TMS320C6X for complex signal*
CLR-2 :	*Learn and code TMS320C6x Assembly level programming for real time signal processing applications*
CLR-3 :	*Design and coding DSP algorithm such as FFT, DFT, Convolution , IIR and FIR filters in TMS320C6x*
CLR-4 :	*Gain knowledge on advance filter concepts and filter signal noise using Filter Bank, adaptive filters and analyzes such filters for high end designing.*
CLR-5 :	*Design DSP system for real time applications.*
CLR-6 :	*Utilize the concept of DSP for Engineering and Technology*

		Learning			Program Learning Outcomes (PLO)														
		1	2	3	1	2	3	4	5	6	7	8	9	10	11	12	13	14	15
Course Learning Outcomes (CLO):	*At the end of this course, learners will be able to:*	Level of Thinking (Bloom)	Expected Proficiency (%)	Expected Attainment (%)	Engineering Knowledge	Problem Analysis	Design & Development	Analysis, Design, Research	Modern Tool Usage	Society & Culture	Environment & Sustainability	Ethics	Individual & Team Work	Communication	Project Mgt. & Finance	Life Long Learning	PSO - 1	PSO - 2	PSO - 3
CLO-1 :	*Acquire in-depth knowledge on DSP architecture and instruction sets of TMS320C6X*	*1*	*85*	*65*	*H*	-	*H*	-	-	-	-	-	-	-	-	-	*H*	*M*	*L*
CLO-2 :	*Attain assembly programming knowledge and analyze using TMS320C6x*	*1, 2*	*85*	*65*	*H*	*H*		*H*	-	-	-	-	-	-	-	-	*H*	*M*	*L*
CLO-3 :	*Implement various DSP algorithm such as FFT, DFT, Convolution , IIR and FIR filters in TMS320C6x*	*2,3*	*85*	*65*	-	*H*	-	*H*	-	-	-	-	-	-	-	-	*M*	*L*	*H*
CLO-4 :	*Acquire knowledge and analyze on Filter Banks and adaptive filters and analyze such filters.*	*1,2*	*85*	*65*	-	*H*	*H*	-	*H*	-	-	-	*H*	-	-	-	*M*	*L*	*H*
CLO-5 :	*Gain knowledge on DSP system design based applications.*	*3*	*85*	*65*	*H*	-	-	-	*H*	-	-	-	*H*	-	-	-	*M*	*L*	*H*
CLO-6 :	*Apply the concept of DSP for real time applications*	*3*	*85*	*65*	-	-	*H*	-	*H*	-	-	-	-	*M*	-	-	*H*	*M*	*M*

Duration (hour)		TMS320C6X Architecture	TMS3206X Assembly Language	Frequency Transforms	Digital Filters	DSP Applications
		15	15	15	15	15
S-1	SLO-1	*Architecture of TMS320C6X*	*TMS320C6X Assembly Language Operations*	*Digital filtering using the DFT*	*Filter banks – Decimation,*	*Dual tone Multi-Frequency (DTMF) Signaling*
	SLO-2	*Pipeline CPU*	*Individual Instruction Descriptions*	*Convolution and correlation*	*Inverse Decimation*	*Software Defined Radio (SDR)*
S-2	SLO-1	*VelociTI, Functional Units,*	*Arithmetic operations, ,*	*Fast Fourier Transform –DIT*	*Perfect Reconstruction*	*QAM Transmitter and QAM Receiver*
	SLO-2	*Addressing modes,*	*logical operations,*	*Fast Fourier Transform –DIT*	*Analysis of M-Band filter Banks*	*Miscellaneous Projects--FSK Modem*
S-3	SLO-1	*Lab1: Generation of sequences (functional & random) (Matlab)*	*Lab 7: MAC operation using various addressing modes*	*Lab 13: Spectrum analysis using DFT(Matlab)*	*Lab 19: FIR Implementation using TMS Processor*	*Lab 25: Equalization (Matlab)*
	SLO-2					
S-4	SLO-1	*Lab 2: Correlation(Matlab)*	*Lab 8: MAC operation using various addressing modes*	*Lab 14: FFT Implementation(DSP processor)*	*Lab 20: FIR Implementation using TMS Processor*	*Lab 26: Equalization (Matlab)*
	SLO-2					
S-5	SLO-1	*TMS320C6X Instruction Sets,*	*Memory data operations*	*Fast Fourier Transform –DIF*	*Orthogonality and Biorthogonality in Filter banks*	*u-Law for Speech Companding,*
	SLO-2	*Assembler directives*	*Conditional Operations*	*Fast Fourier Transform DIF*	*QMF Filter banks and*	*Acoustic Direction Tracker*
S-6	SLO-1	*Multichannel Buffered Serial Ports*	*Floating Point –Data type operations,*	*IFFT*	*CQF Filter Banks*	*MultirateFilter,Neural Network for Signal Recognition*

	SLO-2	*Memory Considerations –Constraints*	*Floating Point –Data type operations*	*FIR filters*	*Transmultiplixers;*	*PID Controller, Four-Channel Multiplexer for Fast Data Acquisition*
S-7	SLO-1	*Lab 3: Linear Convolution (Matlab)*	*Lab 9: MAC operation using various addressing modes*	*Lab 15: FIR filter design-Windowing Techniques(Matlab)*	*Lab 21: IIR implementation using TMS processor*	*Lab 27: Real time audio signal processing with Processor*
	SLO-2					
S-8	SLO-1	*Lab 4 :Circular convolution(Matlab)*	*Lab 10: Linear convolution(DSP processor)*	*Lab 16: FIR filter design-Windowing Techniques(Matlab)*	*Lab 22: IIR implementation using TMS processor*	*Lab 28: Real time audio signal processing with Processor*
	SLO-2					
S-9	SLO-1	*Instruction Operation and Execution notations*	*Fixed- Point Operations,*	*FIR filters*	*Structures and Programming Examples for Noise cancellation*	*Video Line Rate Analysis*
	SLO-2	*Overview of IEEE Standard single and Double Precision formats ,*	*Fixed- Point Operations*	*IIR filter*	*Adaptive Filters-Adaptive filters in DSP simulation software's and TMSC320C6x*	*DSP System Design*
S-10	SLO-1	*Q-format Number Representation on Fixed Point DSPs, Finite Word length effects on Fixed point DSPS*	*Pipeline Operations overview*	*IIR filter*	*Software simulation of FIR*	*MP3 Player*
	SLO-2	*Floating point number representation, , Overflow and Scaling*	*Interrupts-overview.*	*FIR and IIR filter design using TMS320C6x*	*IIRFilters and Filter banks*	*DSP Automotive application*
S-11	SLO-1	*Lab 5: Study of architecture of Digital Signal Processor*	*Lab 11: Circular convolution(DSP processor)*	*Lab 17: IIR filter design-Bilinear and Impulse Invariance Technique(Matlab)*	*Lab 23: Multirate filters*	*Lab 29: Real time audio signal processing with Processor*
	SLO-2					
S-12	SLO-1	*Lab 6: Study of architecture of Digital Signal Processor*	*Lab 12: Waveform generation(DSP processor)*	*Lab 18: IIR filter design-Bilinear and Impulse Invariance Technique(Matlab)*	*Lab 24: Finite Word Length Effect*	*Lab 30: Real time audio signal processing with Processor*
	SLO-2					

Learning Resources	1. *B Venkataramani, M Bhaskar, "Digital Signal Processors: Architecture,Programming and Applications", TMH Publishers, 2nd edition, 2017* 2. *Paulo S. R.DinizEduardo A. B. da Silva and Sergio L. Netto, "Digital Signal Processing System Analysis and Design", Cambridge University Press, 2nd Edition.2010* 3. *Nasser Kehtarnavaz, Namjin Kim, "Digital Signal Processing System-Level Design Using LabVIEW", Newgen Elsevier Publication, 2nd edition, 2014*	4. *RulphChassaing - "DSP Applications Using C and the TMS320C6x DSK" John Wiley & Sons, Inc. 2002.* 5. *Nasser Kehtarnavaz , "Real-Time Digital Signal ProcessingBased on the TMS320C6000", Newnes, 2005.*

Learning Assessment

	Bloom's Level of Thinking	Continuous Learning Assessment (50% weightage)								Final Examination (50% weightage)	
		CLA – 1 (10%)		CLA – 2 (15%)		CLA – 3 (15%)		CLA – 4 (10%)#			
		Theory	Practice	Theory	Practice	Theory	Practice	Theory	Practice	Theory	Practice
Level 1	Remember Understand	20%	20%	15%	15%	15%	15%	15%	15%	15%	15%
Level 2	Apply Analyze	20%	20%	20%	20%	20%	20%	20%	20%	20%	20%
Level 3	Evaluate Create	10%	10%	15%	15%	15%	15%	15%	15%	15%	15%
	Total	100 %		100 %		100 %		100 %		-	

CLA – 4 can be from any combination of these: Assignments, Seminars, Tech Talks, Mini-Projects, Case-Studies, Self-Study, MOOCs, Certifications, Conf. Paper etc.,

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Course Code	18ECE245T	Course Name	ADAPTIVE SIGNAL PROCESSING	Course Category	E	Professional Elective	L	T	P	C
							3	0	0	3

Pre-requisite Courses	18ECC204J	Co-requisite Courses	Nil	Progressive Courses	18ECE342T
Course Offering Department	Electronics and Communication Engineering	Data Book / Codes/Standards	Nil		

Course Learning Rationale (CLR):	The purpose of learning this course is to:	Learning			Program Learning Outcomes (PLO)														
		1	2	3	1	2	3	4	5	6	7	8	9	10	11	12	13	14	15
CLR-1 :	*Have an insight on basics of random processes*	Level of Thinking (Bloom)	Expected Proficiency (%)	Expected Attainment (%)	Engineering Knowledge	Problem Analysis	Design & Development	Analysis, Design, Research	Modern Tool Usage	Society & Culture	Environment & Sustainability	Ethics	Individual & Team Work	Communication	Project Mgt. & Finance	Life Long Learning	PSO–1: Professional Achievement	PSO - 2: Project Management Techniques	PSO - 3: Analyze & Research
CLR-2 :	*Gain knowledge on the applications of adaptive filters*																		
CLR-3 :	*Have an introduction on LMS techniques*																		
CLR-4 :	*Analyze the types of LMS algorithm*																		
CLR-5 :	*Have an introduction on RLS algorithm*																		
CLR-6 :	*Understanding on need and design of adaptive filters using different algorithms*																		
Course Learning Outcomes (CLO):	*At the end of this course, learners will be able to:*																		
CLO-1 :	*To review the basics of statistical signal processing*	*1*	*95*	*70*	*H*	-	-	-	-	--	-	-	--	-		-	-	-	-
-CLO-2 :	*To understand about the need for adaptive filters and learn the design of it.*	*1,2*	*95*	*70*	*H*	*M*	*M*	*H*	-	--	-	-	--	-		-	-	*L*	*M*
CLO-3 :	*To acquire knowledge on LMS algorithms and constraints associated with it.*	*2,3*	*85*	*65*	*H*	*H*	*H*	*H*	*L*							*M*	-	*M*	*M*
CLO-4 :	*To learn the variants of LMS algorithm and design of lattice structures*	*2*	*85*	*65*	*H*	*M*	*H*	*H*	-	--	-	-	--	-		-	-	*M*	*M*
CLO-5 :	*To gain knowledge on design of RLS filters and others aspects of filter design*	*1,2*	*85*	*65*	*H*	*M*	*M*	*H*	*L*	-	-	-	-	-	-	*M*	-	*M*	*M*
CLO-6 :	*To understand the applications of adaptive signal processing and algorithms in designing the adaptive filters*	*1,2*	*85*	*65*	*H*	*H*	*H*	*H*	*L*	-	-	-	-	-	-	*M*	-	*H*	*H*

Duration (hour)		Introduction to Stochastic Process	Adaptive Filters	Least Mean Square Algorithm	Variants of LMS Algorithm And Lattice Structures	Recursive Least Square Algorithm
		9	9	9	9	9
S-1	SLO-1	*Introduction to random process*	*Introduction to adaptive filters*	*Least mean square algorithm*	*Sign LMS algorithm*	*Recursive adaptive filters*
	SLO-2	*Variables, vectors*	*Block diagram of adaptive structure with shift variant filter*	*Derivation*	*Normalized LMS*	*Principle of RLS algorithm*
S-2	SLO-1	*Ensemble averages*	*Properties of adaptive filter*	*Properties of LMS adaptive filters*	*Leaky LMS*	*FIR RLS filter algorithm*
	SLO-2	*Time averages*	*Error sequence generation in adaptive filters*	*Properties of LMS adaptive filters*	*Block LMS*	*Derivation*
S-3	SLO-1	*Stationarity and Stationary random process*	*Channel Equalization- Block diagram of Communication system with Channel equalization*	*Complex LMS algorithm*	*FFT based implementation of block LMS*	*Sliding window RLS*
	SLO-2	*Wide sense stationarity*	*Echo cancellation*	*Convergence of LMS algorithm*	*FFT based implementation of block LMS*	*Derivation*
S-4	SLO-1	*Power Spectral Density*	*Concept of adaptive noise cancelling*	*Learning curve for adaptive filters*	*Comparison of variants on LMS for some practical problem*	*Comparing variants of RLS using MATLAB program*
	SLO-2	*Properties of PSD*	*Beam forming with pilot signals*	*Sample MATLAB program for LMS convergence and plotting learning curve*	*Comparison of variants on LMS for some practical problem*	*Comparing variants of RLS using MATLAB program*
S-5	SLO-1	*Sample problems on WSS random process*	*System modeling using adaptive filters*	*Performance analysis of LMS adaptive filters by varying step size (MATLAB)*	*Lattice filters introduction*	*Kalman filters*

	SLO-2	*Sample problems on WSS random process*	*System Identification structure*	*Performance analysis of LMS adaptive filters by varying step size (MATLAB)*	*Advantages of Lattice structures*	*Kalman filters*
S-6	SLO-1	*Filtering of random process*	*System inversion using adaptive filters*	*Weight error correlation matrix*	*Forward linear prediction*	*Sample problems on RLS algorithms*
	SLO-2	*Filtering of random process*	*Interference cancellation in multi sensor systems*	*LMS misadjustment definition*	*Forward linear prediction*	*Sample problems on RLS algorithms*
S-7	SLO-1	*Autocorrelation Structures*	*Minimization of mean square error*	*Effects of misadjustment factor*	*Backward linear prediction*	*Non linear adaptive filters*
	SLO-2	*Covariance Structures*	*Derivation on MMSE*	*Sample problems for designing adaptive filters using LMS*	*Backward linear prediction*	*Introduction to Neural networks*
S-8	SLO-1	*Eigen value decomposition*	*Steepest Descent algorithm*	*Sample problems on step size*	*Reflection coefficients of forward and backward predictors*	*Neural networks and multilayer perceptorns*
	SLO-2	*Eigen value analysis of autocorrelation matrices*	*Linear prediction example*	*Sample problems on step size*	*Relation between forward and backward prediction coefficients*	*Neural networks and multilayer perceptorns*
S-9	SLO-1	*Ergodicity*	*Wiener filters*	*Stability analysis of LMS algorithms*	*Properties of Lattice structures*	*Adaptive IIR filtering*
	SLO-2	*Ergodic random process*	*Optimization solution in wiener filters*	*Stability analysis of LMS algorithms*	*Updating predictor coefficients*	*Adaptive IIR filtering*

Learning Resources	1. *S. Haykin ,Adaptive Filter Theory, Prentice-Hall, 4-th edition, 2001.* 2. *Ali H. Sayed ,Fundamentals of Adaptive Filtering, John Wiley, 2003.* 3. *D. Manolakis, V. Ingle, S. Kogan,Statistical and Adaptive Signal Processing: Spectral Estimation, Signal Modeling, Adaptive Filtering and Array Processing, McGraw Hill, 1999.*	4. *B. Widrow, S. Stearns,Adaptive Signal Processing, Prentice-Hall, 1985* 5. *Monson H. Hayes,Statistical Digital Signal Processing and Modeling, Edition: 1st, 2008.*

Learning Assessment

	Bloom's Level of Thinking	Continuous Learning Assessment (50% weightage)								Final Examination (50% weightage)	
		CLA – 1 (10%)		CLA – 2 (15%)		CLA – 3 (15%)		CLA – 4 (10%)#			
		Theory	Practice	Theory	Practice	Theory	Practice	Theory	Practice	Theory	Practice
Level 1	Remember Understand	40 %	-	30 %	-	30 %	-	30 %	-	30%	-
Level 2	Apply Analyze	40 %	-	40 %	-	40 %	-	40 %	-	40%	-
Level 3	Evaluate Create	20 %	-	30 %	-	30 %	-	30 %	-	30%	-
	Total	100 %		100 %		100 %		100 %		100 %	

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2. Mr. Hariharasudhan - Johnson Controls, Pune, hariharasudhan.v@jci.com	*2. Dr. Venkatesan, Sr. Scientist, NIOT, Chennai, venkat@niot.res.in*	

Course Code	18ECE340T	Course Name	MACHINE PERCEPTION WITH COGNITION	Course Category	E	Professional Elective	L	T	P	C
							3	0	0	3

Pre-requisite Courses	18ECE242J	Co-requisite Courses	Nil	Progressive Courses	Nil
Course Offering Department	Electronics and Communication Engineering	Data Book / Codes/Standards	Nil		

Course Learning Rationale (CLR):	*The purpose of learning this course is to:*
CLR-1 :	*Have an insight on image and color fundamentals*
CLR-2 :	*Analyze the various shapes and regions for the image description*
CLR-3 :	*Acquire knowledge on the texture analysis of an image*
CLR-4 :	*Identify the relation between the templates to match the image requirements*
CLR-5 :	*Know the practical applications of computer vision in images understanding*

Course Learning Outcomes (CLO):	*At the end of this course, learners will be able to:*	Learning			Program Learning Outcomes (PLO)														
		1	2	3	1	2	3	4	5	6	7	8	9	10	11	12	13	14	15
		Level of Thinking (Bloom)	Expected Proficiency (%)	Expected Attainment (%)	Engineering Knowledge	Problem Analysis	Design & Development	Analysis, Design, Research	Modern Tool Usage	Society & Culture	Environment & Sustainability	Ethics	Individual & Team Work	Communication	Project Mgt. & Finance	Life Long Learning	PSO - 1	PSO - 2	PSO - 3
CLO-1 :	*To outline the fundamentals of image and color models*	*1*	*90*	*85*	*H*		*L*		*M*	*H*							*L*	*L*	*M*
CLO-2 :	*Understand the basic shapes and region based image modeling*	*1*	*85*	*85*		*H*						*H*					*M*	*H*	*M*
CLO-3 :	*Analyze the various textures for image synthesis*	*1&2*	*85*	*80*			*M*			*M*		*H*					*L*	*M*	*M*
CLO-4 :	*Identify the objects based on template relations*	*1&2*	*85*	*75*							*H*	*M*	*M*				*L*	*M*	*M*
CLO-5 :	*To apply the image understanding knowledge for image recognition*	*2&3*	*85*	*80*	*H*	*M*						*H*	*M*				*L*	*M*	*H*
CLO-6:	*To understand the principles of image modeling and synthesis with image recognition*	*1,2,3*	*85*	*80*	*M*	*H*	*H*	*H*	*M*								*M*	*M*	*H*

Duration (hour)		Learning Unit / Module 1 Basic Audio Processing	Learning Unit / Module 2 Human Auditory System	Learning Unit / Module 3 Speech Signal Analysis in Time Domain	Learning Unit / Module 4 Speech Signal Analysis in Frequency Domain	Learning Unit / Module 5 Speech and Audio processing applications
		12	12	12	12	12
S-1	SLO-1	*Review of Image processing methods*	*Binary Shape analysis*	*Representing textures*	*Finding objects by voting on relation between templates*	*Face detection*
	SLO-2	*Review of Image processing methods*	*Binary Shape analysis*	*Representing textures*	*Interest points, Simple voting, Voting on raltions.*	*Face detection*
S-2	SLO-1	*Introduction to image formation*	*Connectedness*	*Extracting image Structure with filter banks*	*Relational reasoning using probabilistic framework*	*Face recognition*
	SLO-2	*Introduction to image formation*	*Object labeling and counting*	*Extracting image Structure with filter banks*	*Growing Assemblies Incrementally, Detection, Pruning*	*Face recognition*
S-3	SLO-1	*Image models*	*Size filtering*	*Representing texture using statistics of filter output*	*Frames and probability models*	*Eigen faces*
	SLO-2	*Camera models*	*Distance functions*	*Representing texture using statistics of filter output*	*Representing coordinate frames*	*Active appearence*
S-4	SLO-1	*Sample programs for reading images, understanding pixels*	*Skeletons and thinning*	*Analysis using oriented pyramids*	*Using probability model for detecting the frames*	*3D shape models of face surveillance*
	SLO-2	*Sample programs for reading images, understanding pixels*	*Deformable shape analysis*	*Laplacian pyramids*	*Building probability models for frame invariant*	*3D shape models of face surveillance*
S-5	SLO-1	*Shadows*	*Boundary tracking procedures*	*Filters in the spatial frequency domain*	*Classifiers to prune search*	*Foreground separation*

	SLO-2	*Color representation*	*Boundary tracking procedures*	*Filters in the spatial frequency domain*	*Identifying acceptable assemblies*	*Background separation*
S-6	SLO-1	*Human color perception*	*Shape models*	*Oriented pyramids*	*Sample examples for prune search*	*Particle filters*
	SLO-2	*Human color perception*	*Shape recognition*	*Oriented pyramids*	*Hidden Markov model*	*Particle filters*
S-7	SLO-1	*Image color*	*Centroidal profiles*	*Synthesizing textures for rendering*	*Computing, Maximizing parameters*	*Champer matching, tracking and occlusions*
	SLO-2	*Image color*	*Handling occlusions*	*Synthesizing textures for Homogeneity*	*Varieties of HMM*	*Champer matching, tracking and occlusions*
S-8	SLO-1	*Handling Color Images (MATLAB)*	*Boundary descriptors*	*Synthesis by sampling local models*	*Background subtraction*	*Combining views from multiple cameras*
	SLO-2	*Handling Color Images (MATLAB)*	*Boundary descriptors*	*Synthesis by sampling local models*	*Sample programs on background subtraction*	*Human gait*
S-9	SLO-1	*Surface Color*	*Region descriptors*	*Shape from texture planes*	*Hough transform*	*Constructing 3D models from image sequences*
	SLO-2	*Surface Color*	*Region descriptors*	*Texture from shape planes*	*Sample problems on Hough transforms*	*Scene modeling from registered and unregistered images*

Learning Resources	1. *E. R. Davies, "Computer & Machine Vision", Fourth Edition, Academic Press, 2012.* 2. *R. Szeliski, "Computer Vision: Algorithms and Applications", Springer 2011.* 3. *Simon J. D. Prince, "Computer Vision: Models, Learning, and Inference", Cambridge University Press, 2012*	4. *Mark Nixon and Alberto S. Aquado, "Feature Extraction & Image Processing for Computer Vision", Third Edition, Academic Press, 2012* 5. *D. L. Baggio et al., "Mastering OpenCV with Practical Computer Vision Projects", Packt Publishing, 2012* 6. *Jan Erik Solem, "Programming Computer Vision with Python: Tools and algorithms for analyzing images", O'Reilly Media, 2012.*

Learning Assessment

	Bloom's Level of Thinking	Continuous Learning Assessment (50% weightage)								Final Examination (50% weightage)	
		CLA – 1 (10%)		CLA – 2 (15%)		CLA – 3 (15%)		CLA – 4 (10%)#			
		Theory	Practice	Theory	Practice	Theory	Practice	Theory	Practice	Theory	Practice
Level 1	Remember Understand	30 %	-	30 %	-	30 %	-	30 %	-	30%	-
Level 2	Apply Analyze	40 %	-	40 %	-	40 %	-	40 %	-	40%	-
Level 3	Evaluate Create	30 %	-	30 %	-	30 %	-	30 %	-	30%	-
	Total	100 %		100 %		100 %		100 %		100 %	

CLA – 4 can be from any combination of these: Assignments, Seminars, Tech Talks, Mini-Projects, Case-Studies, Self-Study, MOOCs, Certifications, Conf. Paper etc.,

Course Designers

Experts from Industry	Experts from Higher Technical Institutions	Internal Experts
1. Mr. Anuj Kumar, Bombardier Transportation, Ahmedabad, kumaranuj.anii@gmail.com	*1. Dr. Meenakshi, Professor of ECE, CEG, Anna University, meena68@annauniv.edu*	*1. Dr. A. Ruhan Bevi, SRM IST*
2. Mr. Hariharasudhan - Johnson Controls, Pune, hariharasudhan.v@jci.com	*2. Dr. Venkatesan, Sr. Scientist, NIOT, Chennai, venkat@niot.res.in*	

Course Code	18ECE341T	Course Name	MULTIMEDIA COMPRESSION TECHNIQUES	Course Category	E	Professional Elective	L	T	P	C
							3	0	0	3

Pre-requisite Courses	18ECE240T	Co-requisite Courses	Nil	Progressive Courses	Nil
Course Offering Department	Electronics and Communication Engineering	Data Book / Codes/Standards	Nil		

Course Learning Rationale (CLR):	*The purpose of learning this course is to:*
CLR-1 :	*Learn about probability model and coding theory*
CLR-2 :	*Understand about lossless compression*
CLR-3 :	*Understand about Lossy data compression*
CLR-4 :	*Learn about the encoding methods*
CLR-5 :	*Compression Techniques and their applications*

Course Learning Outcomes (CLO):	*At the end of this course, learners will be able to:*	Learning 1: Level of Thinking (Bloom)	2: Expected Proficiency (%)	3: Expected Attainment (%)	PLO 1: Engineering Knowledge	2: Problem Analysis	3: Design & Development	4: Analysis, Design, Research	5: Modern Tool Usage	6: Society & Culture	7: Environment & Sustainability	8: Ethics	9: Individual & Team Work	10: Communication	11: Project Mgt. & Finance	12: Life Long Learning	13: PSO - 1	14: PSO - 2	15: PSO - 3
CLO-1 :	*Understand the fundamental concepts of probability model and practical limits specified by coding theory*	*L1&L2*	*90*	*68*	*H*	*H*		*M*	*M*	*M*		*M*				*M*	*H*	*M*	*H*
CLO-2 :	*Learn about rate-distortion theory and what they reveal about efficient information transfer*	*L2&L3*	*86*	*68*	*H*	*H*		*M*	*M*	*M*		*M*				*M*	*H*	*M*	*H*
CLO-3 :	*Understand the fundamental approaches towards lossy image compression*	*L2&L3*	*86*	*68*	*H*	*M*		*H*	*M*	*M*		*M*				*M*	*M*	*M*	*H*
CLO-4 :	*Analyze image, video and audio in the frequency domain to identify important components to be encoded*	*L2*	*85*	*63*	*H*	*M*		*H*	*H*	*M*		*H*				*M*	*M*	*L*	*H*
CLO-5 :	*Applications of various compression techniques*	*L2&L3*	*85*	*63*	*M*	*M*		*M*	*M*	*H*		*M*				*M*	*H*	*M*	*M*
CLO-6:	*Learn about data compression and encoding methods*	*L1,L2,L3*	*90*	*68*	*H*	*M*		*M*	*M*	*M*		*H*				*M*	*H*	*M*	*H*

Duration (hour)		9	9	9	9	9
S-1	SLO-1	*The discrete memory less information source*	*Mathematical Preliminaries for Lossless*	*Rate distortion function*	*Vector Quantization*	*Transform Coding: Introduction, Karhunen-Loeve transform, Image compression – EZW, SPIHT, JPEG 2000- Analysis/Synthesis Schemes.*
	SLO-2	*Kraft inequality; optimal codes*	*Mathematical Preliminaries for Lossless Compression*	*Rate distortion function*	*LBG algorithm*	*Karhunen-Loeve transform*
S-2	SLO-1	*Source coding theorem-Entropy*	*Huffman Coding*	*Properties of RD*	*Tree structured VQ*	*Karhunen-Loeve transform*
	SLO-2	*Joint Entropy and Conditional Entropy*	*Huffman Coding*	*Properties of RD*	*Structured VQ*	*discrete cosine transform,*
S-3	SLO-1	*Relative Entropy*	*Optimality of Huffman codes*	*Calculation of RD for the binary source and the Gaussian source*	*Variations of VQ*	*discrete cosine transform,*
	SLO-2	*Mutual Information*	*Extended Huffman Coding*	*Calculation of RD for the binary source and the Gaussian source*	*Gain shape VQ*	*discrete Walsh Hadamard transform*
S-4	SLO-1	*Chain Rules*	*Adaptive Huffman Coding*	*Rate distortion theorem*	*Mean removed VQ*	*discrete Walsh Hadamard transform*
	SLO-2	*Data-Processing Inequality*	*Arithmetic Coding*	*Rate distortion theorem*	*Classified VQ*	*Quantization and coding of transform coefficients*
S-5	SLO-1	*Fano's Inequality Symmetric Channels*	*Adaptive Arithmetic coding*	*Converse of the Rate distortion theorem*	*Multistage VQ*	*Quantization and coding of transform coefficients*
	SLO-2	*Fano's Inequality Symmetric Channels*	*Run Length Coding*	*Quantization problem*	*Adaptive VQ*	*JPEG*

S-6	SLO-1	*Properties of Channel Capacity, Jointly Typical Sequences*	*Dictionary Techniques*	*Scalar Quantization- Uniform Quantizer*	*Trellis coded quantization Transforms.*	*JPEG*
	SLO-2	*Properties of Channel Capacity, Jointly Typical Sequences*	*Lempel Ziv coding*	*Scalar Quantization- Uniform Quantizer*	*Trellis coded quantization Transforms.*	*MDCT*
S-7	SLO-1	*Channel Coding Theorem*	*Applications*	*Adaptive Quantization*	*Basic algorithm*	*MDCT*
	SLO-2	*Channel Coding Theorem*	*Predictive Coding*	*Adaptive Quantization*	*Prediction in DPCM*	*Image compression – EZW-Analysis/Synthesis Schemes*
S-8	SLO-1	*Fano's Inequality*	*Prediction with Partial Match*	*Non-uniform Quantization*	*Prediction in DPCM*	*Image compression – SPIHT-Analysis/Synthesis Schemes*
	SLO-2	*Fano's Inequality*	*Burrows Wheeler Transform*	*Non-uniform Quantization*	*Adaptive DPCM*	*Image compression – JPEG 2000-Analysis/Synthesis Schemes*
S-9	SLO-1	*Converse to the Coding Theorem*	*Dynamic Markov Compression*	*Entropy coded Quantization*	*Adaptive DPCM*	*Audio coding:-MPEG audio coding*
	SLO-2	*Converse to the Coding Theorem*	*Dynamic Markov Compression*	*Entropy coded Quantization*	*Delta Modulation*	*Audio coding:-MPEG audio coding*

Learning Resources	1. *K. Sayood, "Introduction to Data Compression",3rd Edition, Morgan Kaufmann Publishers, 2006.* 2. *N. Jayant and P. Noll, "Digital Coding of Waveforms: Principles and Applications to Speech and Video", ISBN10 0132119137, Prentice Hall, USA, 1984.* 3. *D. Salomon, "Handbook of Data Compression", 5th Edition, Springer-Verlag London Limited 2010.*	4. *Ze.Nian. Li and M.S. Drew, "Fundamentals of Multimedia",2nd Edition, Pearson Education (Asia) Pvt. Ltd., 2004.* 5. *M.Rabbani: "Digital image compression techniques", 1st Edition, SPIE Press Book, 1991.*

Learning Assessment											
	Bloom's Level of Thinking	Continuous Learning Assessment (50% weightage)								Final Examination (50% weightage)	
		CLA – 1 (10%)		CLA – 2 (15%)		CLA – 3 (15%)		CLA – 4 (10%)#			
		Theory	Practice	Theory	Practice	Theory	Practice	Theory	Practice	Theory	Practice
Level 1	Remember Understand	30 %	-	30 %	-	30 %	-	30 %	-	30%	-
Level 2	Apply Analyze	40 %	-	40 %	-	40 %	-	40 %	-	40%	-
Level 3	Evaluate Create	30 %	-	30 %	-	30 %	-	30 %	-	30%	-
	Total	100 %		100 %		100 %		100 %		100 %	

CLA – 4 can be from any combination of these: Assignments, Seminars, Tech Talks, Mini-Projects, Case-Studies, Self-Study, MOOCs, Certifications, Conf. Paper etc.,

Course Designers		
Experts from Industry	Experts from Higher Technical Institutions	Internal Experts
1. Mr. Anuj Kumar, Bombardier Transportation, Ahmedabad, kumaranuj.anii@gmail.com	*1. Dr. Meenakshi, Professor of ECE, CEG, Anna University, meena68@annauniv.edu*	*1. Dr. S. Dhanalakshmi, SRMIST*
2. Mr. Hariharasudhan - Johnson Controls, Pune, hariharasudhan.v@jci.com	*2. Dr. Venkatesan, Sr. Scientist, NIOT, Chennai, venkat@niot.res.in*	*2. Mrs. K. Harisudha, SRMIST*

Course Code	18ECE342T	Course Name	ACOUSTICAL SIGNAL PROCESSING	Course Category	E	Professional Elective	L	T	P	C
							3	0	0	3

Pre-requisite Courses	18ECE245T	Co-requisite Courses	Nil	Progressive Courses	Nil
Course Offering Department	Electronics and Communication Engineering	Data Book / Codes/Standards	ISO/TC 43/SC 1, ISO/TC 43/SC 2		

Course Learning Rationale (CLR):	*The purpose of learning this course is to:*
CLR-1 :	*learn what is acoustic and its basic sound equations, and how acoustics transmission, reflection, absorption when subjected to various mediums*
CLR-2 :	*learn how does human auditory system and hearing function.*
CLR-3 :	*learn what is acoustic echo, and how to control such echo due to noise and cancel echo using various algorithms.*
CLR-4 :	*learn what are the various types of transducers used for acoustic measurements*
CLR-5 :	*knowwhich transducers can be used in various applications of acoustics.*

Course Learning Outcomes (CLO):	*At the end of this course, learners will be able to:*	Learning 1: Level of Thinking (Bloom)	2: Expected Proficiency (%)	3: Expected Attainment (%)	PLO 1: Engineering Knowledge	2: Problem Analysis	3: Design & Development	4: Analysis, Design, Research	5: Modern Tool Usage	6: Society & Culture	7: Environment & Sustainability	8: Ethics	9: Individual & Team Work	10: Communication	11: Project Mgt. & Finance	12: Life Long Learning	13: PSO - 1	14: PSO - 2	15: PSO - 3
CLO-1 :	*To understand the basics of acoustic such as Sound equation, Transmission, Reflection, Absorption under various mediums*	*L1*	*80*	*65*	*M*											*H*	*H*	*M*	*H*
CLO-2 :	*To acquire knowledge on human auditory system and hearing*	*L1*	*85*	*65*	*M*											*H*	*H*	*M*	*H*
CLO-3 :	*To understand and analyze acoustic echo, noise control and cancel echo using various algorithms.*	*L1, L2*	*85*	*65*	*H*	*H*	*H*	*H*	*H*							*H*	*M*	*M*	*H*
CLO-4 :	*To understand about various types of transducers used for acoustic measurements*	*L1*	*85*	*65*	*M*	*H*	*H*										*H*	*M*	*H*
CLO-5 :	*To gain knowledge on various applications of acoustics.*	*L1, L3*	*85*	*65*		*H*		*H*								*H*	*H*	*M*	*M*
CLO-6	*Speech processing analysis in different environment*	*L1, L2, L3*	*85*	*65*	*H*	*H*	*H*	*H*	*H*							*H*	*H*	*H*	*M*

Duration (hour)		Basics of Acoustic Engineering	Auditory System and Hearing	Acoustic Echo and Noise control	Transducers for Acoustic Measurements	Applications of Acoustics
		9	9	9	9	9
S-1	SLO-1	*Introduction to acoustic*	*Anatomy of the auditory systems*	*Human Perception of Echoes*	*Fundamental properties of Transducers*	*Architectural acoustics – Sound in enclosures*
	SLO-2	*Introduction to acoustic*	*Anatomy of the auditory systems*	*Human Perception of Echoes*	*Fundamental properties of Transducers*	*Reverberation time*
S-2	SLO-1	*Harmonic Plane Waves*	*Physiology of the auditory systems*	*Echo Problem*	*Condenser Microphones*	*Sound absorption materials*
	SLO-2	*Harmonic Plane Waves*	*Physiology of the auditory systems*	*Echo Problem*	*Condenser Microphones*	*Measurements of acoustic output in living rooms*
S-3	SLO-1	*Energy Density*	*Function of the auditory systems*	*Adaptive Filters for Echo Cancellation*	*Dynamic Pressure Microphones*	*Acoustic Factors in architectural design*
	SLO-2	*Energy Density*	*Function of the auditory systems*	*Adaptive Filters for Echo Cancellation*	*Dynamic Pressure Microphones*	*Environmental acoustics – Introduction*
S-4	SLO-1	*Acoustic Intensity*	*Physiological measures*	*LMS algorithm*	*Dynamic Pressure Microphones*	*Weighted sound level*
	SLO-2	*Specific Acoustic Impedance*	*Physiological measures*	*NLMS algorithm*	*Dynamic Pressure difference Microphone*	*speech interference*
S-5	SLO-1	*Spherical Waves*	*Physiological measures*	*Least Squares Algorithms*	*Dynamic Pressure difference Microphone*	*Highway noise*

	SLO-2	*Spherical Waves*	*Auditory processing models*	*Least Squares Algorithms*	*Piezo ceramic accelerometer*	*Aircraft noise rating*
S-6	SLO-1	*Decibel Scales*	*Auditory processing models*	*Recursive Least Squares Algorithms*	*Piezo ceramic accelerometer*	*Virtual Sound--*
	SLO-2	*; Rays and Waves*	*Auditory processing models*	*Recursive Least Squares Algorithms*	*Piezo ceramic accelerometer*	*Sound localization cues*
S-70	SLO-1	*Transmission-Incidence*	*Auditory processing models*	*Affine Projection algorithm*	*Laser Doppler velocimeter*	*synthetic 3D Audio*
	SLO-2	*Transmission-Incidence*	*Auditory processing models*	*Affine Projection algorithm*	*Laser Doppler velocimeter*	*synthetic 3D Audio*
S-8	SLO-1	*Reflection*	*Speech Intelligibility*	*Noise cancellation using Affine Projection algorithm*	*Laser Doppler velocimeter*	*Seismology- Signal Model in seismic processing*
	SLO-2	*Absorption*	*Speech Intelligibility*	*Noise cancellation using Affine Projection algorithm*	*Capacitive sensors*	*Optical sensor Signal Model in seismic processings*
S-9	SLO-1	*Viscosity*	*signal processing in hearing aids*	*Fast Affine Projection Algorithm (FAP).*	*Capacitive sensors*	*Underwater and Oceanographic acoustics*
	SLO-2	*Thermal conduction*	*signal processing in hearing aids*	*Fast Affine Projection Algorithm (FAP)*	*Capacitive sensors*	*Inverse Problems in underwater acoustics*

Learning Resources	1. *Lawrance E Kinseler, Fundamental of Acoustic, , Wiley 4th Edition.* 2. *Steven L. Gay, Jacob Benesty, Acoustic Signal Processing for TeleCommunication, Springer; 2001 edition (March 31, 2000)*	3. *Havelock, David; Kuwano, Sonoko, Vorländer, Michael (Eds.), Handbook of Signal Processing in Acoustics, Springer; 2008 edition.*

Learning Assessment

	Bloom's Level of Thinking	Continuous Learning Assessment (50% weightage)								Final Examination (50% weightage)	
		CLA – 1 (10%)		CLA – 2 (15%)		CLA – 3 (15%)		CLA – 4 (10%)#			
		Theory	Practice	Theory	Practice	Theory	Practice	Theory	Practice	Theory	Practice
Level 1	Remember Understand	40 %	--	30 %	--	30 %	--	30 %	--	30 %	--
Level 2	Apply Analyze	40 %	--	40 %	--	40 %	--	40 %	--	40 %	--
Level 3	Evaluate Create	20 %	--	30 %	--	30 %	--	30 %	---	30 %	--
	Total	100 %		100 %		100 %		100 %		100 %	

CLA – 4 can be from any combination of these: Assignments, Seminars, Tech Talks, Mini-Projects, Case-Studies, Self-Study, MOOCs, Certifications, Conf. Paper etc.,

Course Designers

Experts from Industry	Experts from Higher Technical Institutions	Internal Experts
1. Mr. Anuj Kumar, Bombardier Transportation, Ahmedabad, kumaranuj.anii@gmail.com	*1. Dr. Meenakshi, Professor of ECE, CEG, Anna University, meena68@annauniv.edu*	*1. Dr. S. Dhanalakshmi, SRM IST*
2. Mr. Hariharasudhan - Johnson Controls, Pune, hariharasudhan.v@jci.com	*2. Dr. Venkatesan, Sr. Scientist, NIOT, Chennai, venkat@niot.res.in*	*2. Dr. Damodar Panigrahy, SRMIST*

Course Code	18ECE343T	Course Name	AUTOMATIC SPEECH RECOGNITION	Course Category	E	Professional Elective	L	T	P	C
							3	0	0	3

Pre-requisite Courses	18ECE241J	Co-requisite Courses	Nil	Progressive Courses	Nil
Course Offering Department	Electronics and Communication Engineering		Data Book / Codes/Standards	Nil	

Course Learning Rationale (CLR):	*The purpose of learning this course is to:*	Learning			Program Learning Outcomes (PLO)														
		1	2	3	1	2	3	4	5	6	7	8	9	10	11	12	13	14	15
		Level of Thinking (Bloom)	Expected Proficiency (%)	Expected Attainment (%)	Engineering Knowledge	Problem Analysis	Design & Development	Analysis, Design, Research	Modern Tool Usage	Society & Culture	Environment & Sustainability	Ethics	Individual & Team Work	Communication	Project Mgt. & Finance	Life Long Learning	PSO - 1	PSO - 2	PSO - 3
CLR-1 :	*Understand the basic Techniques of Speech Recognition*																		
CLR-2 :	*Analyze the different Statistical models*																		
CLR-3 :	*Modeling different speech recognition systems*																		
CLR-4 :	*Evaluation of dialogue system design*																		
CLR-5 :	*Analyzing the Stochastic Approaches to dialogue*																		
CLR-6 :	*Utilize the concepts in signal processing for the understanding of engineering and technology*																		
Course Learning Outcomes (CLO):	*At the end of this course, learners will be able to:*																		
CLO-1 :	*Understand the basic techniques in speech signal processing broadly used in the area of speech recognition*	*2*	*80*	*63*	*H*	*H*	-	-	-	-	-	-	-	-	-	-	-	-	-
CLO-2 :	*Learn how hidden Markov models can be used as generative models for speech and how they can be trained*	*2*	*85*	*68*	*H*	*H*	-	-	-	-	-	-	-	-	-	-	-	-	-
CLO-3 :	*To help in understanding account for commercial as well as research-oriented applications within speech recognition*	*2*	*75*	*68*	*H*	-	-	*H*	-	-	-	-	-	-	-	-	-	-	-
CLO-4 :	*To understand basic understanding of dialogue system design and evaluation*	*2*	*85*	*68*	*H*	*H*	-	-	-	-	-	-	-	-	-	-	-	-	-
CLO-5 :	*Implement simple dialogue systems and Stochastic Approaches*	*2*	*85*	*68*	*H*	-	*H*	-	-	-	-	-	-	-	-	-	-	-	-
CLO-6 :	*Apply the speech recognition techniques in real time applications.*	*2*	*80*	*68*	*H*	-	-	-	-	-	-	-	-	-	-	-	-	-	-

Duration (hour)		Distance Measurements For Comparing Speech Patterns	Statistical Models For Speech Recognition	Architecture of Continuous Speech Recognition System	Understanding of Spoken Dialogue Systems	Natural Language Generation and Stochastic Process
		9	9	9	9	9
S-1	SLO-1	*Feature, Feature Extraction and Pattern Comparison Techniques*	*Introduction to Perceptual Motivated Representations*	*Introduction to speech recognition*	*Simple models of dialogue structure:*	*Natural language generation for dialogue systems*
	SLO-2	*Feature, Feature Extraction and Pattern Comparison Techniques*	*Perceptual Motivated Representations*	*Introduction to speech recognition*	*Simple models of dialogue structure:*	*Natural language generation for dialogue systems*
S-2	SLO-1	*Speech Distortion measures-Mathematical*	*Formant Frequencies – Role of Pitch – Pitch Detection of Speech and Music*	*Large vocabulary continuous speech recognition*	*Trees and finite state approaches*	*Text-to-speech synthesis*
	SLO-2	*Speech Distortion measures-Mathematical*	*Formant Frequencies – Role of Pitch – Pitch Detection of Speech and Music*	*Large vocabulary continuous speech recognition*	*Trees and finite state approaches*	*Text-to-speech synthesis*
S-3	SLO-1	*Perpectual-Log spectral distance*	*Channel Vocoders and Predictive Coding Scalar Waveform Coders*	*Architecture of large vocabulary continuous speech recognition system*	*Dialogue acts, key phrase reactive approaches*	*Use of speech synthesizers in dialogue systems*
	SLO-2	*Perpectual-Log spectral distance*	*Channel Vocoders and Predictive Coding Scalar Waveform Coders*	*Architecture of large vocabulary continuous speech recognition system*	*Dialogue acts, key phrase reactive approaches*	*Use of speech synthesizers in dialogue systems*
S-4	SLO-1	*Cepstral Distances, Weighted Cepstral distances and Filtering*	*Scalar Frequency Domain Coders*	*Architecture of large vocabulary continuous speech recognition system*	*Information retrieval-based approaches*	*Dialogue system evaluation*
	SLO-2	*Likelihood Distortions*	*Code excited linear Prediction*	*Architecture of large vocabulary continuous speech recognition system*	*Information retrieval-based approaches*	*Dialogue system evaluation*
S-5	SLO-1 SLO-2	*Spectral distortion using a Warped Frequency scale*	*Low – Bit rate Speech coders Speech Recognition*	*Acoustics model*	*Voice XML*	*Stochastic approaches to dialogue*
S-6	SLO-1	*LPC, PLC and MFCC Coefficients*	*Hidden Markov Models (HMM) – Practical Issues in Using HMMs – HMM Limitations*	*Language model*	*Speech recognition*	*Dialogue policy design and training*

	SLO-2	*LPC, PLC and MFCC Coefficients*	*Hidden Markov Models (HMM) – Practical Issues in Using HMMs – HMM Limitations*	*Language model*	*Speech recognition*	*Dialogue policy design and training*
S-7	SLO-1	*Time Alignment and Normalization*	*Acoustic Modeling – Phonetic Modeling, Language Modeling*	*n-gram model*	*Use of speech recognizers in dialogue systems*	*MDP reinforcement learning*
	SLO-2	*Time Alignment and Normalization*	*Acoustic Modeling – Phonetic Modeling, Language Modeling*	*n-gram model*	*Use of speech recognizers in dialogue systems*	*MDP reinforcement learning*
S-8	SLO-1	*Dynamic Time warping*	*Speaker Recognition Algorithm*	*context dependent sub word units*	*Natural language understanding*	*POMDP reinforcement learning*
	SLO-2	*Dynamic Time warping*	*Speaker Recognition Algorithm*	*context dependent sub word units*	*Natural language understanding*	*POMDP reinforcement learning*
S-9	SLO-1	*Multiple Time-Alignment Paths*	*Signal Enhancement for Mismatched Conditions*	*Applications and present status*	*Natural language understanding*	*Simulated users*
	SLO-2	*Multiple Time-Alignment Paths*	*Signal Enhancement for Mismatched Conditions*	*Applications and present status*	*Natural language understanding*	*Simulated users*

Learning Resources	1. *Huang, A. Acero, H-W. Hon, "Spoken Language Processing: A guide to theory, algorithm and system development", Prentice Hall 2001* 2. *Rabiner and Juang, "Fundamentals of Speech Recognition", Prentice Hall, 1993* 3. *F. Jelinek, "Statistical Methods for Speech recognition", MIT Press, 1997*	4. *Jurafsky, Daniel, and James H. Martin, "Speech and Language Processing: An Introduction to Natural Language Processing, Speech Recognition, and Computational Linguistics", 2nd edition. Prentice-Hall, 2009.* 5. *Jokinen and McTear, "Spoken Dialogue Systems, Morgan & Claypool, Synthesis Lectures on Human Language Technologies", Morgan & Claypool Publishers, 2009*

Learning Assessment

	Bloom's Level of Thinking	Continuous Learning Assessment (50% weightage)								Final Examination (50% weightage)	
		CLA – 1 (10%)		CLA – 2 (15%)		CLA – 3 (15%)		CLA – 4 (10%)#			
		Theory	Practice	Theory	Practice	Theory	Practice	Theory	Practice	Theory	Practice
Level 1	Remember Understand	40%	-	30%	-	30%	-	30%	-	30%	-
Level 2	Apply Analyze	40%	-	40%	-	40%	-	40%	-	40%	-
Level 3	Evaluate Create	20%	-	30%	-	30%	-	30%	-	30%	-
	Total	100 %		100 %		100 %		100 %		100 %	

CLA – 4 can be from any combination of these: Assignments, Seminars, Tech Talks, Mini-Projects, Case-Studies, Self-Study, MOOCs, Certifications, Conf. Paper etc.,

Course Designers

Experts from Industry	Experts from Higher Technical Institutions	Internal Experts
1. Mr. Anuj Kumar, Bombardier Transportation, Ahmedabad, kumaranuj.anii@gmail.com	*1. Dr. Meenakshi, Professor of ECE, CEG, Anna University, meena68@annauniv.edu*	*1. Dr. S. Dhanalakshmi, SRMIST*
2. Mr. Hariharasudhan - Johnson Controls, Pune, hariharasudhan.v@jci.com	*2. Dr. Venkatesan, Sr. Scientist, NIOT, Chennai, venkat@niot.res.in*	*2. Mrs. K. HariSudha, SRM IST*

Course Code	18ECE360T	Course Name	REHABILITATION ENGINEERING	Course Category	E	Professional Elective	L	T	P	C
							3	0	0	3

Pre-requisite Courses	Nil	Co-requisite Courses	Nil	Progressive Courses	Nil
Course Offering Department	Electronics and Communication Engineering	Data Book / Codes/Standards	Nil		

Course Learning Rationale (CLR):	*The purpose of learning this course is to:*
CLR-1 :	*Learn concepts and terminologies in Rehabilitation Engineering*
CLR-2 :	*Understand different types of wheel chair design and mobility aids*
CLR-3 :	*Study the components of orthotic and prosthetic devices and their fabrication*
CLR-4 :	*Become aware of Engineering concepts in sensory substitution and augmentation*
CLR-5 :	*Understand the legal concepts in Rehabilitation Engineering*
CLR-6 :	*Study the contemporary topics in Rehabilitation Engineering*

Course Learning Outcomes (CLO):	*At the end of this course, learners will be able to:*	Learning			Program Learning Outcomes (PLO)														
		1	2	3	1	2	3	4	5	6	7	8	9	10	11	12	13	14	15
		Level of Thinking (Bloom)	Expected Proficiency (%)	Expected Attainment (%)	Engineering Knowledge	Problem Analysis	Design & Development	Analysis, Design, Research	Modern Tool Usage	Society & Culture	Environment & Sustainability	Ethics	Individual & Team Work	Communication	Project Mgt. & Finance	Life Long Learning	PSO - 1	PSO - 2	PSO - 3
CLO-1 :	*Understand the need for rehabilitation Engineering and proficiently use terminologies related to it.*	*1,2*	*80*	*70*						*M*						*L*	*L*		
CLO-2 :	*Know the various wheel chair design and mobility aid design aspects*	*1,2*	*75*	*65*	*M*		*L*			*L*							*L*	*L*	
CLO-3 :	*Learn about orthotic and prosthetic devices, their design and types.*	*2*	*70*	*65*	*L*		*L*				*L*						*L*		
CLO-4 :	*List the various possibilities to augment or substitute visual and auditory capabilities*	*2,3*	*70*	*65*	*M*	*M*	*L*			*L*								*L*	
CLO-5 :	*Describe the legal concepts in Rehabilitation Engineering*	*3*	*80*	*65*						*M*	*M*								*L*
CLO-6 :	*Gain exposure to the latest topics in Rehabilitation Engineering*	*3*	*80*	*65*	*M*	*L*	*L*	*M*		*L*							*L*	*M*	*L*

Duration (hour)		9	9	9	9	9
S-1	SLO-1	*Introduce to Rehabilitation Engineering and Assistive technologies*	*Interventions in seating system*	*Amputation: Definition, need, situations where it can be avoided*	*Basic structure of eye, How it functions, problems that can be faced*	*Application of robots in rehabilitation*
	SLO-2	*Learn Concepts of Rehabilitation Engineering*	*Wheel Chairs-Introduction*	*Classification of amputation*	*Categories of visual impairment, identification of level of intervention needed*	*Types of robots used*
S-2	SLO-1	*Learn Terminologies Rehabilitation Engineering*	*Types of Wheelchairs*	*Prosthetics: Definition, Need for prosthesis*	*Artificial Eye-Complete replacement*	*Challenges in robot design for differently abled people*
	SLO-2	*Considerations for Rehabilitation Engineering*	*Describe on Manual wheelchairs*	*Use of prosthesis, Where prosthesis can't be used*	*Retinal implant*	*Differences in material used*
S-3	SLO-1	*Various approaches for Rehabilitation engineering*	*Component Design*	*Basic types of prosthesis, Prosthesis Prescription*	*Sensory augmentation for blind*	*Functional electrical stimulation definition,*
	SLO-2	*PAD process*	*Electrical Power wheel chairs*	*Prosthesis for shoulder, neck, torso*	*Cortical prosthesis*	*Circuit for stimulations*
S-4	SLO-1	*PHAATE model*	*Power assisted wheelchair-Design*	*Prosthesis for elbow, arm*	*Assist devices for visual rehabilitation*	*Significance of myoelectricl signal*
	SLO-2	*Universal design- Introduction*	*Design types*	*Fabrication and issues involved*	*Auditory devices*	*Acquisition of myoelectricl signal, challenges*
S-5	SLO-1	*Seven Principles of Universal design*	*Wheelchair transportation*	*Parts of Lower extremity*	*Devices for navigation, Design of navigation device*	*Activities of daily living*
	SLO-2	*Benefits of Universal design*	*Lift Mechanism*	*Significance of each part, Different movements involved*	*Tactual sensory substitution, Applications and examples of tactual substitution in real life*	*Low tech and hi tech aids in daily living*
S-6	SLO-1	*Universal design Matrix*	*Wheelchair safety*	*Prosthesis for knee, hip*	*Main part of ear, Measurement of hearing*	*Neural engineering*

	SLO-2	*Design based on human ability*	*Wheelchair standards and tests*	*Material used for fabrication, examples of available prosthesis*	*Problems that can arise, Range of hearing*	*Implementation in rehabilitation*
S-7	SLO-1	*Standards for assistive technology- National and International*	*Intelligent Mobility aids*	*Orthosis: Definition, Difference between orthosis and prosthesis*	*Surgical hearing aids*	*Behavioural disorders and its types*
	SLO-2	*Role of Rehabilitation Engineering in standards development*	*Smart wheeled walkers*	*Orthosis for shoulder, neck*	*Cochlear and eardrum interventions*	*Rehabilitation methods involves*
S-8	SLO-1	*Rehabilitation Engineering and its research opportunities*	*All terrain wheelchair*	*Orthosis for foot, Material used: the problems faced with the material*	*Non surgical hearing aids*	*Sports rehabilitation*
	SLO-2	*Future of Engineering in Rehabilitation*	*Current directions in wheelchair research*	*Components of lower limp prosthesis*	*Design of a simple external hearing aid*	*Measurement technology for sports mechanics*
S-9	SLO-1	*Seating and common pathologies*	*Parts of Upper extremity*	*External circuitry design and support system*	*Sign language*	*Legal aspect in rehabilitation*
	SLO-2	*Seating assessment*	*Significance of each part, Different movements involved*	*Indentifying the orthosis and prosthesis which can be used* *Practice session: student to indentify the area of amputation and what to use in that location*	*Devices for sign language translation*	*Provision for rehabilitation*

Learning Resources	1. *Rory A Cooper, Hisaichi Ohnabe, Douglas A Hodson, "An Introduction to Rehabilitation Engineering", CRC Press, First edition, 2006* 2. *Rory A Cooper, "Rehabilitation Engineering Applied to Mobility and Manipulation", CRC Press, First edition, 2010* 3. *Horia-Nicolai.L. Teodorescu, Lakhsmi.C. Jain, "Intelligent Systems and Technologies in Rehabilitaion Engineering", CRC Press, First Edition, 2010.*	4. *Marion A Hersh, Michale A Johnson, "Assistive Technology fo Visually impaired and blind people", Springers Publications, First edition 2008.* 5. *Suzanne Robitaille, "The illustrated guide to Assistive technology and devices-Tools and gadgets for living independently", Demos Health Newyork, First edition, 2010.*

Learning Assessment

	Bloom's Level of Thinking	Continuous Learning Assessment (50% weightage)								Final Examination (50% weightage)	
		CLA – 1 (10%)		CLA – 2 (15%)		CLA – 3 (15%)		CLA – 4 (10%)#			
		Theory	Practice	Theory	Practice	Theory	Practice	Theory	Practice	Theory	Practice
Level 1	Remember Understand	30 %	-	30 %	-	30 %	-	30 %	-	30%	-
Level 2	Apply Analyze	40 %	-	40 %	-	40 %	-	40 %	-	40%	-
Level 3	Evaluate Create	30 %	-	30 %	-	30 %	-	30 %	-	30%	-
	Total	100 %		100 %		100 %		100 %		100 %	

CLA – 4 can be from any combination of these: Assignments, Seminars, Tech Talks, Mini-Projects, Case-Studies, Self-Study, MOOCs, Certifications, Conf. Paper etc.,

Course Designers

Experts from Industry	Experts from Higher Technical Institutions	Internal Experts
1. Sathyanarayanan J, Mindray Medical India Pvt Ltd, sathyanarayananjayagopal@mindray.com	*1. Dr. S. Poonguzhali, Anna University, poongs@annauniv.edu*	*1. Dr. Varshini karthik, SRMIST*
2. Mr. Anuj Kumar, Bombardier Transportation, Ahmedabad, kumaranuj.anii@gmail.com	*2. Dr. Meenakshi, Professor of ECE, CEG, Anna University, meena68@annauniv.edu*	*2. Mrs. A. Bhargavi haripriya, SRMIST*
3. Mr. Hariharasudhan - Johnson Controls, Pune, hariharasudhan.v@jci.com	*3. Dr. Venkatesan, Sr. Scientist, NIOT, Chennai, venkat@niot.res.in*	

Course Code	18ECE361T	Course Name	BIOMEDICAL NANOTECHNOLOGY	Course Category	E	Professional Elective	L	T	P	C
							3	0	0	3

Pre-requisite Courses	Nil	Co-requisite Courses	Nil	Progressive Courses	Nil
Course Offering Department	Electronics and Communication ERRRngineering		Data Book / Codes/Standards	Nil	

Course Learning Rationale (CLR):	*The purpose of learning this course is to:*	Learning			Program Learning Outcomes (PLO)														
CLR-1 :	*Learn the different synthesis method and its application*	1	2	3	1	2	3	4	5	6	7	8	9	10	11	12	13	14	15
CLR-2 :	*Apply the various characterization techniques in nano materials*	Level of Thinking (Bloom)	Expected Proficiency (%)	Expected Attainment (%)	Engineering Knowledge	Problem Analysis	Design & Development	Analysis, Design, Research	Modern Tool Usage	Society & Culture	Environment & Sustainability	Ethics	Individual & Team Work	Communication	Project Mgt. & Finance	Life Long Learning	PSO - 1	PSO - 2	PSO - 3
CLR-3 :	*Comprehend the principles behind nanomedicine*																		
CLR-4 :	*Gain a broad understanding of concepts and applications of nanomedicine*																		
CLR-5 :	*Apply concepts of nanomedicine to a focused clinical area of their choice*																		
CLR-6 :	*Acquire knowledge to apply these nanosystems for the diagnosis and therapy.*																		
Course Learning Outcomes (CLO):	*At the end of this course, learners will be able to:*																		
CLO-1 :	*Analyze the suitable method in biomedical application*	*3*	*80*	*75*	*M*	-	-	*L*	-	-	-	-	-	-	-	-	*L*	-	*L*
CLO-2 :	*Identify the various characterization techniques in nano materials*	*3*	*80*	*70*	*L*	-	-	*L*	-	-	-	-	-	-	-	-	*L*	-	*L*
CLO-3 :	*Describe the properties and techniques in nano biomaterials*	*3*	*75*	*70*	*L*	-	-	*L*	-	-	-	-	-	-	-	-	*L*	-	*L*
CLO-4 :	*Analyze the concept of nano therapeutics and application in biomedical*	*3*	*80*	*75*	*M*	-	-	*M*	-	-	-	-	-	-	-	-	*L*	-	*L*
CLO-5 :	*Identify the principle behind modern bio nano imaging techniques*	*3*	*80*	*70*	*M*	-	-	*M*	-	-	-	-	-	-	-	-	*L*	-	*L*
CLO-6 :	*Apply the nano materials in 3D printing techniques*	*3*	*80*	*70*	*M*	-	-	*M*	-	-	-	-	-	-	-	-	*L*	-	*L*

Duration (hour)		Synthesis of nano material	Nano materials characterization techniques	Nano biomaterials	Nano therapeutic	Nano biomedical imaging and 3D Bio printing techniques
		9	9	9	9	9
S-1	SLO-1	*Introduction About Nano technology*	*Introduction to Scanning electron microscope(SEM)*	*Introduction to nano biomaterials*	*Drug to delivery to central nervous system*	*Introduction to biomedical imaging*
	SLO-2	*Bulk synthesis:*	*Application of scanning electron microscope*	*Surface and bulk properties of biomaterials*	*Drug delivery across blood brain barrier*	*The emergence of nanoparticle as imaging platform in medicine*
S-2	SLO-1	*Top down and bottom approaches*	*Energy dispersive spectroscopy (EDS)*	*Nano biomaterials, Nano bio ceramics*	*Nano wire monitoring the brain activity*	*Magnetic resonance imaging basics*
	SLO-2	*Physical vapour deposition methods*	*Basics principle of atomic microscopy*	*Hydroxyapatite ant its properties*	*Introduction to Nano robot medical device*	*MRI working ,paramagnetic contrast agents*
S-3	SLO-1	*Electron beam evaporation techniques*	*Construction, working and application of atomic microscopy*	*Hydroxyapatite ant its applications*	*Application of Nano robot medical device*	*Magnetic Nano sensor*
	SLO-2	*Pulsed laser deposition*	*Introduction to transmission electron microscopy*	*Alumina and its properties ,application*	*Introduction to nano drug carrier*	*Radio labeled nano particles.*
S-4	SLO-1	*Sputtering techniques*	*Application of transmission electron microscopy*	*Zirconia and Titania and its properties*	*Nano carrier for ocular drug delivery*	*Sound waves nano particle*

	SLO-2	*Evaporation techniques*	*Scanning probe microscope*	*Zirconia and Titania ant its applications*	*cell therapy for myocardial infection*	*Application in ultra sound imaging*
S-5	SLO-1	*Cathodic arc deposition*	*Nano indentation techniques*	*Nano diamond carbon nano materials*	*Types of cell therapy for myocardial infection*	*Biological imaging*
	SLO-2	*Spin coating unit, spray pyrolysis*	*Cantilever array sensor*	*Nano diamond carbon materials and its applications.*	*Nano neurosurgery,*	*Quantum dot in optical imaging*
S-6	SLO-1	*Chemical vapor deposition(CVD)*	*Basics principle of scanning tunneling microscopy*	*Introduction to surface modification*	*nanolipoblockers*	*3D printing*
	SLO-2	*Types of chemical vapour deposition*	*Constriction and application of scanning tunneling microscope(STM)*	*Types of surface modification method*	*Antirestenosis drugs*	*Introduction and principle*
S-7	SLO-1	*Plasma method: Plasma enhanced CVD*	*Introduction about X-ray diffraction*	*Textured and porous materials*	*Introduction to nano particle drug formulations*	*3D printing technology :ink let based*
	SLO-2	*Hot filament CVD*	*Measurement and application of XRD*	*Cell biomaterials interactions*	*nano particle drug formulations for spray inhalations*	*Pressure assisted, laser assisted*
S-8	SLO-1	*Chemical synthesis: Sol gel processing*	*X-ray photon spectroscopy(XPS)*	*Immune response*	*Introduction to nano bone implants*	*Solenoid valve based, acoustic jet based*
	SLO-2	*hydrothermal,co precipitation,*	*Application XPS*	*Bone Scaffold preparations*	*Nano bone implants and scaffolds*	*3D bio printing in ceramics ,polymers*
S-9	SLO-1	*Wet chemical method*	*Electrochemical work station*	*Scaffold properties and its applications*	*Introduction to nano technology in cardio vascular system*	*3D bio printing in organs*
	SLO-2	*Hydrolysis ,Electrophoretic deposition*	*Application of electrochemical work station*	*In vitro and in vivo tissue biocompatibility*	*Regeneration of cardiovascular system*	*Challenge and future development of 3D bio printing*

Learning Resources	1. *Khandpur R.S, Hand-book of Biomedical Instrumentation, 2nd ed., Tata McGraw Hill, 2003* 2. *Michael Giersig, Gennady B. Khomutov,"Nanomaterials for Application in Medicine and Biology", Springer, 2008* 3. *Jeff W.M., Bulte and Michel M.J. Modo "Nanoparticles in Biomedical Imaging Emerging Technologies and Applications", Springer, 2010*	4. *Guozhong Cao, "Nanostructures and Nanomaterials, synthesis, properties and applications", Imperial College Press, 2004* 5. *C. N. Rao, A. Muller, A. K. Cheetham "The Chemistry of Nanomaterials: Synthesis, Properties and Applications", Wiley, 2004*

Learning Assessment

	Bloom's Level of Thinking	Continuous Learning Assessment (50% weightage)								Final Examination (50% weightage)	
		CLA – 1 (10%)		CLA – 2 (15%)		CLA – 3 (15%)		CLA – 4 (10%)#			
		Theory	Practice	Theory	Practice	Theory	Practice	Theory	Practice	Theory	Practice
Level 1	Remember Understand	30 %	-	30 %	-	30 %	-	30 %	-	30%	-
Level 2	Apply Analyze	40 %	-	40 %	-	40 %	-	40 %	-	40%	-
Level 3	Evaluate Create	30 %	-	30 %	-	30 %	-	30 %	-	30%	-
	Total	100 %		100 %		100 %		100 %		100 %	

CLA – 4 can be from any combination of these: Assignments, Seminars, Tech Talks, Mini-Projects, Case-Studies, Self-Study, MOOCs, Certifications, Conf. Paper etc.,

Course Designers

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1. Sathyanarayanan J, Mindray Medical India Pvt Ltd, sathyanarayananjayagopal@mindray.com	*1. Dr. S. Poonguzhali, Anna University, poongs@annauniv.edu*	*1. Mr. S. Gnanavel, SRMIST*
2. Mr. Anuj Kumar, Bombardier Transportation, Ahmedabad, kumaranuj.anii@gmail.com	*2. Dr. Meenakshi, Professor of ECE, CEG, Anna University, meena68@annauniv.edu*	*2. Dr. D. Ashok Kumar, SRMIST*
3. Mr. Hariharasudhan - Johnson Controls, Pune, hariharasudhan.v@jci.com	*3. Dr. Venkatesan, Sr. Scientist, NIOT, Chennai, venkat@niot.res.in*	

Course Code	18ECE362T	Course Name	PHYSIOLOGICAL MODELING AND SIMULATION	Course Category	E	Professional Elective	L	T	P	C
							3	0	0	3

Pre-requisite Courses	Nil	Co-requisite Courses	Nil	Progressive Courses	Nil
Course Offering Department	Electronics and Communication Engineering	Data Book / Codes/Standards	Nil		

Course Learning Rationale (CLR):	*The purpose of learning this course is to:*
CLR-1 :	*Build an engineering model based on physiological subsystems*
CLR-2 :	*Implement static analysis for physiological systems*
CLR-3 :	*Understand time domain and stability analysis of physiological systems*
CLR-4 :	*Implement frequency response analysis for physiological systems*
CLR-5 :	*Identify and estimate unknown parameters in system modeling*
CLR-6 :	*Represent the working of physiological systems using different modeling techniques*

Course Learning Outcomes (CLO):	*At the end of this course, learners will be able to:*	Learning 1	Learning 2	Learning 3	Program Learning Outcomes (PLO) 1	2	3	4	5	6	7	8	9	10	11	12	13	14	15
		Level of Thinking (Bloom)	Expected Proficiency (%)	Expected Attainment (%)	Engineering Knowledge	Problem Analysis	Design & Development	Analysis, Design, Research	Modern Tool Usage	Society & Culture	Environment & Sustainability	Ethics	Individual & Team Work	Communication	Project Mgt. & Finance	Life Long Learning	PSO - 1	PSO - 2	PSO - 3
CLO-1 :	*Develop a more in-depth level of understanding engineering analysis for modeling physiological systems*	*1,2*	*80*	*70*	*M*	-	-	-	-	-	-	-	-	-	-	-	*M*	-	-
CLO-2 :	*Perform static analysis of a system*	*1,2*	*80*	*70*	-	*M*	-	-	-	-	-	-	-	-	-	-	*M*	-	-
CLO-3 :	*Perform transient and stability analysis of a system.*	*1,2*	*80*	*70*	-	*M*	-	-	-	-	-	-	-	-	-	-	*M*	-	-
CLO-4 :	*Able to do frequency analysis of the system*	*1,2*	*80*	*70*	-	*M*	-	-	-	-	-	-	-	-	-	-	*M*	-	-
CLO-5 :	*Understand and implement system identification techniques*	*1,2*	*80*	*70*	-	*L*	-	-	-	-	-	-	-	-	-	-	*M*	-	-
CLO-6 :	*Implement the various mathematical modeling techniques to physiological systems*	*1,2*	*80*	*70*	*M*		-	-	-	-	-	-	-	-	-	-	*M*	-	-

Duration (hour)		Linear Model	Static Analysis	Time Domain Analysis	Frequency Domain Analysis	System Identification
		9	9	9	9	9
S-1	SLO-1	*Introduction to modeling methodology, need for models, approaches to modeling*	*Static analysis: Open loop versus closed loop*	*Introduction to time domain analysis*	*Frequency response: Open loop frequency response*	*Identification of physiological control system*
	SLO-2	*Model identification, model validation and Simulation*	*Loop gain calculation: Room temperature control*	*Linearized respiratory mechanics transient response*	*Closed loop frequency response*	*Basic problems in Physiological system analysis*
S-2	SLO-1	*System analysis, fundamental concepts*	*Steady state characteristics*	*Linearized respiratory mechanics first order model – impulse response for open loop*	*Relation between transient and frequency response*	*Nonparametric and parametric identification methods*
	SLO-2	*Physiological control system an example*	*Determination of steady state operating point for simple model of muscle stretch reflex*	*Linearized respiratory mechanics first order model – impulse response for closed loop*	*Frequency domain specifications*	*Numerical Deconvolution, Least square estimation*
S-3	SLO-1	*Engineering control system versus physiological control system*	*Human body Glucose – Insulin regulatory system*	*Transient response descriptors : Impulse response*	*Graphical representation of frequency response: Bode plot*	*Estimation using correlation functions*
	SLO-2	*Science of modeling*	*Steady state analysis of glucose –insulin model*	*Transient response descriptors : Step response*	*Bode plot :Linearized lung mechanics*	*Estimation in frequency domain, optimization techniques*
S-4	SLO-1	*Generalized system properties*	*Human body chemical regulation of ventilatory system*	*Concept of sliding theory*	*Graphical representation of frequency response: Nicholas chart*	*Problems in parameter estimation*
	SLO-2	*Models with combinations of system elements*	*Mechanism of respiration*	*Neuromuscular reflex action*	*Nicholas chart : Linearized lung mechanics*	*Input design*
S-5	SLO-1	*Linear model of respiratory mechanics*	*Gas exchanger mathematical modeling*	*Mathematical model of neuromuscular reflex motion*	*Graphical representation of frequency response : Nyquist plot*	*Identification of closed loop systems – "opening the loop"*

	SLO-2	*Linear model of respiratory mechanics: Derivation of transfer function*	*Respiratory controller mathematical modeling*	*Calculation of transfer function*	*Nyquist plot: Linearized lung mechanics*	*Starling heart- lung preparation*
S-6	SLO-1	*Linear model of muscle mechanics*	*Closed loop analysis : lung and controller*	*Stability and transient response*	*Introduction : Circulatory system*	*Kao's cross – circulation experiment*
	SLO-2	*Linear model of muscle mechanics: Derivation of transfer function*	*Calculation of transfer function*	*Root locus and Routh-Hurwitz stability criterion*	*Mathematical model of circulatory system*	*Artificial brain perfusion for partitioning central and chemo reflexes*
S-7	SLO-1	*Distributed versus lumped parameter model*	*Heart and systemic circulation*	*Stability analysis: root locus method*	*Frequency response of circulatory system*	*Voltage clamp*
	SLO-2	*Distributed versus lumped parameter model: Derivation of transfer function*	*Mathematical modeling of cardiac output*	*Introduction to Nyquist plot*	*Graphical representation for frequency response of circulatory system*	*Opening the Pupillary reflex loop, Read rebreathing technique*
S-8	SLO-1	*Linear system and superposition principle*	*Calculation of transfer function for simplified model of cardiac output regulation*	*Nyquist criterion for stability*	*Frequency response of glucose – insulin model*	*Identification under closed loop condition*
	SLO-2	*Laplace transform and transfer function*	*Cardiac characteristics curve analysis*	*Relative stability theory*	*Mathematical model and simulation of glucose – insulin model*	*Minimal model of blood glucose regulation*
S-9	SLO-1	*Impulse function analysis*	*Venous return curve*	*Physiology: Pupillary reflex control*	*Frequency response approach to pupil control*	*Optimization : Introduction*
	SLO-2	*Basics of Linear convolution*	*Closed loop analysis of heart and systemic circulation*	*Mathematical modeling and stability analysis of pupillary reflex control*	*Frequency response characteristics curve for pupillary control*	*Optimization in systems with negative feedback*

Learning Resources	1. *Michael C.K. Khoo, "Physiological Control Systems - Analysis, Simulation and Estimation", Prentice Hall of India Private Ltd., 2nd edition, New Delhi, 2001.* 2. *V.Z. Marmarelis,"Advanced Methods of Physiological System Modeling", Vol.3, Springer Science and Business Media, 2013.*	3. *Claudio Cobelli Ewart Carson, , "Introduction to Modeling in Physiology and Medicine", Academic press series, 1st edition, 2008.* 4. *Johnny T. Ottesen, Mette S. Olufsen, Jesper K. Larsen, "Applied Mathematical Models in Human Physiology", Vol.9,SIAM, 2004.* 5. *Dorf, "Modern Control Systems",Pearson Education India, 1st edition, 2008*

Learning Assessment

	Bloom's Level of Thinking	Continuous Learning Assessment (50% weightage)								Final Examination (50% weightage)	
		CLA – 1 (10%)		CLA – 2 (15%)		CLA – 3 (15%)		CLA – 4 (10%)#			
		Theory	Practice	Theory	Practice	Theory	Practice	Theory	Practice	Theory	Practice
Level 1	Remember Understand	30 %	-	30 %	-	30 %	-	30 %	-	30%	-
Level 2	Apply Analyze	40 %	-	40 %	-	40 %	-	40 %	-	40%	-
Level 3	Evaluate Create	30 %	-	30 %	-	30 %	-	30 %	-	30%	-
	Total	100 %		100 %		100 %		100 %		100 %	

CLA – 4 can be from any combination of these: Assignments, Seminars, Tech Talks, Mini-Projects, Case-Studies, Self-Study, MOOCs, Certifications, Conf. Paper etc.,

Course Designers

Experts from Industry	Experts from Higher Technical Institutions	Internal Experts
1. Sathyanarayanan J, Mindray Medical India Pvt Ltd, sathyanarayananjayagopal@mindray.com	*1. Dr. S. Poonguzhali, Anna University, poongs@annauniv.edu*	*1. Dr. T.Jayanthi, SRMIST*
2. Mr. Anuj Kumar, Bombardier Transportation, Ahmedabad, kumaranuj.anii@gmail.com	*2. Dr. Meenakshi, Professor of ECE, CEG, Anna University, meena68@annauniv.edu*	*2. Mrs.G.Anitha, SRMIST*
3. Mr. Hariharasudhan - Johnson Controls, Pune, hariharasudhan.v@jci.com	*3. Dr. Venkatesan, Sr. Scientist, NIOT, Chennai, venkat@niot.res.in*	

Course Code	15EC363J	Course Name	MEDICAL IMAGE PROCESSING	Course Category	E	Professional Elective	L	T	P	C
							2	0	2	3

Pre-requisite Courses	Nil	Co-requisite Courses	Nil	Progressive Courses	Nil
Course Offering Department	Electronics and Communication Engineering	Data Book / Codes/Standards	Nil		

Course Learning Rationale (CLR):	The purpose of learning this course is to:
CLR-1 :	*Understand the fundamental image operations and image transforms*
CLR-2 :	*Apply various image enhancement techniques in enhancing the medial images*
CLR-3 :	*Analyze the various types of image segmentation algorithms*
CLR-4 :	*Gain knowledge in Image compression and image registration methods*
CLR-5 :	*Understand the image reconstruction techniques used in reconstruction of medical images*
CLR-6 :	*The learner gains knowledge in Image retrieval and digital image watermarking*

Course Learning Outcomes (CLO):	At the end of this course, learners will be able to:	Learning			Program Learning Outcomes (PLO)														
		1	2	3	1	2	3	4	5	6	7	8	9	10	11	12	13	14	15
		Level of Thinking (Bloom)	Expected Proficiency (%)	Expected Attainment (%)	Engineering Knowledge	Problem Analysis	Design & Development	Analysis, Design, Research	Modern Tool Usage	Society & Culture	Environment & Sustainability	Ethics	Individual & Team Work	Communication	Project Mgt. & Finance	Life Long Learning	PSO - 1	PSO - 2	PSO - 3
CLO-1 :	*Describe the 2D Sampling theory and different types of image transforms*	*1, 2*	*80*	*70*	*M*														
CLO-2 :	*Implement the image enhancement techniques for improving the quality of medical images*	*2*	*80*	*70*	*M*														
CLO-3 :	*Apply the different image segmentation algorithms for various medical applications*	*2*	*80*	*70*			*M*		*M*								*M*		*L*
CLO-4 :	*Differentiate and analyze the various image compression and registration algorithms*	*3*	*80*	*70*					*M*										
CLO-5 :	*Analyze the various image reconstruction methods used for medical images*	*3*	*80*	*70*	*M*												*M*		*L*
CLO-6 :	*Illustrate the concepts of wavelet transform and digital image water marking*	*3*	*80*	*70*	*M*														

Duration (hour)		Fundamental Image Operations and Transforms	Image Enhancement methods	Image Segmentation Algorithms	Image compression and image registration methods	Image Reconstruction Methods
		12	12	12	12	12
S-1	SLO-1	*Elements of Visual Perception- structure of human eye and image formation*	*Basic gray level transformation- image negative, intensity slicing techniques*	*Morphological operations-Erosion*	*Image compression-Introduction*	*Image reconstruction from projections- Radon transform- derivation*
	SLO-2	*Brightness range adaptation and discrimination*	*Contrast stretching, dynamic range compression and bit plane slicing*	*Dilation*	*Types of redundancies*	*Properties*
S-2	SLO-1	*Image sampling-2D sampling Theory*	*Histogram equalization*	*Image opening*	*Huffman coding technique*	*Inverse radon transform- convolution back projection*
	SLO-2	*Reconstruction from its samples*	*Histogram specification*	*Image closing*	*Procedure*	*Filter back projection*
S 3-4	SLO-1	*Lab1: Basic operations on images*	*Lab4: Gray transformation and histogram equalization*	*Lab 7: Morphological operations*	*Lab 10: Image compression*	*Lab 13: Image reconstruction from projection data*
	SLO-2					
S-5	SLO-1	*Quantization- optimal mean square quantizer*	*Image smoothening in spatial domain – Low pass filter*	*Edge detection- Marr hildreth edge detector*	*Image registration- Introduction*	*Digital implementation of filter back projection- Block diagram*
	SLO-2	*Uniform quantizer*	*Median filter*	*Algorithm*	*Dimensionality transformation*	*Algorithm*
S-6	SLO-1	*Neighborhood pixel relationships- adjacencies*	*Image sharpening in spatial domain – High pass filter, high boost filter*	*Canny edge detection- smoothing*	*Rigid registration algorithm*	*Wavelet transform-Introduction*

	SLO-2	*Distance measures*	*Derivative filters*	*Non maxima suppression and thresholding*	*Rigid registration algorithm*	*Algorithm*
S 7-8	SLO-1	*Lab2: Image transforms in spatial domain*	*Lab 5: Image smoothening using suitable filters*	*Lab 8: Edge detection techniques*	*Lab 11: Image registration*	*Lab 14: Wavelet transform*
	SLO-2					
S-9	SLO-1	*Image transform –DFT, DCT*	*Image smoothening in frequency domain*	*Thresholding –basics*	*Registration of MRI and PET images*	*Digital image watermarking-Introduction*
	SLO-2	*Properties*	*Image sharpening in frequency domain*	*Global thresholding algorithm*	*Clinical applications*	*Applications*
S-10	SLO-1	*Haar Transform*	*Color image processing-Introduction*	*Region based segmentation-region growing algorithm*	*Registration of MRI and CT images*	*Image retrieval-Introduction*
	SLO-2	*Properties*	*Color models*	*Region splitting and merging algorithm*	*Clinical applications*	*Content based image retrieval*
S 11-12	SLO-1	*Lab3: Image transforms in frequency domain*	*Lab 6: Image sharpening using suitable filters*	*Lab9: Image segmentation using Thresholding*	*Lab 12: Fusion of MRI and CT images*	*Lab 15: Digital image watermarking*
	SLO-2					

Learning Resources	1. *Rafael C., Gonzalez and Richard E. Woods,"Digital Image Processing", Pearson Education Asia, Third Edition, 2007* 2. *Anil.k.Jain, "Fundamentals of Digital image processing", Prentice Hall of India, 2nd edition 1997.*	3. *Joseph V.Hajnal, Derek L.G.Hill, David J Hawkes, "Medical image registration", Biomedical Engineering series, CRC press,2001.*

Learning Assessment											
	Bloom's Level of Thinking	Continuous Learning Assessment (50% weightage)								Final Examination (50% weightage)	
		CLA – 1 (10%)		CLA – 2 (15%)		CLA – 3 (15%)		CLA – 4 (10%)#			
		Theory	Practice	Theory	Practice	Theory	Practice	Theory	Practice	Theory	Practice
Level 1	Remember Understand	20%	20%	15%	15%	15%	15%	15%	15%	15%	15%
Level 2	Apply Analyze	20%	20%	20%	20%	20%	20%	20%	20%	20%	20%
Level 3	Evaluate Create	10%	10%	15%	15%	15%	15%	15%	15%	15%	15%
	Total	100 %		100 %		100 %		100 %		-	

CLA – 4 can be from any combination of these: Assignments, Seminars, Tech Talks, Mini-Projects, Case-Studies, Self-Study, MOOCs, Certifications, Conf. Paper etc.,

Course Designers		
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2. Mr. Anuj Kumar, Bombardier Transportation, Ahmedabad, kumaranuj.anii@gmail.com	*2. Dr. Meenakshi, Professor of ECE, CEG, Anna University, meena68@annauniv.edu*	*2. Dr. D. Ashok kumar, SRMIST*
3. Mr. Hariharasudhan - Johnson Controls, Pune, hariharasudhan.v@jci.com	*3. Dr. Venkatesan, Sr. Scientist, NIOT, Chennai, venkat@niot.res.in*	

Course Code	18ECE364T	Course Name	BODY AREA NETWORK AND MOBILE HEALTHCARE	Course Category	E	Professional Elective	L	T	P	C
							3	0	0	3

Pre-requisite Courses	18ECC205J	Co-requisite Courses	Nil	Progressive Courses	Nil
Course Offering Department	Electronics and Communication Engineering	Data Book / Codes/Standards	Nil		

Course Learning Rationale (CLR):	*The purpose of the learning this course is to:*
CLR-1 :	*Comprehend technical information and challenges in WBAN.*
CLR-2 :	*Describe the hardware requirements of BAN*
CLR-3 :	*Review the wearable sensors and standards for BAN*
CLR-4 :	*Describe the mobile devices that is available for health care*
CLR-5 :	*Summarize the possible and latest applications of mobile healthcare*
CLR-6 :	*Learn about context-aware health care applications*

Course Learning Outcomes (CLO):	*At the end of this course, learns will be able to :*	Learning			Program Learning Outcomes (PLO)														
		1	2	3	1	2	3	4	5	6	7	8	9	10	11	12	13	14	15
		Level of Thinking (Bloom)	Expected Proficiency (%)	Expected Attainment (%)	Engineering Knowledge	Problem Analysis	Design & Development	Analysis, Design, Research	Modern Tool Usage	Society & Culture	Environment & Sustainability	Ethics	Individual & Team Work	Communication	Project Mgt. & Finance	Life Long Learning	PSO - 1	PSO - 2	PSO - 3
CLO-1 :	*List out the BAN challenges*	*1*	*80*	*75*		*L*													
CLO-2 :	*Identify the hardware necessary for BAN*	*1*	*80*	*75*	*L*														
CLO-3 :	*List and describe the various wearable sensors*	*1,2*	*80*	*75*		*L*											*L*		
CLO-4 :	*Appreciate the mobile devices available for healthcare*	*1.2*	*80*	*75*	*L*														
CLO-5 :	*List the latest applications and research opportunities with mobile healthcare.*	*2*	*80*	*75*														*L*	
CLO-6 :	*Think about context-aware health care solutions*	*3*	*80*	*75*															*M*

Duration (hour)		9	9	9	9	9
S-1	SLO-1	*BAN-Definition*	*Processor in BAN*	*RF Communication*	*Sensors for wearable system*	*Mobile health technologies*
	SLO-2	*Terminologies used with BAN*	*Low Power MCUs*	*RF Communication in and around the body*	*Wearable system design for specific applications*	*Mobile nutrition tracking*
S-2	SLO-1	*Technical Challenges*	*Mobile Computing MCU*	*Antennal Design*	*Wearable system for ECG monitoring,*	*Accessing existing virtual electronic patient record*
	SLO-2	*Sensor design concepts*	*Integrated processor*	*Antenna testing*	*Wearable system for EEG monitoring,*	*Mobile personal health records,*
S-3	SLO-1	*Types of sensors*	*Radio transceiver along with the processor*	*Propagation issues*	*Wearable system for Gait analysis*	*Monitoring hospital patients,*
	SLO-2	*Biocompatibility issues*	*Integrated processor with Memory*	*Base Station considerations*	*Evaluation of general performance*	*Sensing vital signs*
S-4	SLO-1	*Energy Requirements*	*Antenna for BAN*	*Network topology*	*Evaluation of night time performance*	*Transmission using wireless networks*
	SLO-2	*Energy supply*	*Antenna Requirements*	*Stand – Alone BAN*	*Evaluation parameters*	*Continuous monitoring*

S-5	SLO-1	*Nodes, number of node*	*Antenna Considerations*	*Wireless personal Area Network*	*Latest health monitoring methods*	*Patient Monitoring and wearable devices*
	SLO-2	*Optimal node placement in BAN*	*Types of antenna*	*Wireless personal Area Network Technologies*	*Smart phone based health care monitoring system*	*Patient Monitoring in Diverse Environments*
S-6	SLO-1	*System security*	*Wire antenna*	*IEEE 802.15.1*	*Phone based fall risk prediction*	*A framework for Capturing Patient Consent in Pervasive Healthcare Applications*
	SLO-2	*System Reliability*	*Ceramic antenna*	*IEEE P802.15.13*	*Emergency alerts*	*M-health application*
S-7	SLO-1	*BAN Standards*	*External antenna*	*IEEE 702.15.14*	*RFID based personal mobile medical assistance*	*Context aware sensing*
	SLO-2	*BAN with other standards*	*Sensor Interface*	*Zigbee*	*Other similar technologies*	*Technology Enablers for context-Aware healthcare Applications*
S-8	SLO-1	*BAN Architecture*	*Considerations on the interface*	*BAN and WBAN technologies*	*Infusing image processing capabilities*	*Case study I*
	SLO-2	*BAN and other technologies*	*Power sources- Batteries*	*Limitations in use*	*Secure medical sensor network with HIP*	*Case study I*
S-9	SLO-1	*BAN and Healthcare*	*Fuel cells for sensor nodes.*	*Coexistence issues with BAN*	*Diagnostic applications*	*Case study II*
	SLO-2	*Medical Applications of BAN*	*Other novel power sources*	*Other practical considerations*	*Therapeutic applications*	*Case study II*

Learning Resources	1. *Annalisa Bonfiglio, Danilo De Rossi, " Wearable Monitoring Systems", Springer, 2011.* 2. *Philip Olla, Josep Tan, " Mobile Health solutions for Biomedical applications", Medical Information science reference, Hershey New York, IGI Global 2009.* 3. *Zhang, Yuan-Ting, Wearable Medical Sensors and systems, Sringers, 2013.* 4. *Guang-Zhogn Yang(ED), " Body Sensor Networks", Springers, 2013* 5. *Mehmet R. Yuce Jamil Y.Khan, " Wireless Body Area Networks Technology, Implementation and applications", Pan Standford Pte. Ltd., Singapore, 2012*	6. *Konstantina, James C. Lin, Dimitrios, Maria Teresa, " Wireless mobile Communication and healthcare", Secon International ICST conference, Mobihealth 2011, Springers 2011.* 7. *Ullah, Sana, Et at, " A review of wireless body area networks for medical applications", arXiv: 1001.083, 2010* 8. *Patel, Shyamal, Et al, " A review of wearable sensors and systems with application in rehabilitation", Neuroeng Rehabil 9.12, 2012, 1-17.*

Learning Assessment

	Bloom's Level of Thinking	Continuous Learning Assessment (50% weightage)								Final Examination (50% weightage)	
		CLA – 1 (10%)		CLA – 2 (15%)		CLA – 3 (15%)		CLA – 4 (10%)#			
		Theory	Practice	Theory	Practice	Theory	Practice	Theory	Practice	Theory	Practice
Level 1	Remember Understand	40 %	-	30 %	-	30 %	-	30 %	-	30%	-
Level 2	Apply Analyze	40 %	-	40 %	-	40 %	-	40 %	-	40%	-
Level 3	Evaluate Create	20 %	-	30 %	-	30 %	-	30 %	-	30%	-
	Total	100 %		100 %		100 %		100 %		100 %	

CLA – 4 can be from any combination of these: Assignments, Seminars, Tech Talks, Mini-Projects, Case-Studies, Self-Study, MOOCs, Certifications, Conf. Paper etc.,

Course Designers

Experts from Industry	Experts from Higher Technical Institutions	Internal Experts
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3. Mr. Hariharasudhan - Johnson Controls, Pune, hariharasudhan.v@jci.com	*3. Dr. Venkatesan, Sr. Scientist, NIOT, Chennai, venkat@niot.res.in*	

Course Code	18ECE365T	Course Name	BIO-INSPIRED HUMAN MACHINE INTERFACE	Course Category	E	Professional Electives	L	T	P	C
							3	0	0	3

Pre-requisite Courses	NIL	Co-requisite Courses	NIL	Progressive Courses	NIL
Course Offering Department	Electronics and Communication Engineering			Data Book / Codes/ Standards	NIL

Course Learning Rationale (CLR):	*The purpose of learning this course is to:*
CLR-1 :	*Study the HMI design, principles and standards*
CLR-2 :	*Attain knowledge in optic and acoustic based HMI design*
CLR-3 :	*Acquire knowledge in Bioelectric interfaces*
CLR-4 :	*Study the brain signal based HMI design*
CLR-5 :	*Have an insight knowledge in advanced HMI design*

Course Learning Outcomes (CLO):	*At the end of this course, learners will be able to:*	Learning 1	Learning 2	Learning 3	PLO 1	PLO 2	PLO 3	PLO 4	PLO 5	PLO 6	PLO 7	PLO 8	PLO 9	PLO 10	PLO 11	PLO 12	PLO 13	PLO 14	PLO 15
		Level of Thinking (Bloom)	Expected Proficiency (%)	Expected Attainment (%)	Engineering Knowledge	Problem Analysis	Design & Development	Analysis, Design, Research	Modern Tool Usage	Society & Culture	Environment & Sustainability	Ethics	Individual & Team Work	Communication	Project Mgt. & Finance	Life Long Learning	PSO - 1	PSO - 2	PSO - 3
CLO-1 :	*Explain the basics, rules and generic design flow of HMI systems*	*3*	*80*	*75*	*M*	*M*			*L*										
CLO-2 :	*Explain and analyze the optic and Acoustic based HMI systems*	*3*	*80*	*70*	*M*	*M*			*L*										
CLO-3 :	*Analyze and discuss the bioelectric based HMI design*	*3*	*75*	*70*	*M*	*M*			*L*										
CLO-4 :	*Explain and analyze brain signal based HMI design*	*3*	*80*	*75*	*M*	*M*			*L*										
CLO-5 :	*Analyze and discuss the advances and challenges in HMI design*	*3*	*80*	*70*	*M*	*M*			*L*										
CLO-6:	*Design a biomimetic system for neural prosthesis*	*3*	*80*	*75*	*M*	*M*			*L*										

Duration (hour)		9	9	9	9	9
S-1	SLO-1	*Introduction to HMI*	*Vision based HMI design-Introduction-*	*Bioelectric Interfaces-Introduction*	*Brain Computer Interfaces-Introduction*	*Affective Computing based HMI-Introduction*
	SLO-2	*Need for HMI systems*	*Face Recognition-Signal Acquisition*	*Myoelectric interfaces-Introduction*	*brain regions and responsibilities*	*Affective Computing based HMI-Data Acquisition*
S-2	SLO-1	*Types of HMI*	*Face Recognition-Data Analysis*	*Muscle regions and responsibilities*	*Active methods for measuring brain activity*	*Affective Computing based HMI-Data Classification*
	SLO-2	*Types of HMI*	*Vision based HMI design-Data Classification*	*Methods for measuring muscle activity*	*Active methods for measuring brain activity(Contd.)*	*Application of Affective Computing based HMI*
S-3	SLO-1	*HMI-guidelines*	*Gait Recognition-Signal Acquisition*	*Myoelectric Signal –Data Analysis*	*Invasive BCI*	*Wearable Computing-Introduction*
	SLO-2	*HMI-principles*	*Gait Recognition-Data Analysis & Classification*	*Myoelectric Signal –Data Analysis(Contd.)*	*Non-invasive BCI*	*Wearable Computing*
S-4	SLO-1	*HMI-standards*	*Gesture Recognition-Data Analysis &Classification*	*Myoelectric Signal –Data Classification*	*EEG based BCI*	*Tactile based HMI*
	SLO-2	*HMI-Ethical Issues*	*People tracking*	*Application of Myoelectric HMI*	*P300 based BCI*	*Tactile based HMI*
S-5	SLO-1	*Interaction design-basics*	*LED based HMI system*	*ECG based HMI design*	*VEP based BCI*	*Motion based HMI*
	SLO-2	*Interaction design-Design rules*	*LASER based HMI system*	*ECG based HMI design(Contd.)*	*NIRS based BCI*	*Motion based HMI*
S-6	SLO-1	*HMI Systems-Data Collection*	*Speech Communication*	*EOG based HMI design-Introduction*	*Application in Prosthetic Control*	*Biomimetic design of neural prosthesis*
	SLO-2	*HMI Systems-Data Analysis*	*Speech Communication (Contd.)*	*EOG based HMI design-Signal Acquisition*	*Application in Prosthetic Control*	*Biomimetic design of neural prosthesis*

S-7	SLO-1	*HMI Systems-Design*	*Fundamentals of Speech Recognition*	*EOG based HMI design-Signal Analysis*	*Neurorehabilitation*	*Intracranial human machine interfaces for Communication and control*
	SLO-2	*HMI Systems-Prototyping*	*Fundamentals of Speech Recognition(Contd.)*	*EOG based HMI design-Signal Analysis(Contd.)*	*Neurorehabilitation*	*Intracranial human machine interfaces for Communication and control*
S-8	SLO-1	*Evaluation of HMI Systems*	*Automatic Speech Recognition*	*EOG based HMI design-Signal Classification*	*Neuromarketing*	*Multimodal approaches for advanced HMI design*
	SLO-2	*Evaluation of HMI Systems*	*Automatic Speech Recognition(Contd.)*	*EOG based HMI design-Signal Classification(Contd.)*	*Neuromarketing*	*Multimodal approaches for advanced HMI design*
S-9	SLO-1	*Bio-inspired HMI Systems*	*Multimodal Interaction &Approaches*	*Applications of EOG based HMI*	*Brain controlled wheel chairs*	*Multimodal approaches for advanced HMI design*
	SLO-2	*Bio-inspired HMI Systems*	*Multimodal Interaction &Approaches (Contd.)*	*Applications of EOG based HMI (Contd.)*	*Brain controlled wheel chairs*	*Multimodal approaches for advanced HMI design*

Learning Resources	1. Yvonne Rogers, Helen Sharp, Jenny Preece, “Interaction Design: Beyond Human Computer Interaction”, 3rd Edition, Willey Publisher, 2012. 2. P C Yuen, Y Y Tang , P S P Wang, “Multimodal Interface For Human-Machine Communication”, World Scientific, 2002. 3. Aboul-Ella Hassanien and Ahmad Taher Azar, “Brain-Computer Interfaces:Current Trends and Applications”, Springer International Publishing AG, 2016.	4. Rajesh P. N. Rao, “Brain-Computer Interfacing : An Introduction”, Cambridge University Press, 2013 5. Masaki Kurosu, Human-Computer Interaction. User Interface Design, Development and Multimodality, Springer International Publishing AG, 2017

Learning Assessment

	Bloom's Level of Thinking	Continuous Learning Assessment (50% weightage)								Final Examination (50% weightage)	
		CLA – 1 (10%)		CLA – 2 (15%)		CLA – 3 (15%)		CLA – 4 (10%)#			
		Theory	Practice	Theory	Practice	Theory	Practice	Theory	Practice	Theory	Practice
Level 1	Remember Understand	30 %	-	30 %	-	30 %	-	30 %	-	30%	-
Level 2	Apply Analyze	40 %	-	40 %	-	40 %	-	40 %	-	40%	-
Level 3	Evaluate Create	30 %	-	30 %	-	30 %	-	30 %	-	30%	-
	Total	100 %		100 %		100 %		100 %		100 %	

CLA – 4 can be from any combination of these: Assignments, Seminars, Tech Talks, Mini-Projects, Case-Studies, Self-Study, MOOCs, Certifications, Conf. Paper etc.,

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. Mr. Hariharasudhan - Johnson Controls, Pune, hariharasudhan.v@jci.com	3. Dr. Venkatesan, Sr. Scientist, NIOT, Chennai, venkat@niot.res.in	

Course Code	18ECE366T	Course Name	IMPLANTABLE BIOELECTRONICS	Course Category	E	Professional Elective	L	T	P	C
							3	0	0	3

Pre-requisite Courses	18EES101J	Co-requisite Courses	Nil	Progressive Courses	Nil
Course Offering Department	Electronics and Communication Engineering	Data Book / Codes/Standards	Nil		

Course Learning Rationale (CLR):	*The purpose of learning this course is to:*
CLR-1 :	*Comprehend technical information about miniaturized Implantable Biomedical devices*
CLR-2 :	*Introduce to neural interfaces and cyborgs*
CLR-3 :	*Know about implantable user interface and CMOS imaging systems*
CLR-4 :	*Learn about implantable electronics biocompatibility criteria and telemetry*
CLR-5 :	*Know the key design trends in implantable systems*
CLR-6 :	*Know the future of Biomedical Implantable systems*

Course Learning Outcomes (CLO):	*At the end of this course, learners will be able to:*	Learning 1: Level of Thinking (Bloom)	Learning 2: Expected Proficiency (%)	Learning 3: Expected Attainment (%)	PLO 1: Engineering Knowledge	PLO 2: Problem Analysis	PLO 3: Design & Development	PLO 4: Analysis, Design, Research	PLO 5: Modern Tool Usage	PLO 6: Society & Culture	PLO 7: Environment & Sustainability	PLO 8: Ethics	PLO 9: Individual & Team Work	PLO 10: Communication	PLO 11: Project Mgt. & Finance	PLO 12: Life Long Learning	PLO 13: PSO - 1	PLO 14: PSO - 2	PLO 15: PSO - 3
CLO-1 :	*Describe the design of Implantable Biomedical Devices*	*1,2*	*80*	*75*	*M*														
CLO-2 :	*Tell about neural interfaces and cyborgs*	*1*	*80*	*75*	*L*														
CLO-3 :	*Describe about implantable user interface and CMOS imaging systems*	*1,2*	*80*	*75*	*M*														
CLO-4 :	*Tell about implantable electronics biocompatibility criteria and telemetry*	*1*	*80*	*75*						*L*	*L*								
CLO-5 :	*Consolidate on design trends in implantable systems*	*2,3*	*80*	*75*	*L*													*L*	
CLO-6 :	*Summarize the future of Biomedical Implantable systems*	*2,3*	*80*	*75*														*L*	

Duration (hour)		9	9	9	9	9
S-1	SLO-1	*Bioelectronics-Introduction*	*Neural interfaces and cyborgs- introduction*	*Implantable user interfaces*	*Biotelemtry*	*Design trends in Biomedical Implantable systems*
	SLO-2	*Energy Harvesting as a Pathway to miniaturization,*	*Fusing Robotics with the Human Body*	*Design Considerations*	*Inductive Link for Forward Data*	*Design of Implant Systems-*
S-2	SLO-1	*Implantable Devices*	*Anatomy of Peripheral Nerves*	*Evaluating Basic Implanted User Interfaces*	*Wireless Power Link*	*Review-History*
	SLO-2	*Implementation of Implantable Devices*	*Interfacing with the periphery for recording and stimulation*	*Qualitative Evaluation,*	*Implantable device with external units*	*Basic Considerations and Characteristics of RF MEMS Implantable Systems-*
S-3	SLO-1	*RF Power Harvesting*	*Listening to the Brain*	*Medical Considerations*	*Implantable Telemetry Link*	*Legal Considerations of the Radio Frequency (RF)*
	SLO-2	*Matching network, rectifier,*	*Interfacing with the Central Nervous System*	*Limitations*	*Wideband telemetry links*	*Field Strength*
S-4	SLO-1	*Regulator and band gap reference*	*Eletrical Modulation of the Human Nervous System*	*CMOS Imaging Devices*	*Multichannel neural recording systems*	*Power Levels*
	SLO-2	*Implant functional block*	*Pain Modulation*	*Fundamentals of CMOS Imaging*	*Wireless endoscope*	*Biocompatibility*
S-5	SLO-1	*Wireless Communication Link,*	*Electrical Modulation of Inflammation*	*Photo sensors,*	*Microelectrode Arrays*	*Protection of the Biomedical Implant*
	SLO-2	*Forward and reserve data link*	*Cyborgs*	*Log sensors*	*Interface Electronics*	*Systems-Characteristics of Biological and Medical Signals*

S-6	SLO-1	*Payload*	*The Neuro-Tech Version*	*SPAD sensors*	*Electrode equivalent circuit*	*Design considerations of Implantable Systems, Micro power Electronic Design*
	SLO-2	*Applications*	*Biological Brains in a Robot Body*	*Artificial Retina*	*Stimulation Front Ends*	*Approaches*
S-7	SLO-1	*Locomotive Implant*	*Deep Brain Stimulation*	*Principle of Artificial Retina*	*Recording Front-Ends*	*Samples*
	SLO-2	*Implantable Cardiac Probe,*	*General Purpose Brain Implants*	*Artificial Retina Based on CMOS Imaging Device*	*Instrumentation amplifier*	*Power Supply design.*
S-8	SLO-1	*Communication power delivery*	*Brain-Computer Interfaces*	*Brain-Implantable CMOS Imaging Device*	*Improving the Biocompatibility of Implantable Bioelectronics Devices.*	*System integration*
	SLO-2	*System Overview of a Generic Bioelectronics Implant*	*Noninvasive Brain-Computer Interfaces*	*Measurement Methods for Brain Activities*	*Implantable Bioelectronics Devices Materials*	*Micro-Packages,*
S-9	SLO-1	*Circuit Design for Low-Power Signal Processing.*	*Sub dermal Magnetic Implants*	*Fiber Endoscope and Head-Mountable Device*	*Surface Composition*	*Present Challenges,*
	SLO-2	*Architecture-Level Optimization for Low-Power Data Processing*	*RF ID Implants.*	*Summary and future directions*	*Response to Implantation*	*Nano-Enabled Implantable Device for In Vivo Glucose Monitoring*

Learning Resources	1. *Evgeny Katz, "Implantable Biolectronics Devices materials and Applications", Wiley-VCH, 2014.* 2. *Vinod Kumar Khanna, "Implantable Medical Electronics Prosthetics, Drug Delivery and Health Monitoring", Springer, 2016*	3. *Swarup Bhunia, Steve Majerus, Mohamad Sawan, Implantable Biomedical Microsystems: Design Principles and Applications", Elsevier, 2015.*

Learning Assessment

	Bloom's Level of Thinking	Continuous Learning Assessment (50% weightage)								Final Examination (50% weightage)	
		CLA – 1 (10%)		CLA – 2 (15%)		CLA – 3 (15%)		CLA – 4 (10%)#			
		Theory		Theory	Practice	Theory	Practice	Theory	Practice	Theory	Practice
Level 1	Remember Understand	30 %	-	30 %	-	30 %	-	30 %	-	30%	-
Level 2	Apply Analyze	40 %	-	40 %	-	40 %	-	40 %	-	40%	-
Level 3	Evaluate Create	30 %	-	30 %	-	30 %	-	30 %	-	30%	-
	Total	100 %		100 %		100 %		100 %		-	

CLA – 4 can be from any combination of these: Assignments, Seminars, Tech Talks, Mini-Projects, Case-Studies, Self-Study, MOOCs, Certifications, Conf. Paper etc.,

Course Designers

Experts from Industry	Experts from Higher Technical Institutions	Internal Experts
1. Sathyanarayanan J, Mindray Medical India Pvt Ltd, sathyanarayananjayagopal@mindray.com	*1. Dr. S. Poonguzhali, Anna University, poongs@annauniv.edu*	*Dr. Varshini Karthik, SRMIST*
2. Mr. Anuj Kumar, Bombardier Transportation, Ahmedabad, kumaranuj.anii@gmail.com	*2. Dr. Meenakshi, Professor of ECE, CEG, Anna University, meena68@annauniv.edu*	*Mr.Karthik Raj, SRMIST*
3. Mr. Hariharasudhan - Johnson Controls, Pune, hariharasudhan.v@jci.com	*3. Dr. Venkatesan, Sr. Scientist, NIOT, Chennai, venkat@niot.res.in*	

Course Code	18ECE367T	Course Name	REGULATORY AFFAIRS IN MEDICAL INSTRUMENTS	Course Category	E	Professional Elective	L	T	P	C
							3	0	0	3

Pre-requisite Courses	18ECC201J, 18ECE260J	Co-requisite Courses	Nil	Progressive Courses	Nil
Course Offering Department		Electronics and Communication Engineering		Data Book / Codes/Standards	Nil

Course Learning Rationale (CLR):	*The purpose of learning this course is to:*
CLR-1 :	*Understand the fundamental troubleshooting procedures and testing of basic electronic components*
CLR-2 :	*Get an idea about the fault diagnosis in analog circuits and digital ICs.*
CLR-3 :	*Acquire an idea about the basic troubleshooting procedures for biomedical equipment*
CLR-4 :	*Get an idea about the medical device classification globally and regulatory standards*
CLR-5 :	*Get an idea about the Indian perspective medical device regulatory system*
CLR-6 :	*Get an overall idea about the importance of troubleshooting and medical device classification in India*

Course Learning Outcomes (CLO):	*At the end of this course, learners will be able to:*	Learning 1 Level of Thinking (Bloom)	2 Expected Proficiency (%)	3 Expected Attainment (%)	PLO 1 Engineering Knowledge	2 Problem Analysis	3 Design & Development	4 Analysis, Design, Research	5 Modern Tool Usage	6 Society & Culture	7 Environment & Sustainability	8 Ethics	9 Individual & Team Work	10 Communication	11 Project Mgt. & Finance	12 Life Long Learning	13 PSO - 1	14 PSO - 2	15 PSO - 3
CLO-1 :	*Apply the common troubleshooting procedures in Electronic Equipment and Outline the testing procedures of active and passive components*	*1, 2*	*80*	*70*	*M*	-	-	-	-	-	-	-	-	-	-	-	-	-	-
CLO-2 :	*Analyze the faults in analog circuits and digital ICs*	*1, 2*	*80*	*70*	*M*	-	-	-	-	-	-	-	-	-	-	-	*M*	-	-
CLO-3 :	*Identify the problems in common biomedical equipment in hospitals when it is not working and provide a suitable solution*	*2*	*80*	*70*	-	*M*	-	-	-	-	-	-	-	-	-	-	*M*		-
CLO-4 :	*Outline the importance of medical device classification based on the application and ISO standards*	*1*	*80*	*70*	-	-	*H*	-	-	-	-	-	-	-	-	*M*	-	*M*	-
CLO-5 :	*Describe the Indian medical device regulatory system*	*1*	*80*	*70*	-	-	-	-	-	-	-	-	-	-	-	*M*	-	-	-
CLO-6 :	*Outline the job opportunities in regulatory affairs in India*	*1,2*	*80*	*70*	-	-	-	-	-	-	-	-	-	-	-	*L*	-	-	-

Duration (hour)		Basic Troubleshooting Techniques& Testing Procedures	Fault Diagnosis in Analog, Digital Integrated Circuits and Home care device	Biomedical Machine Troubleshooting in Hospitals	Medical Device Classification and Standards	Medical Device Regulatory System in India
		9	9	9	9	9
S-1	SLO-1	*Equipment failure and its types*	*Characteristics of ideal op-amps*	*Troubleshooting- ECG Machine*	*Global Harmonization Task Force (GHTF) definition for medical device*	*Importance of regulatory system*
	SLO-2	*Causes of Equipment failure*	*Typical op-amp based medical circuits*	*And its preventive maintenance*	*Medical Device Life Cycle: Identify, Characterize*	*Market Overview*
S-2	SLO-1	*Functional block diagram of a troubleshooting system*	*Typical op-amp based medical circuits*	*Troubleshooting- EEG Machine*	*Medical Device Life Cycle: Optimize, Verify/Validate*	*Overview of Regulatory Environment*
	SLO-2	*Functional block diagram of a troubleshooting system*	*Fault diagnosis in op-amp circuits*	*And its preventive maintenance*	*Global Perspective on medical device regulations: USA, European Union*	*Overview of Regulatory Environment*
S-3	SLO-1	*Troubleshooting process*	*Example: Inverting amplifier troubleshooting process*	*Troubleshooting- defibrillator, suction machine*	*Global Perspective on medical device regulations: Canada, Australia, Japan*	*Functions Undertaken by DCGI and Central Government*
	SLO-2	*Fault finding aids*	*Typical Faults in digital circuits*	*And its preventive maintenance*	*Medical device classification: USA*	*Functions Undertaken by the FDA and State Governments*
S-4	SLO-1	*Troubleshooting techniques: Preliminary Observations*	*Different testing methods in digital circuits: Functional Testing, DC Test*	*Troubleshooting- electrosurgical unit*	*Medical device classification: European Union, GHTF*	*Indian Pharmacopoeia Commission*
	SLO-2	*Troubleshooting techniques: Functional block diagram approach*	*AC Test*	*And its preventive maintenance*	*Premarket Notification 510(k), Premarket Approval*	*Details of Key Regulator*
S-5	SLO-1	*Troubleshooting techniques: Split half method*	*Digital IC Troubleshooter:, Logic clip, Logic probe*	*Troubleshooting- anesthesia machine*	*Standards and its need*	*Organization Chart — CDSCO*
	SLO-2	*Application of Split half method in circuit troubleshooting*	*Digital IC Troubleshooters: Logic pulser, Logic current tracer*	*And its preventive maintenance*	*ISO 9000 core standards: Basic overview*	*Role of Distributors or Local Subsidiaries*

S-6	SLO-1	*Troubleshooting techniques: Systematic Troubleshooting*	*Digital IC Troubleshooters: Logic comparator*	*Troubleshooting- autoclaves & sterilizers*	*ISO 13485: Basic overview*	*Product Registration*
	SLO-2	*Correction action*	*Circuit board Troubleshooting*	*And its preventive maintenance*	*ISO 14971: Basic overview*	*Manufacturing site and product registration: process flow chart*
S-7	SLO-1	*Testing of passive components: Resistors, Capacitors*	*Troubleshooting- oxygen concentrators*	*Troubleshooting- endoscope*	*ISO 10933: Basic overview*	*Quality System Regulation*
	SLO-2	*Testing of passive components: Inductors, Diodes, LDR*	*And its preventive maintenance*	*And its preventive maintenance*	*ISO 14155: Basic overview*	*Technical Material Requirement & Labelling Requirement of Medical Device*
S-8	SLO-1	*Testing of active components: BJT*	*Troubleshooting- sphygmomanometers, Analog Blood pressure apparatus*	*Troubleshooting- incubators*	*ISO 11607: Basic overview*	*Manufacturing-Related Regulation*
	SLO-2	*Testing of active components: JFET*	*And its preventive maintenance*	*And its preventive maintenance*	*ISO 11137: Basic overview*	*Clinical Trial-Related Regulation*
S-9	SLO-1	*Testing of active components: MOSFET*	*Troubleshooting- nebulizer*	*Troubleshooting- X-ray Machine*	*IEC 60601: Basic overview*	*Commercial Aspect*
	SLO-2	*Testing of variable resistors and its different types*	*And its preventive maintenance*	*And its preventive maintenance*	*IEC 62353: Basic overview*	*Related Agencies/Departments and Ministries*

Learning Resources	1. *Joseph D Bronzino& Donald R Peterson, "Medical Devices and Human Engineering", CRC Press, 4th Edition, 2015* 2. *Myer Kutz, "Biomedical Engineering and Design Handbook- Volume 2: Applications", McGraw-Hill, 2nd Edition, 2009* 3. *Richard Fries, "Reliable Design of Medical Devices", CRC Press, 2nd Edition, 2006* 4. *Basem S EL-Haik & Khalid S Mekki, "Medical Device Design for Six Sigma: A Road Map for Safety and Effectiveness", John Wiley & Sons, 1st Edition, 2008* 5. *John J Tobin & Gary Walsh, "Medical Product Regulatory Affairs- Pharmaceutical, Diagnostics, Medical Devices", Wiley-Blackwell, 1st Edition, 2008* 6. *Norbert Leitgeb, "Safety of Electromedical Devices Law – Risks – Opportunities", SpringerWienNewYork, 1st Edition, 2010*	7. *"Medical Device Regulations Global overview and guiding principles", World Health Organization Geneva, 2003* 8. *Jack Wong and Raymond K Y Tong, "Handbook of Medical device regulatory affairs in Asia", Pan Stanford Publishing Pte. Ltd., 2ndEdition, 2018* 9. *Khandpur R S, "Troubleshooting Electronic Equipment- Includes Repair & Maintenance", Tata McGraw-Hill, 2nd Edition, 2009* 10. *Nicholas Cram & Selby Holder, "Basic Electronic Troubleshooting for Biomedical Technicians", TSTC Publishing, 2nd edition, 2010* 11. *Dan Tomal& Neal Widmer, "Electronic Troubleshooting", McGraw Hill, 3rd edition, 2004* 12. *Ministry of Health &Family Welfare, "Medical Equipment Maintenance Manual- A first line maintenance guide for end users", New Delhi, 2010*

Learning Assessment

	Bloom's Level of Thinking	Continuous Learning Assessment (50% weightage)								Final Examination (50% weightage)	
		CLA – 1 (10%)		CLA – 2 (15%)		CLA – 3 (15%)		CLA – 4 (10%)#			
		Theory	Practice	Theory	Practice	Theory	Practice	Theory	Practice	Theory	Practice
Level 1	Remember Understand	40 %	-	40 %	-	40 %	-	30 %	-	30%	-
Level 2	Apply Analyze	40 %	-	40 %	-	40 %	-	40 %	-	40%	-
Level 3	Evaluate Create	20 %	-	20 %	-	20 %	-	30 %	-	30%	-
	Total	100 %		100 %		100 %		100 %		100 %	

CLA – 4 can be from any combination of these: Assignments, Seminars, Tech Talks, Mini-Projects, Case-Studies, Self-Study, MOOCs, Certifications, Conf. Paper etc.,

Course Designers

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3. Mr. Hariharasudhan - Johnson Controls, Pune, hariharasudhan.v@jci.com	*3. Dr. Venkatesan, Sr. Scientist, NIOT, Chennai, venkat@niot.res.in*	

Course Code	18ECE280T	Course Name	INDUSTRIAL INSTRUMENTATION	Course Category	E	Professional Elective	L	T	P	C
							3	0	0	3

Pre-requisite Courses	Nil	Co-requisite Courses	Nil	Progressive Courses	Nil
Course Offering Department	Electronics and Communication Engineering			Data Book / Codes/Standards	Nil

Course Learning Rationale (CLR):	*The purpose of learning this course is to:*
CLR-1 :	*Acquire familiarity about various industrial instrumentation types, their parameters and different types of measurement techniques.*
CLR-2 :	*Gain knowledge about pressure measurement techniques.*
CLR-3 :	*Learn about the different techniques of measurement of flow.*
CLR-4 :	*Get exposed to the various techniques of measurement of level.*
CLR-5 :	*Gain knowledge about the temperature measurement techniques.*
CLR-6 :	*Familiarize the measuring devices used in industrial applications.*

Course Learning Outcomes (CLO):	*At the end of this course, learners will be able to:*	Learning 1: Level of Thinking (Bloom)	2: Expected Proficiency (%)	3: Expected Attainment (%)
CLO-1 :	*Understand the need for measurement in industries and the basic measurement techniques.*	*3*	*80*	*75*
CLO-2 :	*Elucidate the construction & working of various industrial devices used to measure pressure.*	*3*	*80*	*70*
CLO-3 :	*Summarize the different methods for flow measurement.*	*3*	*75*	*70*
CLO-4 :	*Illustrate the different methods for the measurement of level.*	*3*	*80*	*75*
CLO-5 :	*Analyze different techniques to measure temperature.*	*3*	*80*	*70*
CLO-6 :	*Analyze, formulate and select suitable sensor for the given industrial applications.*	*3*	*80*	*70*

Program Learning Outcomes (PLO)

	1 Engineering Knowledge	2 Problem Analysis	3 Design & Development	4 Analysis, Design, Research	5 Modern Tool Usage	6 Society & Culture	7 Environment & Sustainability	8 Ethics	9 Individual & Team Work	10 Communication	11 Project Mgt. & Finance	12 Life Long Learning	13 PSO - 1	14 PSO - 2	15 PSO - 3
CLO-1	H	H	-	H	H	-	-	H	L	-	H	H	M	H	L
CLO-2	H	H	H	H	H	-	-	H	L	-	H	H	H	H	L
CLO-3	H	H	H	H	H	-	-	H	L	-	H	H	H	H	L
CLO-4	H	H	H	H	H	-	-	H	L	-	H	H	H	H	H
CLO-5	H	H	H	H	H	-	-	H	L	-	H	H	H	H	H
CLO-6	H	H	-	H	H	-	-	H	L	-	H	H	M	H	H

Duration (hour)		Force, Acceleration and Speed Measurement	Pressure Measurement	Level Measurement	Flow Measurement	Temperature Measurement
		9	9	9	9	9
S-1	SLO-1	*Introduction to industrial symbols and standards*	*Units of pressure and vacuum*	*Need for level Measurement*	*General concepts - Laminar flow, Reynolds's number*	*Definitions and standards*
	SLO-2	*Classification of industry*	*Need for pressure measurement*	*Visual level indicators*	*Effect of temperature and pressure on flow rate measurement*	*Primary and secondary fixed points*
S-2	SLO-1	*Definitions of Process variable*	*Manometer Dynamics*	*Purge method*	*Calibration of flow meters.*	*Calibration of thermometer*
	SLO-2	*Unit conversions*	*Types- U tube, Inclined Tube and Well type Manometers*	*Buoyancy method*	*Head type flow measurement -Principle*	*Different types of filled in system thermometer*
S-3	SLO-1	*Types of measurement required*	*Elastic Pressure Sensor Instruments – Bourdon Tube Pressure Gauge, Capsule Gauge*	*Resistance, Capacitance and inductive probes*	*Orifice , Venturi tube*	*Sources of errors in filled in systems and their compensation*
	SLO-2	*Detectors, probe analyzers, actuators*	*Diaphragm gauges, bellows and force balance type sensors*	*Ultrasonic type*	*Pitot Tubes, Flow nozzle*	*Bimetallic thermometers*
S-4	SLO-1	*Measurement of force*	*Electronic Pressure / DP transmitters- capacitive type*	*Laser type*	*Variable Area Flow meters-Principle*	*Review of RTD and Thermistors*
	SLO-2	*Different types of load cells – Magneto-elastic load cell, Strain gauge load cell*	*Piezo - resistive and resonating wire type*	*Optical fiber, Thermal type*	*Rotameters*	*Signal conditioning of industrial RTDs and their characteristics*
S-5	SLO-1	*Acceleration Measurement*	*Vacuum pressure Measurements- Mcleod Gauge*	*Radar, Radiation type*	*Electrical Type Flow meters-Principle*	*Three lead and four lead RTDs.*

	SLO-2	*Strain gauges, Piezoelectric*	*Pirani gauge*	*Solid level measurement*	*Electromagnetic type, Ultrasonic type*	*Thermocouples – Laws of thermocouple*
S-6	SLO-1	*Translational and rotational displacement using potentiometers*	*Thermocouple gauge*	*Boiler drum level measurement :– Differential pressure method*	*Positive displacement type*	*Fabrication of industrial thermocouples*
	SLO-2	*Differential transformers*	*Knudsen gauge*	*Hydrastep method*	*Nutating disc, Reciprocating piston*	*Commercial circuits for cold junction compensation*
S-7	SLO-1	*Mechanical type vibration instruments – Seismic instrument as an accelerometer*	*Ionization gauge- cold cathode and hot cathode types*	*Miscellaneous Measurement,*	*Mass flow meters - Coriolis type*	*Pyrometers:Total radiation pyrometers*
	SLO-2	*Vibrometer*	*Thermal conductivity gauge*	*Humidity – Dry and wet bulb psychrometers*	*Thermal, Impeller type*	*Selective radiation pyrometers*
S-8	SLO-1	*Speed measurement – Revolution counter*	*Testing and calibration of pressure gauges*	*Resistive and capacitive type hygrometers*	*Weirs, Flumes*	*Optical pyrometer*
	SLO-2	*D.C and A.C tachogenerators*	*Dead weight tester*	*Moisture measurement in solids- Conductivity sensor-Microwave and IR sensors.*	*Open channel flow measurement*	*Two colour radiation pyrometers*
S-9	SLO-1	*Stroboscope.*	*Discussion of device types and models used in practical industrial applications*	*Discussion of device types and models used in practical industrial applications*	*Discussion of device types and models used in practical industrial applications*	*Discussion of device types and models used in practical industrial applications*
	SLO-2	*Discussion of device types and models used in practical industrial applications*	*Installation Requirements*	*Installation Requirements*	*Installation Requirements*	*Installation Requirements*

Learning Resources	1. *Liptak B.G., "Instrument Engineers Handbook (Measurement)", Chilton book Co., McGraw Hill, publishing Ltd., 19th Revised edition-2011.* 2. *A.K. Sawhney , "A course in Electrical and Electronic Measurements and instrumentation Dhanpatrai co., 19th Revised edition-2011. Reprint 2014* 3. *Patranabis D, "Principles of industrial Instrumentation", Tata McGraw Hill, 3rd Edition, New Delhi, Reprint 2010*	4. *Tony R. Kuphaldt, "Lessons In Industrial Instrumentation ", Version 2.02, 2014* 5. *Singh S. K., "Industrial Instrumentation& Control", Tata McGraw Hill, 2nd Edition, Reprint 2007* 6. *NPTEL video lectures on "Industrial Instrumentation" by Prof. AlokBarua, IIT Kharagpur*

Learning Assessment

	Bloom's Level of Thinking	Continuous Learning Assessment (50% weightage)								Final Examination (50% weightage)	
		CLA – 1 (10%)		CLA – 2 (15%)		CLA – 3 (15%)		CLA – 4 (10%)#			
		Theory	Practice	Theory	Practice	Theory	Practice	Theory	Practice	Theory	Practice
Level 1	Remember Understand	30 %	-	30 %	-	30 %	-	30 %	-	30%	-
Level 2	Apply Analyze	40 %	-	40 %	-	40 %	-	40 %	-	40%	-
Level 3	Evaluate Create	30 %	-	30 %	-	30 %	-	30 %	-	30%	-
	Total	100 %		100 %		100 %		100 %		100 %	

CLA – 4 can be from any combination of these: Assignments, Seminars, Tech Talks, Mini-Projects, Case-Studies, Self-Study, MOOCs, Certifications, Conf. Paper etc.,

Course Designers

Experts from Industry	Experts from Higher Technical Institutions	Internal Experts
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2. Mr. Hariharasudhan - Johnson Controls, Pune, hariharasudhan.v@jci.com	*2. Dr. D. Nedumaran, Madras University, dnmaran@gmail.com*	*2. Dr. A. Vimala Juliet, SRMIST*

Course Code	18ECE281J	Course Name	PROCESS DYNAMICS AND CONTROL	Course Category	E	Professional Elective	L	T	P	C
							2	0	2	3

Pre-requisite Courses	Nil	Co-requisite Courses	Nil	Progressive Courses	Nil
Course Offering Department	Electronics and Communication Engineering		Data Book / Codes/Standards	Nil	

Course Learning Rationale (CLR):	*The purpose of learning this course is to:*
CLR-1 :	*Impart fundamental knowledge on the dynamics and mathematical modeling of various processes*
CLR-2 :	*Introduce the effect of various control actions and the tuning techniques of controllers.*
CLR-3 :	*Impart knowledge on final control elements*
CLR-4 :	*Get exposed different types of advanced control schemes*
CLR-5 :	*Explore the computer as controller in digital control system.*
CLR-6 :	*Identify the different type of control schemes used in process industries and paraphrase their importance*

Course Learning Outcomes (CLO):	*At the end of this course, learners will be able to:*	Learning 1: Level of Thinking (Bloom)	Learning 2: Expected Proficiency (%)	Learning 3: Expected Attainment (%)	PLO 1: Engineering Knowledge	PLO 2: Problem Analysis	PLO 3: Design & Development	PLO 4: Analysis, Design, Research	PLO 5: Modern Tool Usage	PLO 6: Society & Culture	PLO 7: Environment & Sustainability	PLO 8: Ethics	PLO 9: Individual & Team Work	PLO 10: Communication	PLO 11: Project Mgt. & Finance	PLO 12: Life Long Learning	PLO 13: PSO - 1	PLO 14: PSO - 2	PLO 15: PSO - 3
CLO-1 :	*Analyze and mathematically model the process systems*	3	80	75	H	H	M	H	H	-	-	H	H	-	H	H	M	L	L
CLO-2 :	*Select and optimize the tuning of a controller*	3	80	70	H	H	H	H	H	-	-	H	H	-	H	H	H	L	L
CLO-3 :	*Demonstrate the working and application of different type of actuators and control valves*	3	75	70	H	H	H	H	H	-	-	H	H	-	H	H	H	M	L
CLO-4 :	*Understand and analyze the various advanced control schemes*	3	80	75	H	H	H	H	H	-	-	H	H	-	H	H	H	M	H
CLO-5 :	*Design suitable digital controllers for the process*	3	80	70	H	H	H	M	H	-	-	H	H	-	H	H	H	H	H
CLO-6 :	*Recommend the right choice of control schemes for the application*	3	80	70	H	H	M	H	H	-	-	H	H	-	H	H	M	H	H

Duration (hour)		Process Dynamics	Control Action and Tuning of controllers	Final Control Elements	Advanced Control Schemes	Digital Control System
		12	12	12	12	12
S-1	SLO-1	*Need for process control*	*Basic control actions*	*I/P converter*	*Feedback and Feed-forward control*	*Introduction to state space ,Basic building blocks of computer control system*
	SLO-2	*The process control loop*	*Characteristics of ON- OFF controllers*	*P/I converter*	*Application of feed forward control in various processing units*	*Data loggers*
S-2	SLO-1	*Need for process modeling*	*Characteristics of Single speed floating controllers*	*Pneumatic actuators*	*Split-range control*	*Data acquisition systems*
	SLO-2	*Servo and Regulatory operation*	*P+I, P+D and P+I+D control modes*	*Electric actuators*	*Application of cascade control in various processing units*	*Supervisory control , SCADA, Direct digital control*
S 3-4	SLO-1 SLO-2	*Lab1: Identify the components of the process control loop.*	*Lab 4: Design the on-off, P,PI and PID controller for the Pressure Process*	*Lab 7: Determine the characteristics of I/P and P/I converter*	*Lab10: Tune the PID Controller for mathematically described process using ZN method*	*Lab13:Determine the state model for the mechanical system using MATLAB*
S-5	SLO-1	*Continuous and batch processes*	*Practical forms of PID controller*	*Control Valves*	*Inferential control*	*Review of z transforms*
	SLO-2	*Self-regulation, Degrees of freedom*	*Auto/manual transfer, Reset windup*	*Characteristic of Control Valves:- Inherent characteristics*	*Ratio control*	*Digital PID , Position and velocity form*
S-6	SLO-1	*Mathematical model of level, flow processes*	*Evaluation criteria- Quarter Decay Ratio, IAE, ISE and ITAE*	*Installed characteristics*	*Cascade control.*	*Implementation of digital controllers*
	SLO-2	*Interacting and non interacting systems*	*Selection of Time Integral performance Criteria*	*Modeling of control valves and types*	*Fuzzy controllers*	*Design of Deadbeat controller, Dahlin's controller*
S	SLO-1					

7-8	SLO-2	*Lab 2 : Determine the characteristics of interacting system*	*Lab 5: Design the on-off control, P,PI and PID controller for the flow Process*	*Lab 8: Determine the characteristics of Pneumatically Actuated Control Valve*	*Lab11: Tune the PID Controller for mathematically described process using ZN open loop method*	*Lab14:Design the Deadbeat algorithm for the given system using MATLAB*
S-9	SLO-1	*Laws and assumptions governing gas process*	*Tuning – Process reaction curve method*	*Valve Positioner and its importance*	*Adaptive controllers*	*Multi-loop multivariable control , Introduction*
	SLO-2	*Mathematical models of pressure processes*	*Z-N open loop tuning techniques*	*Control valve sizing*	*Model predictive control*	*Interaction between control loops*
S-10	SLO-1	*Laws and assumptions governing thermal process*	*Continuous cycling method*	*Cavitation and flashing*	*Smith predictor control scheme*	*The Relative Gain Array (RGA)*
	SLO-2	*Mathematical models of thermal processes*	*Damped oscillation method*	*Selection criteria*	*Internal model control (IMC) ,P& I diagram*	*Decoupling of control loops*
S 11-12	SLO-1 SLO-2	*Lab3: Determine the characteristics of non interacting system*	*Lab 6: Design on-off control, P,PI and PID controller for the level Process*	*Lab 9: Determine the characteristics of Pneumatically Actuated Control Valve (with and without Positioner)*	*Lab12: Compare the responses of simple and cascade control system using MATLAB*	*Case study : Design of computerized multi loop controller*

Learning Resources	1. Seborg ,D.E., Mellichamp, D.P., Edgar, T.F., and Doyle,F.J., III, "Process Dynamics and Control", John Wiley and Sons, 4thEdition 2016 2. Stephanopoulos. G" Chemical Process Control - An Introduction to Theory and Practice", Prentice Hall of India,2nd Edition,2015 3. Gopal, M., "Digital Control and State Variable Methods", Tata McGraw Hill,2003	4. D.R. Coughanour, 'Process Systems analysis and Control', McGraw-Hill, 3rd Edition, 2013 5. Bela.G.Liptak., "Process Control and Optimization"., Instrument Engineers' Handbook., volume 2,CRC press and ISA, 2005 6. Curtis D. Johnson Process Control Instrumentation Technology, 8th Edition, Pearson, 2006 7. NPTEL video lectures on "Chemical Process Control" by Prof. SujitJogwar, IITM. 8. P.W. Murrill.,"Fundamentals of Process Control Theory", 3rd Edition-ISA Books

Learning Assessment

	Bloom's Level of Thinking	Continuous Learning Assessment (50% weightage)								Final Examination (50% weightage)	
		CLA – 1 (10%)		CLA – 2 (15%)		CLA – 3 (15%)		CLA – 4 (10%)#			
		Theory	Practice	Theory	Practice	Theory	Practice	Theory	Practice	Theory	Practice
Level 1	Remember Understand	20%	20%	15%	15%	15%	15%	15%	15%	15%	15%
Level 2	Apply Analyze	20%	20%	20%	20%	20%	20%	20%	20%	20%	20%
Level 3	Evaluate Create	10%	10%	15%	15%	15%	15%	15%	15%	15%	15%
	Total	100 %		100 %		100 %		100 %		-	

CLA – 4 can be from any combination of these: Assignments, Seminars, Tech Talks, Mini-Projects, Case-Studies, Self-Study, MOOCs, Certifications, Conf. Paper etc.,

Course Designers		
Experts from Industry	Experts from Higher Technical Institutions	Internal Experts
1. D. Karthikeyan, Controlsoft Engineering India Pvt Ltd, karthikeyan.d@controlsoftengg.in	*1. Dr. J. Prakash, MIT, Chennai, prakaiit@rediffmail.com*	*1. Mrs. N. Deepa, SRMIST*
2. Mr. Hariharasudhan - Johnson Controls, Pune, hariharasudhan.v@jci.com	*2. Dr. D. Nedumaran, Madras University, dnmaran@gmail.com*	*2. Mrs. Indirani, SRMIST*

Course Code	18ECE282T	Course Name	MODERN CONTROL SYSTEMS	Course Category	E	Professional Elective	L	T	P	C
							3	0	0	3

Pre-requisite Courses	18ECS201T	Co-requisite Courses	Nil	Progressive Courses	Nil
Course Offering Department	Electronics and Communication Engineering	Data Book / Codes/Standards	Nil		

Course Learning Rationale (CLR):	*The purpose of learning this course is to:*
CLR-1 :	*Know and design various conventional compensators.*
CLR-2 :	*Know and develop mathematical modeling using state space technique.*
CLR-3 :	*Know and analyze the system using state space analysis techniques.*
CLR-4 :	*Know the importance of structural properties and to analyze the stability of the system.*
CLR-5 :	*Study the state space control methodologies for various systems.*
CLR-6 :	*Know and design modern control techniques which are linear.*

Course Learning Outcomes (CLO):	*At the end of this course, learners will be able to:*	Learning 1: Level of Thinking (Bloom)	Learning 2: Expected Proficiency (%)	Learning 3: Expected Attainment (%)	PLO 1: Engineering Knowledge	PLO 2: Problem Analysis	PLO 3: Design & Development	PLO 4: Analysis, Design, Research	PLO 5: Modern Tool Usage	PLO 6: Society & Culture	PLO 7: Environment & Sustainability	PLO 8: Ethics	PLO 9: Individual & Team Work	PLO 10: Communication	PLO 11: Project Mgt. & Finance	PLO 12: Life Long Learning	PLO 13: PSO - 1	PLO 14: PSO - 2	PLO 15: PSO - 3
CLO-1 :	*Design cascade compensators in time domain and design PID controllers in time domain.*	3	80	75	H	H	H	-	L	-	-	H	-	-	-	H	H	-	H
CLO-2 :	*Understand and develop state space model for different systems*	3	80	70	H	L	H	-	H	-	-	H	-	-	-	-	M	-	H
CLO-3 :	*Analyze the controllability and observability of a system and to design controllers and observers.*	3	75	70	H	H	-	H	H	-	-	H	-	-	-	-	M	-	H
CLO-4 :	*Implement procedure to find the structural properties of any linear system*	3	80	75	H	H		H	H	-	-	H	-	-	-	-	M	-	H
CLO-5 :	*Understand the procedure of applying the control methodology on various linear systems*	3	80	70	H	H	H	H	H	-	-	H	-	-	-	H	M	-	H
CLO-6 :	*Design and apply linear based modeling and modern control methods for different linear systems.*	3	80	70	H	H	H	-	L	-	-	-	-	-	-	H	H	-	H

Duration (hour)		Linear Control Design	State Space Analysis	Controllability And Observability	Controller Design For Linear System	Applications
		9	9	9	9	9
S-1	SLO-1	*Design specifications*	*Concept of State variables*	*Concept of Stability*	*Pole placement using feedback*	*State space Modeling of Inverted Pendulum*
	SLO-2	*Compensator configuration (series and feedback)-*	*Concept of State space model*	*Computation of Stability of State space model*	*Eigen value placement theorem*	
S-2	SLO-1	*Design cascade compensators - lag by using time domain*	*Relationship between transfer function and State space model*	*Concept of Controllability*	*Selection of desired poles*	*State space Modeling of Ball and Beam system*
	SLO-2	*Design feedback compensators - lag by using time domain*	*State space representation of linear continuous time systems using physical variables*	*Computation of Controllability of State space model*	*Eigen structure assignment*	
S-3	SLO-1	*Design cascade compensators - lead by using time domain*	*State space representation of linear continuous time systems using phase variables*	*Concept of Observability*	*State controller design exercise*	*State space Modeling of Translational Mechanical Systems*
	SLO-2	*Design feedback compensators - lead by using time domain*	*State space representation of linear continuous time systems using canonical variables*	*Computation of Observability of State space model*		
S-4	SLO-1	*Compensator design exercises*	*Conversion of transfer function to various state space representations*	*Computation of structural properties using Controllability & Observability*	*State controller design exercise*	*State space Modeling of Rotational Mechanical Systems*
	SLO-2	*Compensator design exercises*				
S-5	SLO-1	*Design cascade compensators – lead-lag by using time domain*	*Diagonalization*	*Computation of structural properties using eigen decomposition*	*State controller design exercise*	*Modeling exercises for Translational and Rotational Mechanical Systems*

	SLO-2	*Design feedback compensators – lead-lag by using time domain*	*State space representation of discrete time systems*			
S-6	SLO-1	*Design specifications – PID Controllers*	*Solution of state equations – from differential equations*	*Concept of Pole Placement by state feedback*	*Optimal Control – Linear Quadratic Regulation (LQR)*	*State space Modeling of Electrical Systems*
	SLO-2	*Effect of PID on linear systems*		*Concept of State Observers*	*Infinite Horizon Regulator*	
S-7	SLO-1	*Design of PD controller using time domain*	*Solution of state equations – from Transfer Functions*	*Control System Design Via Pole Placement by state feedback*	*Receding Horizon Regulator*	*Modeling exercises for Electrical Systems*
	SLO-2	*PD Controller design exercises*			*Receding Horizon Regulator - Design Parameters*	
S-8	SLO-1	*Design of PI controller using time domain*	*Concepts of state transition matrix.*	*Effect of state feedback*	*Controller Design with Reference Input*	*State space Modeling of Field controlled DC Motor*
	SLO-2	*PI Controller design exercises*	*Computation of state transition matrix*		*Tracking/ Servo Control using State Feedback*	
S-9	SLO-1	*Design of PID controller using time domain*	*Computation of state transition matrix*	*State feedback Controller design exercises*	*State controller with reference input design exercise*	*State space Modeling of Armature controlled DC Motor*
	SLO-2	*PID Controller design exercises*				

Learning Resources	1. *Katsuhiko Ogata, "Modern Control Engineering"-fifth edition, Prentice Hall of India Private Ltd, New Delhi, 2009.* 2. *Kirk D.E, "Optimal control theory-an introduction", Dover Publications, 2004.* 3. *Richard .C, Dorf and Robert.H.Bishop, "Modern Control System Engineering", Pearson Education (US), United States, 2010.*	4. *Gopal. M, "Modern Control System theory", New age international(P) ltd, 2012.* 5. *Nagarath, I.J. and Gopal, M., "Control Systems Engineering", New Age InternationalPublishers, 2010.* 6. *NPTEL Video Lecture Notes on "Advanced Linear Continuous Control Systems "by Prof. Yogesh Vijay Hote, IIT Roorkee. https://nptel.ac.in/courses/108107115/*

Learning Assessment

	Bloom's Level of Thinking	Continuous Learning Assessment (50% weightage)								Final Examination (50% weightage)	
		CLA – 1 (10%)		CLA – 2 (15%)		CLA – 3 (15%)		CLA – 4 (10%)#			
		Theory	Practice	Theory	Practice	Theory	Practice	Theory	Practice	Theory	Practice
Level 1	Remember Understand	30 %	-	30 %	-	30 %	-	30 %	-	30%	-
Level 2	Apply Analyze	40 %	-	40 %	-	40 %	-	40 %	-	40%	-
Level 3	Evaluate Create	30 %	-	30 %	-	30 %	-	30 %	-	30%	-
	Total	100 %		100 %		100 %		100 %		100 %	

CLA – 4 can be from any combination of these: Assignments, Seminars, Tech Talks, Mini-Projects, Case-Studies, Self-Study, MOOCs, Certifications, Conf. Paper etc.,

Course Designers

Experts from Industry	Experts from Higher Technical Institutions	Internal Experts
1. D. Karthikeyan, Controlsoft Engineering India Pvt Ltd, karthikeyan.d@controlsoftengg.in	*1. Dr. J. Prakash, MIT, Chennai, prakaiit@rediffmail.com*	*1. Mr. Arockia Vijay Joseph, SRMIST*
2. Mr. Hariharasudhan - Johnson Controls, Pune, hariharasudhan.v@jci.com	*2. Dr. D. Nedumaran, Madras University, dnmaran@gmail.com*	*2. Mr. P. Jekan, SRMIST*

Course Code	18ECE283J	Course Name	PROGRAMMABLE LOGIC CONTROLLER	Course Category	E	Professional Elective

L	T	P	C
2	0	2	3

Pre-requisite Courses	Nil	Co-requisite Courses	Nil	Progressive Courses	Nil
Course Offering Department	Electronics and Communication Engineering	Data Book / Codes/Standards	Nil		

Course Learning Rationale (CLR):	*The purpose of learning this course is to:*
CLR-1 :	*Study the hardware components of Programmable Logic Controller*
CLR-2 :	*Understand the need of programming languages for PLC*
CLR-3 :	*Explore the ladder logic program for control application*
CLR-4 :	*Identify applications of timers and counters in process automation*
CLR-5 :	*Locate the malfunctions and troubleshooting various types of errors in Programmable Logic Controller*
CLR-6 :	*Provide the knowledge of Commissioning, Maintenance and their importance in industry.*

Course Learning Outcomes (CLO):	*At the end of this course, learners will be able to:*	Learning 1: Level of Thinking (Bloom)	Learning 2: Expected Proficiency (%)	Learning 3: Expected Attainment (%)	PLO 1: Engineering Knowledge	PLO 2: Problem Analysis	PLO 3: Design & Development	PLO 4: Analysis, Design, Research	PLO 5: Modern Tool Usage	PLO 6: Society & Culture	PLO 7: Environment & Sustainability	PLO 8: Ethics	PLO 9: Individual & Team Work	PLO 10: Communication	PLO 11: Project Mgt. & Finance	PLO 12: Life Long Learning	PLO 13: PSO - 1	PLO 14: PSO - 2	PLO 15: PSO - 3
CLO-1 :	*Select right I/O modules in PLC for process control*	3	80	75	H	L	-	-	-	-	-	-	L	-	-	H	H	H	H
CLO-2 :	*Develop ladder logic program for control application*	3	80	70	H	H	H	H	H	-	-	H	H	M	-	H	H	H	H
CLO-3 :	*Use timers and counters in process automation*	3	75	70	H	H	H	H	H	-	-	H	H	M	-	H	H	H	H
CLO-4 :	*Interpret data compare instruction in PLC program*	3	80	75	H	H	H	H	H	-	-	H	H	M	-	H	H	H	H
CLO-5 :	*Troubleshoot the input and output malfunctions in PLC*	3	80	70	H	H	-	H	H	-	-	-	H	H	-	H	M	H	H
CLO-6 :	*Select a right PLC for the given application*	3	80	70	H	H	-	-	-	-	-	H	H	-	M	M	H	H	H

Duration (hour)		PLC Hardware Components	PLC Programming and Wiring	Timers and Counters	Data manipulation and Math instructions	Troubleshooting
		12	12	12	12	12
S-1	SLO-1	*Evolution of Programmable logic controllers*	*PLC programming languages-Ladder Logic*	*Timer Instructions*	*Data manipulation*	*Electrical Noise*
	SLO-2	*Architecture of a PLC*	*Function Block Diagram, Instruction List*	*On-Delay timer instruction*	*Data transfer operations*	*Leaky Inputs and Outputs*
S-2	SLO-1	*Principles of Operation*	*Instruction Addressing*	*Off-delay timer instruction*	*Data compare instructions*	*Grounding*
	SLO-2	*PLCs versus Computers*	*Branch Instructions*	*Retentive Timer*	*Data manipulation programs*	*Voltage Variations and Surges*
S 3-4	SLO-1 SLO-2	*Lab1: PLC Wiring*	*Lab 4: Traffic light control system*	*Lab 7: HMI Programming*	*Lab10: Lift control*	*Lab13: Electro pneumatic direction control*
S-5	SLO-1	*PLC size and application*	*Electromagnetic Control Relays*	*Cascading Timers*	*Numerical Data I/O Interfaces*	*Program Editing and Commissioning*
	SLO-2	*Discrete I/O modules*	*Contactors*	*Up-Counter*	*Closed-Loop Control*	*Preventive Maintenance*
S-6	SLO-1	*Sinking and sourcing*	*Manually Operated Switches*	*One-Shot Instruction*	*Math Instructions*	*Troubleshooting*
	SLO-2	*Analog I/O modules*	*Mechanically Operated Switches*	*Down-Counter*	*Addition Instruction*	*Processor Module*
S 7-8	SLO-1 SLO-2	*Lab 2 :Water level control system*	*Lab 5: Sequential operation of motor*	*Lab 8: DC motor speed control system*	*Lab11: Car parking system*	*Lab14: Stamping machine control*

S-9	SLO-1	*Special I/O modules*	*Proximity Sensor, Magnetic Reed Switch*	*Cascading Counters*	*Subtraction Instruction*	*Input Malfunctions*
	SLO-2	*I/O Specifications*	*Light Sensors, Velocity and Position Sensors*	*Combining Counter and Timer Functions*	*Multiplication Instruction*	*Output Malfunctions*
S-10	SLO-1	*Human Machine Interfaces (HMIs)*	*Output Control Devices, Seal-In Circuits, Electrical Interlocking Circuits*	*High-Speed Counters*	*Division Instruction*	*Comparative study of Industrial PLCs.*
	SLO-2	*Alarms, Graphics Library*	*Converting Relay Schematics into PLC Ladder Programs*	*Problems*	*Other Word-Level Math Instructions*	
S 11-12	SLO-1 SLO-2	*Lab3: Material handling system*	*Lab 6: Bottle filling system*	*Lab 9: Temperature control system*	*Lab12: Flow control system*	*Lab15: Servo controller programming*

Learning Resources	1. *Frank D. Petruzella, "Programmable Logic Controller",Tata McGraw Hill 5th Edition, 2017.* 2. *Bolton. W, "Programmable Logic Controllers", 6thEdition, Elsevier Newnes, 2016.* 3. *John W. Webb, Ronald A. Reis, "Programmable Logic Controllers", Principles and Applications, Prentice Hall, 5th Edition, 2011*	4. *Gary Dunning, "Programmable Logic Controllers", Cengage Learning, 3rdEdition, 2009.* 5. *John R. Hackworth, "Programmable logic controllers Programming Methods and Applications", Pearson, 1stEdition, 2006* 6. *NPTEL Video Lecture Notes on "Industrial Automation and Control "by Prof. S. Mukhapadhyay, IIT Kharagpur*

Learning Assessment

	Bloom's Level of Thinking	Continuous Learning Assessment (50% weightage)								Final Examination (50% weightage)	
		CLA – 1 (10%)		CLA – 2 (15%)		CLA – 3 (15%)		CLA – 4 (10%)#			
		Theory	Practice	Theory	Practice	Theory	Practice	Theory	Practice	Theory	Practice
Level 1	Remember / Understand	20%	20%	15%	15%	15%	15%	15%	15%	15%	15%
Level 2	Apply / Analyze	20%	20%	20%	20%	20%	20%	20%	20%	20%	20%
Level 3	Evaluate / Create	10%	10%	15%	15%	15%	15%	15%	15%	15%	15%
	Total	100 %		100 %		100 %		100 %		-	

CLA – 4 can be from any combination of these: Assignments, Seminars, Tech Talks, Mini-Projects, Case-Studies, Self-Study, MOOCs, Certifications, Conf. Paper etc.,

Course Designers

Experts from Industry	Experts from Higher Technical Institutions	Internal Experts
1. D. Karthikeyan, Controlsoft Engineering India Pvt Ltd, karthikeyan.d@controlsoftengg.in	*1. Dr. J. Prakash, MIT, Chennai, prakaiit@rediffmail.com*	*1. Mr. J. Sam Jebakumar, SRMIST*
2. Mr. Hariharasudhan - Johnson Controls, Pune, hariharasudhan.v@jci.com	*2. Dr. D. Nedumaran, Madras University, dnmaran@gmail.com*	*2. Dr. G. Joselin Retna Kumar, SRMIST*

Course Code	18ECE284J	Course Name	GRAPHICAL SYSTEM DESIGN IN VIRTUAL INSTRUMENTATION	Course Category	E	Professional Elective	L	T	P	C
							2	0	2	3

Pre-requisite Courses	Nil	Co-requisite Courses	Nil	Progressive Courses	Nil
Course Offering Department	Electronics and Communication Engineering	Data Book / Codes/Standards	Nil		

Course Learning Rationale (CLR):	*The purpose of learning this course is to:*
CLR-1 :	*Study the concepts of Virtual instrumentation and to learn the programming concepts in VI.*
CLR-2 :	*Study about the various measurement systems and their data acquisition methods in real time.*
CLR-3 :	*Study about the various Instrument Interfacing concepts.*
CLR-4 :	*Explore various control techniques using VI software*
CLR-5 :	*Explore various remote accessing techniques*
CLR-6 :	*Get exposed with various analysis tools for Process control applications.*

Course Learning Outcomes (CLO):	*At the end of this course, learners will be able to:*	Learning 1: Level of Thinking (Bloom)	Learning 2: Expected Proficiency (%)	Learning 3: Expected Attainment (%)	PLO 1: Engineering Knowledge	PLO 2: Problem Analysis	PLO 3: Design & Development	PLO 4: Analysis, Design, Research	PLO 5: Modern Tool Usage	PLO 6: Society & Culture	PLO 7: Environment & Sustainability	PLO 8: Ethics	PLO 9: Individual & Team Work	PLO 10: Communication	PLO 11: Project Mgt. & Finance	PLO 12: Life Long Learning	PLO 13: PSO - 1	PLO 14: PSO - 2	PLO 15: PSO - 3
CLO-1 :	*Identify the purpose and need of virtual instrumentation in process control Industries*	*1,2*	*80*	*70*	*H*	-	-	-	-	-	-	-	*H*	-	-	-	*H*	-	-
CLO-2 :	*Measure the parameters using various data acquisition methods.*	*2,3*	*85*	*75*	*H*	*H*	-	-	-	-	-	*H*	*H*	-	*H*	*H*	*H*	-	-
CLO-3 :	*Implement the available interfacing instruments*	*2,3*	*75*	*70*	*H*	*H*	*H*	*H*	*H*	-	-	-	*H*	-	*H*	*H*	*H*	*H*	-
CLO-4 :	*Implement various control techniques using VI software*	*2,3*	*85*	*80*	*H*	*H*	*H*	*H*	*H*	-	-	*H*	*H*	-	*H*	*H*	*H*	*H*	*H*
CLO-5 :	*Apply remote accessing Techniques*	*2,3*	*85*	*75*	*H*	*H*	*H*	*H*	*H*	-	-	-	*H*	*H*	*H*	*H*	*H*	-	*H*
CLO-6 :	*Develop a system for an engineering application.*	*2,3*	*80*	*70*	*H*	*H*	*H*	*H*	*H*	-	-	*H*	*H*	*H*	*H*	*H*	*H*	*H*	*H*

Duration (hour)		Programming Concepts in LabVIEW	Measuring Concepts in Virtual Instrumentation	Controlling Concepts in Virtual Instrumentation	Final Control Elements and its implementation	Signal Processing and Applications
		12	12	12	12	12
S-1	SLO-1	*Historical perspective, Need of VI, Advantages of VI, Virtual Instruments versus Traditional Instruments*	*Components of Measuring System,Origin of signals*	*Introduction to Non continuous controllers in LabVIEW*	*Final Control Operation*	*PC based digital storage oscilloscope*
	SLO-2	*Review of software in Virtual Instrumentation ,Software environment Architecture of VI, Introduction to the block diagram and Front panel Pallets*	*Transducer, Sensors, Differences between chemical sensors, physical sensors, Biosensors. Selection criteria*	*Introduction to continuous controllers in LabVIEW*	*Fundamentals of Mechatronic Actuators*	*Sensor Technology*
S-2	SLO-1	*Creating and saving a VI, Front Panel Tool Bar, Block diagram Tool Bar, Palettes*	*General Conditioning Functions, A/D Control ,D/A Control in VI platform*	*Design of ON/OFF controller*	*Position-Controlled Actuators*	*Oscillators, counters*
	SLO-2	*Creating sub VI, Creating an ICON, Building a connector pane, Displaying VI'S Placing and Saving Sub VI'S on block diagram* *Example of full adder circuit using half adder circuit*	*Introduction to MyRIO ,Applications of MyRIO*	*P,PI,PID controllers for a mathematically described processes using VI software.*	*open-loop and closed-loop actuator position control in a hands-on application*	*Signal and image processing Techniques*
S-3,4	SLO-1 SLO-2	*Lab 1: Verification of Arithmetic Operations & Verification of Half Adder*	*Lab 4 :Design a VI to measure angle with my RIO using Y-axis onboard accelerometer*	*Lab 7: To apply on-off controller using QNET HVAC in virtual instrumentation platform*	*Lab 10: To apply Position Controlled actuators*	*Lab 13: To Design of DSO*
S-5	SLO-1	*Loops-For Loop,*	*Introduction to PC Buses*	*Modeling of level process*	*Manipulator Importance, Operation of Manipulators*	*Spectrum Analyzer*
	SLO-2	*While Loop*	*Local Buses-ISA, PCI,*	*Basic control of level process in LabVIEW*	*Types of Manipulators Selection Criteria,*	

						Waveform Generator
S-6	SLO-1	*Arrays*	*RS232, RS422*	*Modeling of Reactor Processes*	*Controlling techniques on Manipulators*	*Data visualization from multiple locations*
	SLO-2	*Clusters, plotting data*	*RS485*	*Basic control of Reactor process in LabVIEW*	*Controlling techniques on Manipulators*	*Distributed monitoring and control*
S-7,8	SLO-1	*Lab 2:Program to find Addition of First n natural numbers using for loop*	*Lab 5:To implement Speed Control of DC Motor (QNET)*	*Lab 8:Continous Control of any process using LabVIEW*	*Lab 11:To apply PID to Control Manipulators*	*Lab 14:Real time spectrum analysis using LabVIEW*
	SLO-2					
S-9	SLO-1	*Charts, Graphs, Formula nodes,*	*Interface Buses-USB,PXI*	*Case studies on development of HMI in VI*	*Remote access using LabVIEW*	*Vision and Motion Control*
	SLO-2	*Case and Sequence Structures*	*VXI,*	*Case studies on development of HMI in VI*	*Different types of Protocols*	*Examples on Integrating Measurement with vision and motion*
S-10	SLO-1	*Acquiring Data Using Hardware*	*SCXI*	*Case studies on development of SCADA in VI*	*Case study on TCP/IP Protocol application*	*NI Motion control*
	SLO-2	*DAQ Devices*	*PCMCIA*	*Case studies on development of SCADA in VI*	*Case studies on web publishing tool*	*Speed control system*
S-11,12	SLO-1	*Lab 3:Design a Voltmeter by using AO to generate a signal and AI to acquire the signal using DAQ*	*Lab 6: Simple Modeling of QNET Rotary Inverted Pendulum*	*Lab 9:Controlling of Rotary Inverted Pendulum*	*Lab 12:Online process control using LabVIEW using TCP/IP and web publishing*	*Lab 15 :Minor Project*
	SLO-2					

Learning Resources	1. *Nadovich, C., "Synthetic Instruments Concepts and Applications", Elsevier, 2005.* 2. *Bitter, R., Mohiuddin, T. and Nawrocki, M., "Labview Advanced Programming Techniques", CRC Press, 2nd Edition, 2007.* 3. *Gupta, S. and Gupta, J. P., "PC Interfacing for Data Acquisition and Process Control", 2nd Edition, Instrument Society of America, 1994* 4. *Liptak,"Instrument Engineers Handbook Process Measurement and Analysis", Elsevier, 2005*	5. *Jamal, R. and Picklik, H., "Labview – Applications and Solutions", National Instruments Release.* 6. *Johnson, G., "Labview Graphical programming", McGraw-Hill, Newyork, 1997.* 7. *Wells, L.K. and Travis, J., "Labview for Everyone", Prentice Hall, NewJersey, 1997.* 8. *Buchanan, W., "Computer Busses", CRC Press, 2000.*

Learning Assessment

	Bloom'sLevel of Thinking	Continuous Learning Assessment (50% weightage)								Final Examination (50% weightage)	
		CLA – 1 (10%)		CLA – 2 (15%)		CLA – 3 (15%)		CLA – 4 (10%)#			
		Theory	Practice	Theory	Practice	Theory	Practice	Theory	Practice	Theory	Practice
Level 1	Remember Understand	20%	20%	15%	15%	15%	15%	15%	15%	15%	15%
Level 2	Apply Analyze	20%	20%	20%	20%	20%	20%	20%	20%	20%	20%
Level 3	Evaluate Create	10%	10%	15%	15%	15%	15%	15%	15%	15%	15%
	Total	100 %		100 %		100 %		100 %		100 %	

CLA – 4 can be from any combination of these: Assignments, Seminars, Tech Talks, Mini-Projects, Case-Studies, Self-Study, MOOCs, Certifications, Conf. Paper etc.,

Course Designers

Experts from Industry	Experts from Higher Technical Institutions	Internal Experts
1. D. Karthikeyan, Controlsoft Engineering India Pvt Ltd, karthikeyan.d@controlsoftengg.in	*1. Dr. J. Prakash, MIT, Chennai, prakaiit@rediffmail.com*	*1. Dr. K.A.Sunitha, SRMIST*
2. Mr. Hariharasudhan - Johnson Controls, Pune, hariharasudhan.v@jci.com	*2. Dr. D. Nedumaran, Madras University, dnmaran@gmail.com*	

Course Code	18ECE380T	Course Name	INSTRUMENTATION AND CONTROL IN PROCESS INDUSTRIES	Course Category	E	Professional Elective	L	T	P	C
							3	0	0	3

Pre-requisite Courses	Nil	Co-requisite Courses	Nil	Progressive Courses	Nil
Course Offering Department	Electronics and Communication Engineering	Data Book / Codes/Standards	Nil		

Course Learning Rationale (CLR):	*The purpose of learning this course is to:*
CLR-1 :	*Learn various methods involved in the petroleum industries.*
CLR-2 :	*Import the knowledge of control and measurement used in iron and steel industries.*
CLR-3 :	*Study the various instruments and the role of instrumentation in paper industries.*
CLR-4 :	*Learn the measurement and control in thermal industries.*
CLR-5 :	*Study the industry standards and safety consciousness in process industries.*
CLR-6 :	*Import the knowledge of chemical process hazards in industries.*

Course Learning Outcomes (CLO):	*At the end of this course, learners will be able to:*	Learning 1 Level of Thinking (Bloom)	2 Expected Proficiency (%)	3 Expected Attainment (%)	Program Learning Outcomes (PLO) 1 Engineering Knowledge	2 Problem Analysis	3 Design & Development	4 Analysis, Design, Research	5 Modern Tool Usage	6 Society & Culture	7 Environment & Sustainability	8 Ethics	9 Individual & Team Work	10 Communication	11 Project Mgt. & Finance	12 Life Long Learning	13 PSO - 1	14 PSO - 2	15 PSO - 3
CLO-1 :	*Understand the basics of petrochemical industries.*	*3*	*80*	*75*	*H*	-	-	-	-	-	-	-	*H*	-	-	*H*	*H*	-	-
CLO-2 :	*Apply knowledge in working of various instruments that are used in iron and steel industries.*	*3*	*80*	*70*	*H*	*H*	-	-	-	-	-	*H*	*H*	-	-	*H*	*H*	-	*H*
CLO-3 :	*Acquire the knowledge of analyzers and measurement of density, level in paper industries.*	*3*	*75*	*70*	*H*	*H*	*M*	-	-	-	-	*H*	*H*	-	-	*H*	*H*	*H*	*H*
CLO-4 :	*Understand the operation of boiler in thermal industries.*	*3*	*80*	*75*	*H*	*H*	*M*	*H*	-	-	-	*H*	*H*	-	-	*H*	*H*	*H*	*H*
CLO-5 :	*Understand the process safety in chemical industries.*	*3*	*80*	*70*	*H*	*H*	*M*	*H*	-	*H*	-	-	*H*	-	-	*H*	*M*	*M*	*H*
CLO-6 :	*Apply the knowledge of process hazards in industries.*	*3*	*80*	*70*	*H*	-	-	-	-	*H*	-	-	-	-	-	*H*	-	*M*	*H*

Duration (hour)		Instrumentation in Petroleum Industry	Measurement and control in Iron and Steel Industry	Instrumentation and control in Paper Industry	Boiler operation and control in Thermal Industry	Industrial Safety Management
		9	9	9	9	9
S-1	SLO-1	*Introduction to petroleum*	*Introduction: Steel Production*	*Conventional and non-conventional raw materials for paper manufacture*	*Introduction to power generation*	*Introduction to process safety*
	SLO-2	*Petroleum exploration Methods*	*Basic oxygen furnace*	*Different pulping processes*	*Importance of instrumentation & control in power generation*	*Importance of Safety consciousness in Indian Chemical Industries*
S-2	SLO-1	*Magnetic Survey*	*Blast furnace*	*Continuous and batch digesters*	*Classification of instruments in power plant*	*Industry Standards and Regulations.*
	SLO-2	*Drilling process*	*Rolling process*	*Chemical recovery process*	*Building blocks*	*Set of Standards. HSE – PES, AIChE – CCPS,*
S-3	SLO-1	*Rotary Drilling*	*Hot rolling process*	*Conversion process*	*Combined Heat and Power System*	*Process hazard analysis*
	SLO-2	*Petroleum production*	*Cold rolling process*	*Identification of various process parameters*	*Control Loops in Boiler*	*Chemical process hazards*
S-4	SLO-1	*Petroleum refining and unit operations in refinery*	*Temperature measurement*	*pH measurement*	*Combustion Control,*	*Material hazards*
	SLO-2	*Constituents of crude oil*	*Pressure measurement*	*Density measurement*	*Air/fuel ratio control*	*Energy hazards*
S-5	SLO-1	*Atmospheric distillation of crude oil*	*Shape and thickness measurement*	*Level measurement*	*Steam flow measurement*	*Chemical interaction hazards*

	SLO-2	*Vacuum distillation process*	*Analyzers in iron and steel industry*	*Special applications for control*	*Smoke, density measurement*	*Layers of protection*
S-6	SLO-1	*Thermal conversion process*	*Oxygen analyzer*	*Digester blow tank control*	*Turbine speed and vibration measurement*	*Types of safeguard*
	SLO-2	*Control of distillation column*	*Blast furnace and stove combustion control system*	*Dryer temperature control.*	*Use of feed forward and cascade control in process industries*	*Safety performance measurement tools*
S-7	SLO-1	*Temperature control.*	*Casting mold Level Control*	*Fuel gas oxygen analyzer*	*Instrumentation and control in reactors*	*Techniques used to reduce explosion hazards*
	SLO-2	*Pressure control*	*Computer Applications*	*Dissolved oxygen analyzer*	*Sodium analyzer*	*Hazard identification techniques*
S-8	SLO-1	*Level measurement of petroleum*	*Data logging applied to Steel Making*	*Computer applications: Direct Digital Control*	*Flue gas analyzer*	*Fault tree analysis*
	SLO-2	*Temperature measurement of petroleum*	*Steel rolling mill Control*	*Distributed control system in power plant*	*Fuel composition analyzer*	*Operation and maintenance*
S-9	SLO-1	*Case Study: An. Application for Petroleum Refineries.*	*Case Study on iron and steel manufacturing process.*	*Case Study: Water Treatment for Paper and Pulp Industry*	*Case Study: Chandrapura Thermal Power Station*	*Case Study: Safety in Explosive*
	SLO-2	*Case Study: Control of an Industrial Distillation Column*	*Case Study: Analysis of the Production Processes in a Steel Factory*	*Case Study: Boiler Materials for the Pulp and Paper Industry*	*Case Study:Boiler tube failures*	*Case Study: Chemical splash at process plant.*

Learning Resources	*1. Mian.M.A, "Petroleum Engineering Handbook for the Practicing Engineer", Gulf Professional Publishing, 2005.* *2. Liptak, Bela G, "Instrumentation in the Processing Industries" , Chilton Publishers, 1973.* *3. Considine D. M.," Process/Industrial Instruments and control Handbook", McGraw Hill, 6th Edition2019.*	*4. Sam .G.Duke low, "The Control of boilers" , instrument Society of America,1991.* *5. Paul Gruhn& Harry Cheddie,Safety Instrumented Systems: Design, Analysis and Justification, 2nd Edition, International Society of Automation,2005.*

Learning Assessment

	Bloom's Level of Thinking	Continuous Learning Assessment (50% weightage)								Final Examination (50% weightage)	
		CLA – 1 (10%)		CLA – 2 (15%)		CLA – 3 (15%)		CLA – 4 (10%)#			
		Theory	Practice	Theory	Practice	Theory	Practice	Theory	Practice	Theory	Practice
Level 1	Remember Understand	30 %	-	30 %	-	30 %	-	30 %	-	30%	-
Level 2	Apply Analyze	40 %	-	40 %	-	40 %	-	40 %	-	40%	-
Level 3	Evaluate Create	30 %	-	30 %	-	30 %	-	30 %	-	30%	-
	Total	100 %		100 %		100 %		100 %		100 %	

CLA – 4 can be from any combination of these: Assignments, Seminars, Tech Talks, Mini-Projects, Case-Studies, Self-Study, MOOCs, Certifications, Conf. Paper etc.,

Course Designers

Experts from Industry	Experts from Higher Technical Institutions	Internal Experts
1. D. Karthikeyan, Controls of Engineering India Pvt Ltd, karthikeyan.d@controlsoftengg.in	*1. Dr. J. Prakash, MIT, Chennai, prakaiit@rediffmail.com*	*1. Ms. A.Asuntha, SRMIST*
2. Mr. Hariharasudhan - Johnson Controls, Pune, hariharasudhan.v@jci.com	*2. Dr. D. Nedumaran, Madras University, dnmaran@gmail.com*	*2. Dr. A. Vimala Juliet, SRMIST*

Course Code	18ECE381T	Course Name	DISTRIBUTED CONTROL SYSTEM AND SCADA	Course Category	E	Professional Elective	L	T	P	C
							3	0	0	3

Pre-requisite Courses	Nil	Co-requisite Courses	Nil	Progressive Courses	Nil
Course Offering Department	Electronics and Communication Engineering	Data Book / Codes/Standards	Nil		

Course Learning Rationale (CLR):	*The purpose of learning this course is to:*
CLR-1 :	*Give basic knowledge in SCADA in the field of automation*
CLR-2 :	*Understand the Communication modules used in SCADA*
CLR-3 :	*Give basic knowledge in different architectures of DCS*
CLR-4 :	*Explore the local control unit of distributed control system*
CLR-5 :	*Impart adequate information in the interfaces used in DCS*
CLR-6 :	*Learn the applications of DCS in process industries*

Course Learning Outcomes (CLO):	*At the end of this course, learners will be able to:*	Learning 1: Level of Thinking (Bloom)	Learning 2: Expected Proficiency (%)	Learning 3: Expected Attainment (%)	PLO 1: Engineering Knowledge	PLO 2: Problem Analysis	PLO 3: Design & Development	PLO 4: Analysis, Design, Research	PLO 5: Modern Tool Usage	PLO 6: Society & Culture	PLO 7: Environment & Sustainability	PLO 8: Ethics	PLO 9: Individual & Team Work	PLO 10: Communication	PLO 11: Project Mgt. & Finance	PLO 12: Life Long Learning	PLO 13: PSO - 1	PLO 14: PSO - 2	PLO 15: PSO - 3
CLO-1 :	*Understand the elements of SCADA system*	3	80	75	H	-	-	-	-	H	-	-	-	-	-	H	M	H	-
CLO-2 :	*Develop any application based on SCADA along with GUI using SCADA software.*	3	80	70	H	-	-	-	-	H	-	-	-	-	H	H	-	H	-
CLO-3 :	*Understand evolution and architecture of DCS and hierarchical control in DCS*	3	75	70	H	H	M	H	M	H	-	M	M	-	H	H	H	H	H
CLO-4 :	*Demonstrate interfacing of hardware and software of computer based automation system.*	3	80	75	H	H	M	H	M	-	-	M	H	-	H	H	M	H	H
CLO-5 :	*Select and use the most appropriate automation technologies for a given application*	3	80	70	H	-	M	-	H	-	-	H	H	-	H	H	M	H	H
CLO-6 :	*Evaluate computer based automation system used in industries ranging from discrete, continuous process to hybrid processes.*	3	80	70	H	-	-	-	-	H	-	H	H	-	H	H	H	H	H

Duration (hour)		SCADA Elements	Communication	DCS Architecture	Operator interface	DCS Application
		9	9	9	9	9
S-1	SLO-1	*SCADA basics introduction*	*SCADA Communication introduction*	*DCS - basics*	*DCS operator interfaces- introduction*	*DCS Application in Power plant*
	SLO-2	*Elements of SCADA*	*Communication system components*	*Evolution of Distributed Control System*	*Operator Interface Requirements*	*Automation strategy*
S-2	SLO-1	*Functionality of SCADA*	*Structure of a SCADA Communications Protocol*	*DCS Architecture*	*Low-level Operator Interface*	*Distributed system structure*
	SLO-2	*Process example*	*Field/RTU Communication*	*Local control unit*	*Continuous control station*	*Application functions*
S-3	SLO-1	*History of SCADA*	*Analog electronic controllers*	*I/O module(Analog & Digital)*	*Manual Loader Station*	*DCS Application in cement plant*
	SLO-2	*Development from Telemetry*	*Communication Topology*	*Basic elements*	*Indicator/Logic Station*	*System architecture*
S-4	SLO-1	*Key features*	*RTU/MTU Communication*	*Architectural parameters*	*Smart annunciators*	*DCS Application in iron plant*
	SLO-2	*Real time systems*	*System components*	*Types of architecture*	*High level Operator interface*	*System architecture*
S-5	SLO-1	*Analog signals measurement*	*Communication Protocols*	*CPU, Memory*	*Architectural Models*	*DCS Application in steel plant*
	SLO-2	*Control techniques*	*Operator interface*	*Local control unit languages*	*Hardware Elements*	*System architecture*

S-6	SLO-1	*Discrete signals measurement*	*Monitoring alarms*	*Language requirements*	*Operator displays*	*DCS Application in Paper and pulp industry*
	SLO-2	*Control techniques*	*Status points*	*Functional blocks*	*Engineering interface- Introduction*	*System architecture*
S-7	SLO-1	*Remote terminal unit*	*Control interfacing*	*Problem-oriented languages*	*System configuration requirements*	*DCS Application in petroleum-refining industry*
	SLO-2	*Analog and Discrete control*	*Parallel operator interface*	*High-level languages*	*Diagnosis of System Problems*	
S-8	SLO-1	*Monitoring signals*	*SCADA Development for any one typical application*	*Process interfacing issues*	*Low-level engineering interface*	*DCS Application in oil and gas processing industry.*
	SLO-2	*Master terminal unit*		*Security design issues*	*System configuration*	
S-9	SLO-1	*Process configuration*	*Programming for GUI development using SCADA software*	*Process input/output design issues*	*High-level engineering interface*	*DCS Application in water treatment plant*
	SLO-2	*Applications*		*Remote I/O and Communication modules*	*System configuration*	*System architecture*

Learning Resources	1. *Stuart Boyer A, "SCADA : Supervisory control and data Acquisition", Fourth Edition, ISA-The Instrumentation, Systems, and Automation Society, 2010* 2. *Dobrivojie Poppovik, Vijay P Bhatkar, "Distributed Computer Control Systems in Industrial Automation" CRC Press, 1990*	3. *Michael Lucas, "Distributed Control Systems", Van Nostrand Reinhold Co., 1986* 4. *IDC Technologies, "Practical Distributed Control Systems (DCS) for Engineers and Technicians"2012* 5. *Krishna Kant, Computer Based Industrial Control, 2nd Edition, Prentice Hall of India, New Delhi, 2010*

Learning Assessment

	Bloom's Level of Thinking	Continuous Learning Assessment (50% weightage)								Final Examination (50% weightage)	
		CLA – 1 (10%)		CLA – 2 (15%)		CLA – 3 (15%)		CLA – 4 (10%)#			
		Theory	Practice	Theory	Practice	Theory	Practice	Theory	Practice	Theory	Practice
Level 1	Remember Understand	30 %	-	30 %	-	30 %	-	30 %	-	30%	-
Level 2	Apply Analyze	40 %	-	40 %	-	40 %	-	40 %	-	40%	-
Level 3	Evaluate Create	30 %	-	30 %	-	30 %	-	30 %	-	30%	-
	Total	100 %		100 %		100 %		100 %		100 %	

CLA – 4 can be from any combination of these: Assignments, Seminars, Tech Talks, Mini-Projects, Case-Studies, Self-Study, MOOCs, Certifications, Conf. Paper etc.,

Course Designers

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2. Mr. Hariharasudhan - Johnson Controls, Pune, hariharasudhan.v@jci.com	*2. Dr. D. Nedumaran, Madras University, dnmaran@gmail.com*	*2. Mr. J. SamJeba Kumar, SRMIST*

Course Code	18ECE382T	Course Name	BUILDING AUTOMATION	Course Category	E	Professional Elective	L	T	P	C
							3	0	0	3

Pre-requisite Courses	Nil	Co-requisite Courses	Nil	Progressive Courses	Nil
Course Offering Department	Electronics and Communication Engineering	Data Book / Codes/Standards	Nil		

Course Learning Rationale (CLR):	The purpose of learning this course is to:
CLR-1 :	*Give basic knowledge in intelligent building and building automation systems*
CLR-2 :	*Gain Knowledge on different sensors and measurement systems in BMS system*
CLR-3 :	*Know the basic concepts of HVAC Air handling unit*
CLR-4 :	*Understand the basic concepts of HVAC terminal unit*
CLR-5 :	*Explore the BAS Architecture*
CLR-6 :	*Present an overview of different Communication protocols*

Course Learning Outcomes (CLO):	At the end of this course, learners will be able to:	Learning 1: Level of Thinking (Bloom)	2: Expected Proficiency (%)	3: Expected Attainment (%)	PLO 1: Engineering Knowledge	2: Problem Analysis	3: Design & Development	4: Analysis, Design, Research	5: Modern Tool Usage	6: Society & Culture	7: Environment & Sustainability	8: Ethics	9: Individual & Team Work	10: Communication	11: Project Mgt. & Finance	12: Life Long Learning	13: PSO - 1	14: PSO - 2	15: PSO - 3
CLO-1 :	*Understand the need of intelligent buildings and automation systems*	3	80	75	H	-	-	-	-	H	H	-	-	-	-	H	H	H	H
CLO-2 :	*Measure the parameters and design of sensors*	3	80	70	H	-	-	-	-	H	H	-	-	-	H	H	-	M	H
CLO-3 :	*Design different Air handling units*	3	75	70	H	H	M	H	M	H	M	H	-	-	H	H	H	M	H
CLO-4 :	*Understand and design terminal units*	3	80	75	H	H	M	H	M	-	M	H	H	-	-	H	-	M	H
CLO-5 :	*Familiarize with the components of BAS architecture*	3	80	70	H	-	M	-	H	-	M	H	-	-	-	H	-	M	H
CLO-6 :	*Select the Communication protocol for a particular application*	3	80	70	H	-	-	-	-	H	-	H	-	H	M	H	H	-	H

Duration (hour)		Introduction to Building automation systems	Comfort parameters	HVAC Basic Concepts- Air handling unit	Terminal Unit	BAS Architecture
		9	9	9	9	9
S-1	SLO-1	*Introduction to intelligent building*	*Temperature*	*Concept of Air handling unit*	*Concept of Variable Air Volume (VAV) system*	*BAS Hierarchy*
	SLO-2	*intelligent architecture*	*Enthalpy, Entropy*	*components in AHU*	*different types of VAV*	*Field level components*
S-2	SLO-1	*structure*	*Heat Transfer - Conduction, Convection, Radiation*	*different types of dampers*	*Design, working*	*Direct Digital Control (DDC)*
	SLO-2	*Facility management vs. intelligent buildings*	*Working Principle, Characteristics of RTD*	*Working, configuration,*	*series fan powered*	*Supervisory Controller*
S-3	SLO-1	*Lifecycle of building*	*Thermistor, Thermocouple*	*different types of AHU*	*parallel fan powered*	*Server, Operator Workstation (OWS)*
	SLO-2	*Evolution of intelligent buildings*	*Bimetallic strip*	*Design and working*	*pressure dependent*	*Different Communication protocol*
S-4	SLO-1	*Introduction to BAS*	*Humidity, Specific Humidity,*	*Operation of different modes in AHU*	*supply-exhaust VAV*	*addressing concepts*
	SLO-2	*Different systems of BAS*	*Relative Humidity, Due point, Saturation point*	*humidification*	*dual duct VAV*	*Open Protocols -BACnet, LON*
S-5	SLO-1	*HVAC*	*Working principle of relative humidity sensors*	*dehumidification*	*Design, working, use of radiation coil*	*Profibus, Modbus*
	SLO-2	*HVAC Applications*	*mounting for humidity sensors in BAS*	*static pressure control*	*chilled beam*	*M-bus*

S-6	SLO-1	*Security system*	*Psychrometric chart*	*volume matching*	*CRAC unit, VRV systems*	*Proprietary Protocols- N2, CBUS*
	SLO-2	*Field Devices*	*Pressure, Static Pressure, Velocity pressure, Absolute Pressure*	*cooling, heating,*	*unit heater, Fan coil unit and unit ventilator*	*Wireless filed devices*
S-7	SLO-1	*Fire alarm system*	*Gauge Pressure, Vacuum Pressure, Differential Pressure, Sealed Pressure*	*economizer mode*	*Chilled water system*	*controllers*
	SLO-2	*Types of Detectors*	*Working Principle of Different types of Pressure Sensors*	*Heat recovery techniques*	*Concept of refrigeration cycle, components used in refrigeration cycle*	*routers*
S-8	SLO-1	*Modules*	*Working of principle of different air flow sensors*	*plate heat exchanger*	*different types of chilled water system*	*coordinators*
	SLO-2	*Indicating Devices*	*Working of principle of different water flow sensors*	*heat recovery wheel*	*Working and design of different types of boilers*	*Benefits of a Wireless BAS*
S-9	SLO-1	*lighting systems*	*Measurement of CO2 level*	*AHU for different applications*	*Working and design of different types of heat exchanger*	*Wireless Field Bus*
	SLO-2		*Working principal of BTU meter*			*Basic Reference Model (BRM)*

Learning Resources	1. *Smart Buildings by Jim Sinopoli, Butterworth-Heinemann imprint of Elsevier, 2nd Edition., 2010* 2. *Intelligent Building Systems by Albert Ting-Pat So, WaiLok Chan, Kluwer Academic publisher, 3rd Edition., 2012.*	3. *Design of Special Hazards and Fire Alarm Systems by Robert Gagnon, Thomson Delmar Learning; 2nd Edition, 2007.*

Learning Assessment

	Bloom's Level of Thinking	Continuous Learning Assessment (50% weightage)								Final Examination (50% weightage)	
		CLA – 1 (10%)		CLA – 2 (15%)		CLA – 3 (15%)		CLA – 4 (10%)#			
		Theory	Practice	Theory	Practice	Theory	Practice	Theory	Practice	Theory	Practice
Level 1	Remember Understand	30 %	-	30 %	-	30 %	-	30 %	-	30%	-
Level 2	Apply Analyze	40 %	-	40 %	-	40 %	-	40 %	-	40%	-
Level 3	Evaluate Create	30 %	-	30 %	-	30 %	-	30 %	-	30%	-
	Total	100 %		100 %		100 %		100 %		100 %	

CLA – 4 can be from any combination of these: Assignments, Seminars, Tech Talks, Mini-Projects, Case-Studies, Self-Study, MOOCs, Certifications, Conf. Paper etc.,

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Course Code	18ECE383J	Course Name	INSTRUMENTATION SYSTEM DESIGN	Course Category	E	Professional Elective	L	T	P	C
							2	0	2	3

Pre-requisite Courses	Nil	Co-requisite Courses	Nil	Progressive Courses	Nil
Course Offering Department	Electronics and Communication Engineering	Data Book / Codes/Standards	Nil		

Course Learning Rationale (CLR):	*The purpose of learning this course is to:*
CLR-1 :	*Impart knowledge on basic signal conditioning circuits.*
CLR-2 :	*Familiarize students on the requirements of industry.*
CLR-3 :	*Obtain adequate knowledge on process parameter optimization.*
CLR-4 :	*Gain expertise to handle basic instruments in Industry.*
CLR-5 :	*Acquire knowledge of piping diagram in Industry.*
CLR-6 :	*Bridge the gap between industrial requirements and operational constraints.*

Course Learning Outcomes (CLO):	*At the end of this course, learners will be able to:*	Learning			Program Learning Outcomes (PLO)														
		1	2	3	1	2	3	4	5	6	7	8	9	10	11	12	13	14	15
		Level of Thinking (Bloom)	Expected Proficiency (%)	Expected Attainment (%)	Engineering Knowledge	Problem Analysis	Design & Development	Analysis, Design, Research	Modern Tool Usage	Society & Culture	Environment & Sustainability	Ethics	Individual & Team Work	Communication	Project Mgt. & Finance	Life Long Learning	PSO - 1	PSO - 2	PSO - 3
CLO-1 :	*Apply mathematical knowledge, science, engineering fundamentals to design circuits pertaining to various process measurements*	*3*	*80*	*75*	*H*	*H*	*H*	*M*	-	-	-	-	-	-	-	*M*	*H*	-	-
CLO-2 :	*Design signal conditioning circuits for various process parameters.*	*3*	*80*	*70*	*H*	*H*	-	*M*	*H*	-	-	-	*H*	-	*L*	-	*M*	*M*	*H*
CLO-3 :	*Optimize the performance of process output.*	*3*	*75*	*70*	*H*	-	*M*	*M*	*M*	-	*H*	*M*	-	-	-	-	-	-	*M*
CLO-4 :	*Select optimal sensor for process measurement.*	*3*	*80*	*75*	*H*	*M*	-	*M*	-	*M*	*M*	-	-	-	-	-	-	*M*	-
CLO-5 :	*Choose type of indication circuits for industry.*	*3*	*80*	*70*	*H*	-	*H*	-	-	-	*M*	-	*H*	*M*	-	-	*H*	-	*L*
CLO-6 :	*Analyze and select the suitable sensing and transduction unit.*	*3*	*80*	*70*	*H*	*H*	-	-	-	-	-	-	-	-	-	-	*H*	*M*	*H*

Duration (hour)		Review of Signal Conditioning circuits	Design of Level and Pressure Measurement	Design of Flow measurements and Control Valve	Design of Transmitters and final control element	Design of indicators and Logic circuits
		12	12	12	12	12
S-1	SLO-1	*Requirements of Signal Conditioning*	*Electronic PID controller Design.*	*Study of Orifice, Venturi and Rotameter.*	*2 wire and 3 wire transmitter*	*Alarm circuit design*
	SLO-2	*Analog, Digital and adaptive filter design*	*P,I,D modes of operation Solving numerical..*	*Review of design requirements.*	*Thermocouple based temperature transmitter*	*Annunciator circuit design*
S-2	SLO-1	*V/I and I/V Converter design. Design of amplifiers – Pre amplifier*	*Composite modes – PI, PD and PID.*	*Design of Orifice.*	*Design of transmitter*	*Interlocks*
	SLO-2	*Instrumentation Amplifier, Bridge and Isolation Amplifier.*	*Realization using composite modes.*	*Design of Rotameter.*	*Capacitance based flow transmitter*	*Overview of Programmable logic controllers*
S 3-4	SLO-1 SLO-2	*Lab1: Design of Active Filters – LPF, HPF and BPF.*	*Lab 4: Design, Fabrication and Testing of Analog PID Controller.*	*Lab 7: Development of Software Program for sizing Orifice.*	*Lab10: Design, Fabrication and Testing of 2-wire Analog Transmitter.*	*Lab 13: Sequential controller using PLD*
S-5	SLO-1	*Signal conditioning circuits for temperature measurement. – RTD.*	*Requirements of Pressure Measurement.*	*Design constraints.*	*Level transmitter*	*Microprocessor based PID controller*
	SLO-2	*Design of RTD*	*Bourdon tube, Bellows, Diaphragms*	*Study of Valve characteristics and valve body*	*Flapper nozzle amplifier characteristics*	*Study of recorders*
S-6	SLO-1	*Signal Conditioning for Thermocouple.*	*Factors affecting sensitivity.*	*Design of Actuator and positioner*	*Pneumatic actuator*	*Numerical in alarm circuit*
	SLO-2	*Design of thermocouple*		*Control Valve sizing*	*Hydraulic actuator*	*Real time case study*

			Adjustment of set point, bias and controller settings			
S 7-8	SLO-1	*Lab 2 :Design of Instrumentation Amplifier.*	*Lab 5: Design of V/I and I/V converter.*	*Lab 8: Development of Software Program for sizing Rotameter.*	*Lab11: Design of multi channel data acquisition system*	*Lab 14: Functional constraints and specification in industry*
	SLO-2					
S-9	SLO-1	*Cold junction compensation and Linearization.*	*Air purge Level Measurement*	*Design of Control valve factor and plug area.*	*Characteristics of pumps*	*Operating console and control room panel design.*
	SLO-2	*Design of cold junction compensation circuits.*	*Design of air purge system*	*Selection of material for body and trim.*	*Instruments used in pumping practices*	*Instrument symbols and signals*
S-10	SLO-1	*Zero and Span adjustment in Temperature Transmitters.*	*Capacitive based level Measurement.*	*Cavitation and flashing in Control valve*	*Pump operation and maintenance*	*Mini project on any process application.*
	SLO-2	*Temperature indicators and selection criteria for temperature sensing instruments.*	*Design of capacitance based level measurement.*	*Characteristics of control valve for typical applications*	*Selection of pumps*	*Discussion on project*
S 11-12	SLO-1	*Lab3: Design of regulated power supply.*	*Lab 6: Design of signal conditioning circuits for level measurements.*	*Lab 9: Study of control valve characteristics*	*Lab12: Study of P&I diagrams*	*Lab 15: Process application*
	SLO-2					

Learning Resources	1. *C.D.Johnson, ""Process Control Instrumentation Technology", 8th Edition, Prentice Hall, 2015.* 2. *Bentley, J. P., Principles of Measurement Systems, Pearson Education, 2015.* 3. *Beta G.Liptak, "Instrument Engineers Handbook – Process Control and Optimization". 4th Edition. CRC Press. 2008.*	4. *N.A.Anderson, Instrumentation for Process Measurment and Control, Chilton Company, 2003.* 5. *R.W.Miller, " Flow measurement engineering Handbook", McGraw hill. New York, 1996.*

Learning Assessment

	Bloom's Level of Thinking	Continuous Learning Assessment (50% weightage)								Final Examination (50% weightage)	
		CLA – 1 (10%)		CLA – 2 (15%)		CLA – 3 (15%)		CLA – 4 (10%)#			
		Theory	Practice	Theory	Practice	Theory	Practice	Theory	Practice	Theory	Practice
Level 1	Remember Understand	20%	20%	15%	15%	15%	15%	15%	15%	15%	15%
Level 2	Apply Analyze	20%	20%	20%	20%	20%	20%	20%	20%	20%	20%
Level 3	Evaluate Create	10%	10%	15%	15%	15%	15%	15%	15%	15%	15%
	Total	100 %		100 %		100 %		100 %		-	

CLA – 4 can be from any combination of these: Assignments, Seminars, Tech Talks, Mini-Projects, Case-Studies, Self-Study, MOOCs, Certifications, Conf. Paper etc.,

Course Designers

Experts from Industry	Experts from Higher Technical Institutions	Internal Experts
1. D. Karthikeyan, Controlsoft Engineering India Pvt Ltd, karthikeyan.d@controlsoftengg.in	*1. Dr. J. Prakash, MIT, Chennai, prakaiit@rediffmail.com*	*1.S.Sharanya SRM IST*
2. Mr. Hariharasudhan - Johnson Controls, Pune, hariharasudhan.v@jci.com	*2. Dr. D. Nedumaran, Madras University, dnmaran@gmail.com*	*2.Dr.G.Joselin Retna Kumar*

Course Code	18ECE384T	Course Name	FACTORY INSTRUMENTATION NETWORKS	Course Category	E	Professional Elective	L	T	P	C
							3	0	0	3

Pre-requisite Courses	Nil	Co-requisite Courses	Nil	Progressive Courses	Nil
Course Offering Department	Electronics and Communication Engineering			Data Book / Codes/Standards	Nil

Course Learning Rationale (CLR):	*The purpose of learning this course is to:*
CLR-1 :	*Educate on the basic concepts of data networks*
CLR-2 :	*Introduce the basics of inter-networking and serial Communications*
CLR-3 :	*Provide details on HART and Field buses*
CLR-4 :	*Know different techniques on Modbus, PROFIBUS and other Communication protocols*
CLR-5 :	*Present an overview of industrial Ethernet*
CLR-6 :	*Study the working of computer busses and protocols*

Course Learning Outcomes (CLO):	*At the end of this course, learners will be able to:*	Learning 1: Level of Thinking (Bloom)	2: Expected Proficiency (%)	3: Expected Attainment (%)	PLO 1: Engineering Knowledge	2: Problem Analysis	3: Design & Development	4: Analysis, Design, Research	5: Modern Tool Usage	6: Society & Culture	7: Environment & Sustainability	8: Ethics	9: Individual & Team Work	10: Communication	11: Project Mgt. & Finance	12: Life Long Learning	13: PSO - 1	14: PSO - 2	15: PSO - 3
CLO-1 :	*Understand the basic concepts of data networks*	3	80	75	H	H	-	-	M	H	-	-	-	-	-	H	H	-	H
CLO-2 :	*Analyze the techniques of inter-networking and serial Communications*	3	80	70	H	-	-	H	-	H	-	-	-	-	-	H	-	M	H
CLO-3 :	*Understand the protocols and layers of HART and field bus*	3	75	70	H	-	M	H	M	H	-	H	-	H	M	H	M	H	H
CLO-4 :	*Analyze the techniques of MODBUS, PROFIBUS and other Communication protocol*	3	80	75	H	H	M	H	M	-	-	H	H	H	H	H	-	H	H
CLO-5 :	*Utilize the concept of industrial Ethernet*	3	80	70	H	-	M	-	H	-	-	H	-	H	H	H	H	H	H
CLO-6 :	*Analyze the working of computer busses and protocols*	3	80	70	H	-	M	-	-	H	-	H	-	H	-	H	H	H	H

Duration (hour)		OSI Model	Inter-Networking	HART and Field bus	PROFIBUS and Modbus	Industrial Ethernet
		9		9	9	9
S-1	SLO-1	*Introduction to Modern instrumentation*	*Introduction to RS-232*	*Introduction to HART and smart instrumentation*	*Introduction to PROFIBUS*	*Introduction to Industrial Ethernet*
	SLO-2	*Introduction to control systems*	*RS-422 and RS-423*	*HART protocol*	*PROFIBUS protocol stack*	*10 Mbps Ethernet*
S-2	SLO-1	*Open systems interconnection (OSI) model*	*Electrical characteristics of RS 232*	*Physical layer- Analog 4–20 mA*	*Physical layer (layer 1)*	*Media systems*
	SLO-2	*Representation of the OSI model*	*Examples*	*Digital frequency shift keying (FSK)*	*Type A cable*	*10Base5, 10Base2, 10BaseT*
S-3	SLO-1	*Protocols*	*Communications between two nodes*	*Data link layer*	*Type B cable*	*Signaling methods*
	SLO-2	*Basic structure of an information frame defined by a protocol*	*Transmission and reception of characters*	*HART protocol implementation of OSI model layer*	*Data link layer (layer 2)*	*Medium access control*
S-4	SLO-1	*Standards*	*Simple no-handshaking Communications*	*Application layer- Universal commands*	*Hybrid medium access control*	*Frame transmission*
	SLO-2	*EIA-232 interface standard*	*Software handshaking*	*Common practice commands, Device specific commands*	*Application layer*	*Frame reception*
S-5	SLO-1	*EIA-485 interface standard*	*Hardware handshaking*	*Troubleshooting*	*Introduction to Modbus*	*MAC frame format*
	SLO-2	*Interoperabiltity, Interchangeability*	*Two-way Communications with handshaking*	*HART cable length calculation*	*Modbus protocol structure*	*Differences between IEEE 802.3 and Blue Book Ethernet (V2)*

S-6	SLO-1	*Mod bus*	*DTE-DCE connections (PC to modem)*	*Introduction to foundation field bus*	*Function codes*	*IEEE 802.2 LLC*
	SLO-2	*Data Highway Plus protocol structure*	*Exercises*	*Physical layer*	*Read coil or digital output status (function code 01) and Read digital input status (function code 02)*	*Reducing collisions*
S-7	SLO-1	*DeviceNet*	*Introduction to RS-485 (ISO 8482)*	*Wiring rules*	*Read holding registers (function code 03) and Reading input registers (function code 04)*	*Design rules*
	SLO-2	*Profibus*	*RS-485 connecting to multiple nodes*	*Encoding rule, permeable and delimiters*	*Force single coil (function code 05)*	*Length of the cable segments*
S-8	SLO-1	*Introduction to OLE for process control*	*Line drivers*	*Data link layer*	*Preset single register (function code 06)*	*100 Mbps Ethernet*
	SLO-2	*Common problems and solutions*	*Unbalanced digital interface circuit (RS-423) and balanced digital interface circuit (RS-422)*	*Data link layer: packet format*	*Troubleshooting*	*Media access: full-duplex*
S-9	SLO-1	*General comments on troubleshooting*	*RS-232/485 converter*	*Application layer*	*Common Problems and Discussion*	*Auto-negotiation*
	SLO-2	*Specific Methodology*	*Exercises*	*User layer*	*Modbus Plus protocol overview*	*Fiber optic cable distances 100BaseFX*

Learning Resources	1. *Steve Mackay, Edwin Wrijut, Deon Reynders, John Park, "Practical Industrial Data Networks Design, Installation and Troubleshooting", Newnes Publication, Elsevier 1st edition, 2004.* 2. *Ian Verhappen and Augusto Pereira , "Foundation Field bus", 4th Edition, Feb 29, 2012* 3. *William Buchanan, "Computer Buses", CRC Press, 2000.*	4. *Andrew S. Tanenbaum, David J. Wetherall, "Computer Networks", Prentice Hall of India Pvt. Ltd., 5th Edition. 2011.* 5. *A. Behrouz Forouzan, "Data Communications & Networking", 3rd edition, Tata Mc Graw hill,2006.*

Learning Assessment

	Bloom's Level of Thinking	Continuous Learning Assessment (50% weightage)								Final Examination (50% weightage)	
		CLA – 1 (10%)		CLA – 2 (15%)		CLA – 3 (15%)		CLA – 4 (10%)#			
		Theory	Practice	Theory	Practice	Theory	Practice	Theory	Practice	Theory	Practice
Level 1	Remember Understand	30 %	-	30 %	-	30 %	-	30 %	-	30%	-
Level 2	Apply Analyze	40 %	-	40 %	-	40 %	-	40 %	-	40%	-
Level 3	Evaluate Create	30 %	-	30 %	-	30 %	-	30 %	-	30%	-
	Total	100 %		100 %		100 %		100 %		100 %	

CLA – 4 can be from any combination of these: Assignments, Seminars, Tech Talks, Mini-Projects, Case-Studies, Self-Study, MOOCs, Certifications, Conf. Paper etc.,

Course Designers

Experts from Industry	Experts from Higher Technical Institutions	Internal Experts
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2. Mr. Hariharasudhan - Johnson Controls, Pune, hariharasudhan.v@jci.com	*2. Dr. D. Nedumaran, Madras University, dnmaran@gmail.com*	*2. Dr. A. Vimala Juliet, SRMIST*

Course Code	18ECE385T	Course Name	IoT IN PROCESS INSTRUMENTATION AND AUTOMATION	Course Category	E	Professional Elective	L	T	P	C
							3	0	0	3

Pre-requisite Courses	Nil	Co-requisite Courses	Nil	Progressive Courses	Nil
Course Offering Department	Electronics and Communication Engineering		Data Book / Codes/Standards	Nil	

Course Learning Rationale (CLR):	*The purpose of learning this course is to:*
CLR-1 :	*Impart fundamental knowledge on the concepts of Internet of Things with its Architecture.*
CLR-2 :	*Provide an overview of various techniques that are using Internet of Things in Industry applications.*
CLR-3 :	*Understand the working of Internet of Things in Industry with the advanced Industry 4.0 platforms.*
CLR-4 :	*Understand the application of Internet of Things in Automation*
CLR-5 :	*Gain knowledge on the operation of Engineering in IoT Automation with arrowhead framework.*
CLR-6 :	*Explore the working of IoT in various real-time industries*

Course Learning Outcomes (CLO):	*At the end of this course, learners will be able to:*	Learning 1: Level of Thinking (Bloom)	2: Expected Proficiency (%)	3: Expected Attainment (%)	1: Engineering Knowledge	2: Problem Analysis	3: Design & Development	4: Analysis, Design, Research	5: Modern Tool Usage	6: Society & Culture	7: Environment & Sustainability	8: Ethics	9: Individual & Team Work	10: Communication	11: Project Mgt. & Finance	12: Life Long Learning	13: PSO - 1	14: PSO - 2	15: PSO - 3
CLO-1 :	*Understand the basic concepts of IoT, Architecture and Its Applications*	3	85	80	H	-	-	-	-	-	-	-	-	-	-	H	-	H	-
CLO-2 :	*Analyze the techniques to apply IoT for Industry*	3	85	75	H	H	H	H	H	-	-	H	-	-	-	H	-	H	-
CLO-3 :	*Apply the knowledge of different techniques of IoT in industry with an advanced platform of Industry 4.0*	3	80	80	H	H	H	H	H	H	-	-	-	-	-	H	-	H	H
CLO-4 :	*Develop the knowledge of IoT in Automation.*	3	85	80	H	H	H	H	H	-	-	-	H	-	-	H	-	H	H
CLO-5 :	*Apply the knowledge of Engineering in IoT Automation System*	3	80	75	H	-	H	-	H	-	-	H	-	-	-	H	H	H	H
CLO-6 :	*Design the IoT based real-time projects*	3	85	85	H	-	H	H	H	H	H	H	H	H	H	H	H	H	H

Duration (hour)		IoT – Landscape, System Architectures	Industrial Internet of Things(IIoT)	IIoT Platforms	IoT Automation	Engineering of IoT Automation System
		9	9	9	9	9
S-1	SLO-1	*Introduction to IoT*	*Introduction to IIoT*	*Introduction to IIoT Conceptual diagram*	*From DCS and SCADA to IoT*	*Engineering of an Arrowhead domain facility*
	SLO-2	*Applications and Architectures*	*IIoT Architecture*	*Middleware Architecture*	*Automation System Architectures*	*Engineering Tool Interoperability*
S-2	SLO-1	*Wireless Networks, Devices*	*Communication Methods for IoT Devices*	*Functions of Middleware Platforms*	*Automation System Properties*	*Component based Engineering Method*
	SLO-2	*Security and Privacy*	*IoT Reference Model by ITU*	*IIoT WAN and Protocol*	*Communication within Automation Systems*	*Life Cycle Dimensions*
S-3	SLO-1	*Event-Driven Systems*	*IoT Business Model by ITU*	*IIoT Device for M2M*	*Current Trends in Automation System*	*Data Model*
	SLO-2	*IoT System Architectures*	*Designing Industrial Internet Systems*	*Securing the Industrial Internet*	*Automation System Security*	*Design Guidelines for Component based Engineering*
S-4	SLO-1	*Protocols Concepts*	*OSI Table*	*Security in Manufacturing*	*Future Automation System Requirements*	*Safety and Security Engineering of IoT Automation System*
	SLO-2	*IoT- Oriented Protocols*	*Web 2.0 Layers*	*OT Manufacturing Network*	*Next Generation Automation*	*Security Analysis*
S-5	SLO-1	*Data bases & Time Bases*	*IP Layers vs IIoT Layers*	*OT vs IT Security Domains*	*Internet of Things*	*ETSI and STRIDE method*
	SLO-2	*IoT Device Design Space*	*Modern Communication Protocols*	*Defining Industry 4.0*	*System of Systems*	*Safety Analysis*

S-6	SLO-1	*Cost of Ownership*	*Wireless Communication Technologies*	*Characteristics of Industry 4.0*	*Service Oriented Architecture*	*FMEA / FMECA Analysis*
	SLO-2	*Power Consumption*	*Proximity Network Communication Protocols*	*Industry 4.0 Design Principles*	*Local Automation Cloud Concept*	*Engineering Scenarios*
S-7	SLO-1	*Cost per Transistor and Chip Size*	*Access Network Technology*	*Building Blocks of Industry 4.0*	*Local Cloud Properties*	*Efficient Deployment of IoT Sensors*
	SLO-2	*Duty Cycle and Power Consumption*	*Ethernet, IP Routing*	*Industry 4.0 Reference Architecture*	*Local Cloud Establishment*	*Network Deployment tool*
S-8	SLO-1	*Platform Design*	*TCP/IP*	*Smart Factories - Introduction*	*Automation Support*	*Cost of Wireless Sensor Network*
	SLO-2	*IoT Network Model*	*Application Programming Interface*	*Smart Factory Production line*	*Latency in Local Clouds*	*Swift Deployment and Configuration*
S-9	SLO-1	*Single and Multi – Hub Networks*	*API – Technical Perspective with Example*	*Smart Manufacturing*	*Security in Local Clouds*	*Deployment Procedure*
	SLO-2	*Physical Networks*	*Summary*	*Real World Smart Factories*	*System of System Scalability*	*Replacement of Device*

Learning Resources	1. *DimiriosSerpanos and Marilyn Wolf, Internet-of-Things (IoT) Systems, Architectures, Algorithms, Methodologies, Springer, 2018.* 2. *Alasdair Gilchrist, Industry 4.0 – The Industrial Internet of Things, Apress, 2016.* 3. *"IoT Automation Arrowhead Framework", Jerker Delsing, CRC Press, Taylor & Francis Group, 2017.*	4. *Patel Chintan, Internet of Things Security: Challenges, Advances, and Analytics, Auerbach Publications, 2019.* 5. *Jeschke S Brecher, Song C, Industrial Internet of Things – Cyber Manufacturing Systems, Springer, 2017.* 6. *Stamatios Manesis, George Nikolakopoulos, Introduction to Industrial Automation, CRC Press, Taylor & Francis Group, 2018.*

Learning Assessment

	Bloom's Level of Thinking	Continuous Learning Assessment (50% weightage)								Final Examination (50% weightage)	
		CLA – 1 (10%)		CLA – 2 (15%)		CLA – 3 (15%)		CLA – 4 (10%)#			
		Theory	Practice	Theory	Practice	Theory	Practice	Theory	Practice	Theory	Practice
Level 1	Remember Understand	30 %	-	30 %	-	30 %	-	30 %	-	30%	-
Level 2	Apply Analyze	40 %	-	40 %	-	40 %	-	40 %	-	40%	-
Level 3	Evaluate Create	30 %	-	30 %	-	30 %	-	30 %	-	30%	-
	Total	100 %		100 %		100 %		100 %		100 %	

CLA – 4 can be from any combination of these: Assignments, Seminars, Tech Talks, Mini-Projects, Case-Studies, Self-Study, MOOCs, Certifications, Conf. Paper etc.,

Course Designers

Experts from Industry	Experts from Higher Technical Institutions	Internal Experts
1. D. Karthikeyan, Controlsoft Engineering India Pvt Ltd, karthikeyan.d@controlsoftengg.in	*1. Dr. J. Prakash, MIT, Chennai, prakaiit@rediffmail.com*	*1. Dr. G. Y.RajaaVikhram, SRMIST*
2. Mr. Hariharasudhan - Johnson Controls, Pune, hariharasudhan.v@jci.com	*2. Dr. D. Nedumaran, Madras University, dnmaran@gmail.com*	*2. Dr. Joselin Retna Kumar, SRMIST*

Course Code	18ECE386T	Course Name	MEMS BASED MICROSYSTEM ANALYSIS AND DESIGN	Course Category	E	Professional Elective	L	T	P	C
							3	0	0	3

Pre-requisite Courses	Nil	Co-requisite Courses	Nil	Progressive Courses	Nil
Course Offering Department	Electronics and Communication Engineering		Data Book / Codes/Standards		Nil

Course Learning Rationale (CLR):	The purpose of learning this course is to:
CLR-1 :	*Study the basics of microfabrication and its techniques*
CLR-2 :	*Impart the knowledge ofmechanicalmicrosensors*
CLR-3 :	*Understand the mechanism for various actuators*
CLR-4 :	*Know the behavior of fluid at the micro level, working of microfluidic devices and its fabrication techniques*
CLR-5 :	*Identify the correct interfacing circuits for microsystem*
CLR-6 :	*Know the working and readout mechanism for microdevices or microsystems*

Course Learning Outcomes (CLO):	At the end of this course, learners will be able to:	Learning 1: Level of Thinking (Bloom)	2: Expected Proficiency (%)	3: Expected Attainment (%)	PLO 1: Engineering Knowledge	2: Problem Analysis	3: Design & Development	4: Analysis, Design, Research	5: Modern Tool Usage	6: Society & Culture	7: Environment & Sustainability	8: Ethics	9: Individual & Team Work	10: Communication	11: Project Mgt. & Finance	12: Life Long Learning	13: PSO - 1	14: PSO - 2	15: PSO - 3
CLO-1 :	*Apply the knowledge of micro technology to fabricate micro devices*	3	80	80	H	H	-	H	H	-	-	H	H	-	-	H	M	-	H
CLO-2 :	*Design a microsensor based on an application with a suitable working principle.*	3	80	80	H	H	H	H	H	-	-	H	H	-	-	H	M	-	H
CLO-3 :	*Design, analyse and optimise the microactuator for different applications.*	3	80	80	H	H	H	H	H	-	-	H	H	-	-	H	M	-	H
CLO-4 :	*Design a microfluidic device for automobile, medical, electronics and industrial applications*	3	80	80	H	H	H	H	H	-	-	H	H	-	-	H	M	-	H
CLO-5 :	*Design an interfacing circuit for reading output from microsystems*	3	80	80	H	H	H	H	H	-	-	H	H	-	-	H	M	-	H
CLO-6 :	*Develop a microsystem for a specific application*	3	80	80	H	H	H	H	H	-	-	H	H	-	-	H	M	-	H

Duration (hour)		Micromachining Technology	Mechanical Microsensors	Microactuators	Microfluidics	Interface Circuitry and Microsystems
		9	9	9	9	9
S-1	SLO-1	*Introduction*	*Introduction*	*Introduction*	*Introduction*	*Introduction*
	SLO-2	*Bulk Micromachining*	*Automotive*	*Actuators: Transducers with Mechanical Output*	*Properties of Fluids*	*Microsensor Systems*
S-2	SLO-1	*Wet Etching*	*Computers and Peripherals*	*Transduction Mechanisms*	*Volumes and Length Scales*	*Microsensor System Applications - Automotive Sensors*
	SLO-2	*High-Aspect-Ratio Micromachining*	*Consumer Products*	*Scaling Advantages and Issues*	*Mixtures, Physical Properties*	*Biomedical Sensors*
S-3	SLO-1	*Surface Micromachining*	*Medical and Biological Applications*	*Electrical Microactuators*	*Vapour Pressure, Surface Tension*	*Sensors for Household Appliances, Building Control*
	SLO-2	*Basic Process Sequence*	*Inertial Sensors*	*Electrostatic Forces*	*Electrical Properties, Optical Properties, Transport Phenomena*	*Industrial Control*
S-4	SLO-1	*Deposition , Sputtering and Etching*	*Accelerometers*	*Electrostatic Systems*	*Physics of Microfluidic Systems*	*Environmental Sensors*
	SLO-2	*Epi-Micromachining*	*Yaw-Rate Sensors*	*Forces in Electrostatic Systems*	*Navier-Stokes Equations*	*Interface Circuit Architecture*
S-5	SLO-1	*SIMPLE, SCREAM*	*Pressure Sensors*	*Scaling Properties*	*Laminar Flow, Dynamic Pressure*	*Requirements and Specifications*
	SLO-2	*Black Silicon, MELO*	*Fundamentals*	*Electrostatic Microactuator Configurations*	*Fabrication Technologies*	*Analog Front-End*

S-6	SLO-1	*Porous Silicon*	*Bulk-Micromachined Pressure Sensors*	*Gap-Closing Electrostatic Microactuators& Examples*	*Silicon, Plastics,*	*Voltage Output - Current or Charge Output*
	SLO-2	*SIMOX*	*Surface-Micromachined Pressure Sensors*	*Constant-Gap Electrostatic Microactuators& Examples*	*Quartz, Glass*	*Impedance Variation*
S-7	SLO-1	*Epi-Po1y*	*Signal Generation*	*Hybrid Electrostatic Microactuators*	*Microarrays*	*A/D Converter*
	SLO-2	*Release and Stiction*	*Force and Torque Sensors*	*Electrostatic Induction, Issues and Challenges*	*Concept, Fabrication, Particle-Based Microarray Concepts*	*Types of converters*
S-8	SLO-1	*IC Compatibility Issues*	*Linking the Macro World to the Micro World*	*Piezoelectric Microactuators*	*Micropumps*	*Digital Processing and Output Interface*
	SLO-2	*Compatible Bulk Micromachining*	*Fabrication*	*Piezoelectric Energy Density*	*Microdisplacement Pumps, Charge-Induced Pumping Mechanisms, Other Pumping Mechanisms*	*Digital Signal Processing*
S-9	SLO-1	*Compatible Surface Micromachining*	*Protection*	*Piezoelectric Microactuator Configurations & Design Issues*	*Microanalytical Chips*	*Wired Output Interfaces*
	SLO-2	*Compatible Epi-Micromachining*	*Test and Calibration*	*Electrostriction, Electrets, and E1ectrorheo1ogical Fluids*	*Lab-on-a-Chip Systems, Chip-Based Capillary Electrophoresis*	*Wireless Output Interfaces*

Learning Resources	1. *Jan G. Korvink, Oliver Paul, "MEMS: A Practical Guide to Design, Analysis and Applications", William Andrew, Inc. & Springer, 2006* 2. *Chang Liu, "Foundations of MEMS", Pearson; 2nd edition, 2011* 3. *Mohamed Gad-el-Hak, "MEMS: Design and Fabrication", CRC Press; 1st edition, 2005.*	4. *Julian W. Gardner, "Micro sensors, MEMS, and Smart Devices", John Wiley & Sons Inc, 2001* 5. *John A. Pelesko, "Modeling MEMS and NEMS", CRC Press; 1stedition, 2002* 6. *Stephen Beeby, "MEMS Mechanical Sensors", ARTECH HOUSE, INC 2004*

Learning Assessment

	Bloom's Level of Thinking	Continuous Learning Assessment (50% weightage)								Final Examination (50% weightage)	
		CLA – 1 (10%)		CLA – 2 (15%)		CLA – 3 (15%)		CLA – 4 (10%)			
		Theory	Practice	Theory	Practice	Theory	Practice	Theory	Practice	Theory	Practice
Level 1	Remember Understand	30 %	-	30 %	-	30 %	-	30 %	-	30%	-
Level 2	Apply Analyse	40 %	-	40 %	-	40 %	-	40 %	-	40%	-
Level 3	Evaluate Create	30 %	-	30 %	-	30 %	-	30 %	-	30%	-
	Total	100 %		100 %		100 %		100 %		100 %	

CLA – 4 can be from any combination of these: Assignments, Seminars, Tech Talks, Mini-Projects, Case-Studies, Self-Study, MOOCs, Certifications, Conf. Paper etc.,

Course Designers

Experts from Industry	Experts from Higher Technical Institutions	Internal Experts
1. D. Karthikeyan, Controlsoft Engineering India Pvt Ltd, karthikeyan.d@controlsoftengg.in	*1. Dr. J. Prakash, MIT, Chennai, prakaiit@rediffmail.com*	*1. Mr.C. Likith Kumar, SRMIST*
2. Mr. Hariharasudhan - Johnson Controls, Pune, hariharasudhan.v@jci.com	*2. Dr. D. Nedumaran, Madras University, dnmaran@gmail.com*	*2. Dr. A. Vimala Juliet, SRMIST*

Course Code	18ECE387T	Course Name	MICRO SENSORS AND SMART DEVICES	Course Category	E	Professional Elective	L	T	P	C
							3	0	0	3

Pre-requisite Courses	Nil	Co-requisite Courses	Nil	Progressive Courses	Nil
Course Offering Department	Electronics and Communication Engineering	Data Book / Codes/Standards	Nil		

Course Learning Rationale (CLR):	*The purpose of learning this course is to:*
CLR-1 :	*To realize the importance of micro sensors and actuators*
CLR-2 :	*To learn the operating principle of various micro sensors*
CLR-3 :	*To analyze the applications of various micro fabrication techniques*
CLR-4 :	*To understand the different packaging techniques*
CLR-5 :	*To appreciate the significance of available MEMS based smart devices*
CLR-6 :	*To recognize recent developments and challenges in MEMS*

Course Learning Outcomes (CLO):	*At the end of this course, learners will be able to:*	Learning 1 Level of Thinking (Bloom)	2 Expected Proficiency (%)	3 Expected Attainment (%)	PLO 1 Engineering Knowledge	2 Problem Analysis	3 Design & Development	4 Analysis, Design, Research	5 Modern Tool Usage	6 Society & Culture	7 Environment & Sustainability	8 Ethics	9 Individual & Team Work	10 Communication	11 Project Mgt. & Finance	12 Life Long Learning	13 PSO - 1	14 PSO - 2	15 PSO - 3
CLO-1 :	*Appreciate the importance of sensors and actuators based on MEMS technology*	3	80	75	H	-	-	-	-	H	-	-	-	-	-	H	H	-	H
CLO-2 :	*Understand the fabrication and machining techniques of MEMS devices*	3	80	70	H	-	-	-	-	H	-	-	-	-	-	H	-	-	H
CLO-3 :	*Familiarize with the concepts of packaging and interfaces in MEMS devices*	3	75	70	H	H	M	H	M	H	-	-	-	-	-	H	H	-	H
CLO-4 :	*Appreciate the significance of general micro fabrication processes*	3	80	75	H	H	M	H	M	-	-	-	H	-	-	H	-	-	H
CLO-5 :	*Differentiate between the working principle of various micro sensors*	3	80	70	H	-	M	-	H	-	-	-	-	-	-	H	-	-	H
CLO-6 :	*Analyze recently developed smart devices employing MEMS technology*	3	80	70	H	-	-	-	-	H	-	-	-	-	-	H	H	-	H

Duration (hour)		9	9	9	9	9
S-1	SLO-1	*Introduction to Microelectronics*	*Micro thermal Sensors-overview*	*Micro machining techniques*	*MEMS Packaging*	*Smart Devices-Overview*
	SLO-2	*Evolution& History of MEMS*	*TEG and Thermopiles*	*Significance and types*	*Objectives in Packaging*	*Functionalities*
S-2	SLO-1	*Overview of Micro system technology*	*Micro radiation Sensors-overview*	*Bulk MMC-overview*	*Flip chip assembly*	*Features & requirements*
	SLO-2	*Broad applications of Micro systems*	*Implementation*	*Principle and block diagram*	*Ball grid array*	*Broad applications*
S-3	SLO-1	*Miniaturization & Scaling laws*	*Micro mechanical Sensors-overview*	*Surface MMC-overview*	*wire bonding techniques*	*Airbag deployment*
	SLO-2	*Micro devices -examples*	*Vibration sensor -Accelerometer*	*Principle and block diagram*	*Types*	*Tire pressure monitoring*
S-4	SLO-1	*Types of Micro Sensors*	*Micro pressure Sensors-overview*	*LIGA process-overview*	*surface bonding techniques*	*GPS-Gyro sensor*
	SLO-2	*Types of Micro actuators*	*Parameter measurement*	*Principle and block diagram*	*Types*	*Micro Energy harvesters*
S-5	SLO-1	*Si and other substrates*	*Micro humidity Sensors-overview*	*Photolithography*	*sealing*	*Smart home automation*
	SLO-2	*Special MEMS Materials& properties*	*Types of Sensing film & measurement*	*Process Description, implementation*	*Different types of sealing*	*MEMS devices in agriculture*

S-6	SLO-1	*Polymer materials*	*Micro SAW Sensors-overview*	*Ion implantation and oxidation*	*Process design*	*Blood pressure monitor*
	SLO-2	*Electro active polymers*	*Implementation*	*Process Description, implementation*	*Block diagram*	*Heart Parameter monitors*
S-7	SLO-1	*Shape memory alloys*	*Micro magnetic Sensors-overview*	*PVD-CVD*	*Interferences*	*RF MEMS technology*
	SLO-2	*Shape memory polymers*	*Si* *gnificance & measurement*	*Process Description, implementation*	*Types of interferences*	*Optical Mirrors*
S-8	SLO-1	*Piezoelectric materials*	*Micro bio chemical Sensors-overview*	*Wet and dry etching*	*Electronic Interfacing*	*Micro fluidics*
	SLO-2	*Ceramic materials*	*Parameter measurement*	*Isotrophic and Anisotrophic*	*Electro mechanical interfacing*	*LOC module*
S-9	SLO-1	*Case study-1*	*Micro optical Sensors-overview*	*Case study-1*	*Case study-1*	*Case study-1*
	SLO-2	*Case study -2*	*Types & Implementation*	*Case study -2*	*Case study -2*	*Case study -2*

Learning Resources	1. *Marc Madou,"Fundamentals of Microfabrication" CRC Press* 2. *Tai Ran Tsu,"MEMS and Microsystems: Design Manufacture", Tata McGraw Hill*	3. *Vardhan Gardener,"Micro sensors and smart devices", John Wiley & Sons*

Learning Assessment

	Bloom's Level of Thinking	Continuous Learning Assessment (50% weightage)								Final Examination (50% weightage)	
		CLA – 1 (10%)		CLA – 2 (15%)		CLA – 3 (15%)		CLA – 4 (10%)#			
		Theory	Practice	Theory	Practice	Theory	Practice	Theory	Practice	Theory	Practice
Level 1	Remember Understand	30 %	-	30 %	-	30 %	-	30 %	-	30%	-
Level 2	Apply Analyze	40 %	-	40 %	-	40 %	-	40 %	-	40%	-
Level 3	Evaluate Create	30 %	-	30 %	-	30 %	-	30 %	-	30%	-
	Total	100 %		100 %		100 %		100 %		100 %	

CLA – 4 can be from any combination of these: Assignments, Seminars, Tech Talks, Mini-Projects, Case-Studies, Self-Study, MOOCs, Certifications, Conf. Paper etc.,

Course Designers

Experts from Industry	Experts from Higher Technical Institutions	Internal Experts
1. D. Karthikeyan, Controlsoft Engineering India Pvt Ltd, karthikeyan.d@controlsoftengg.in	*1. Dr. J. Prakash, MIT, Chennai, prakaiit@rediffmail.com*	*1. Dr. A. Vimala Juliet, SRMIST*
2. Mr. Hariharasudhan - Johnson Controls, Pune, hariharasudhan.v@jci.com	*2. Dr. D. Nedumaran, Madras University, dnmaran@gmail.com*	*2. Mrs. R. Bakiya Lakshmi, SRMIST*

ACADEMIC CURRICULA

Professional Elective Courses

MECHANICAL ENGINEERING

Regulations - 2018

SRM INSTITUTE OF SCIENCE AND TECHNOLOGY

(Deemed to be University u/s 3 of UGC Act, 1956)

Kattankulathur, Kancheepuram, Tamil Nadu, India

Course Code	18MEE301T	Course Name	FUNDAMENTALS OF VIBRATION AND NOISE	Course Category	E	Professional Elective	L	T	P	C
							3	0	0	3

Pre-requisite Courses	18MEC201T Machines and Mechanisms	Co-requisite Courses	NIL	Progressive Courses	NIL
Course Offering Department	Mechanical Engineering	Data Book / Codes/Standards			

Course Learning Rationale (CLR):	The purpose of learning this course is to:
CLR-1 :	*Be familiar with the vibrations of two degree of freedom systems*
CLR-2 :	*Be familiar with the vibrations of multi degree of freedom systems*
CLR-3 :	*Be familiar with the vibrations of continuous systems*
CLR-4 :	*Be familiar with the Numerical Integration methods in Vibration analysis*
CLR-5 :	*Be familiar with the vibration measurement devices*
CLR-6	*Be familiar with the vibrations of multi degree of freedom systems & Continuous systems, numerical integration methods in vibration analysis and vibration measuring devices*

Course Learning Outcomes (CLO):	At the end of this course, learners will be able to:	Learning 1 Level of Thinking (Bloom)	2 Expected roficiency (%)	3 Expected Attainment (%)	PLO 1 Engineering Knowledge	2 Problem Analysis	3 Design & Development	4 Analysis, Design, Research	5 Modern Tool Usage	6 Society & Culture	7 Environment & Sustainability	8 Ethics	9 Individual & Team Work	10 Communication	11 Project Mgt. & Finance	12 Life Long Learning	13 PSO - 1	14 PSO - 2	15 PSO - 3
CLO-1 :	*Able to learn the concepts of vibration analysis of two degree of freedom systems and vibration absorbers*	*1& 2*	*75*	*70*	*H*	*M*	*M*	*H*	*L*	*L*	*M*	*L*	*L*	*L*	*L*	*M*			
CLO-2 :	*Able to Understand and apply the various numerical methods for vibration analysis of three degree of freedom systems*	*1*	*75*	*70*	*H*	*M*	*M*	*H*	*L*	*L*	*M*	*L*	*L*	*L*	*L*	*L*			
CLO-3 :	*Able to learn the concepts of vibration analysis of continuous systems*	*1*	*75*	*70*	*H*	*M*	*M*	*L*	*M*	*L*	*M*	*L*	*L*	*L*	*L*	*L*			
CLO-4 :	*Able to apply the knowledge of numerical integration methods in vibration analysis*	*1*	*75*	*70*	*H*	*M*	*M*	*L*	*M*	*L*	*M*	*L*	*L*	*L*	*L*	*L*			
CLO-5 :	*Able to Understand the vibration measurement devices and condition monitoring techniques*	*1&2*	*75*	*70*	*H*	*H*	*M*	*M*	*H*	*L*	*H*	*L*	*L*	*M*	*L*	*M*			
CLO-6:	*Able to understand the vibrations of two, multi degree of freedom systems and continuous sytems and apply the knowledge of numerical integration methods in vibration analysis and vibration measuring devices in field measurement.*	*1&2*	*75*	*70*	*H*	*H*	*M*	*M*	*H*	*L*	*H*	*L*	*L*	*M*	*L*	*L*			

		Vibrations of Two degree of freedom systems / Module 1	Vibrations of Three Degree of freedom systems / Module 2	Vibrations of Continuous systems Numerical Integration Methods in Vibration Analysis / Module 3	Numerical Integration Methods in Vibration Analysis / Module 4	Vibration Measuring Instruments / Module 5
Duration (hour)		9	9	9	9	9
S-1	SLO-1	*Introduction to vibration terminologies and multidegree of freedom systems*	*Equation of Motion for free undamped three degrees of freedom systems using Newton's Method, Orthogonality Condition*	*Transverse Vibrations of String or a cable*	*Introduction to Finite Difference method*	*Vibration Measuring Devices – Transducer, Vibrometer*
S-2	SLO-1	*Equation of Motion for free undamped two degrees of freedom systems using Newton's method*	*Multidegree of freedom systems – Matrix method , Eigen Value Method – Eigen values and Eigen vector*	*Longitudinal vibrations of a Bar or a Rod*	*Central difference method for single degree of freedom systems*	*Vibration Measuring Devices – Accelerometer and Seismometer.*
S-3	SLO-1	*Equation of Motion for free undamped two degrees of freedom systems using Lagrangian energy method*	*Tutorials on Multidegree of freedom systems – Newton's Method, Matrix method , Eigen Value Method*	*Tutorials on Transverse Vibrations of Strings and Longitudinal vibrations of Rods*	*Central difference method for multi degree of freedom systems*	*Tutorials on vibrometer, Accelerometer and Seismometer.*
S-4	SLO-1	*Tutorials on free undamped two degrees of freedom systems using Newton's method and Lagrangian method*	*Influence Coefficients Method – Stiffness and Flexibility matrix – spring mass system*	*Torsional vibrations of rods*	*Tutorials on central difference method*	*Frequency Measuring devices – Single Reed, Multi reed and stroboscope.*

S-5	SLO-1	*Determine the natural frequencies and mode shapes for coordinate coupling*	*Dunkerly's Method for closed coupled system , Rayleigh's Method for spring mass system*	*Lateral Vibrations of a Beam*	*Runge-Kutta Method for single degree of freedom systems*	*Vibration exciters*
S-6	SLO-1	*Concept of Linear undamped vibration absorber*	*Tutorials on Influence Coefficients Method, Dunkerly's Method and Rayleigh's Method*	*Tutorials on Torsional vibration of rods and lateral vibration of a Beams*	*Runge-Kutta Method for multi degree of freedom systems*	*Tutorials on vibration exciters.*
S-7	SLO-1	*Tutorials on coordinate coupling and Linear undamped vibration absorber*	*Concept of Holzer's Method for Far Coupled systems and Close Coupled Sytems*	*Rayleigh's method for continuous system*	*Tutorials on Runge-Kutta Method*	*Experimental Modal Analysis, Condition Monitoring techniques*
S-8	SLO-1	*Torsional Vibration of Two rotor systems.*	*Torsional Vibration of Three rotor systems-Equivalent Length Determination*	*Rayleigh's Ritz method for continuous system*	*Finite Difference Methods for Longitudinal vibration of bars*	*Balancing Machines – Single plane and two plane balancing*
S-9	SLO-1	*Torsional Vibration of Geared Systems with Two rotor System*	*Tutorials on Hozler's method and Three rotor systems.*	*Tutorials on Rayleigh's method and Rayleigh's Ritz method*	*Finite Difference Methods for transverse vibration of beams*	*Tutorials on Modal analysis*

Learning Resources	1. *Rao.S.S, "Mechanical Vibrations", 5th Edition, Pearson Education Inc. Delhi 2009.* 2. *Ambekar.A.G, "Mechanical Vibrations and Noise engineering", PHI New Delhi, 2015.* 3. *Thomson.W.T, "Theory of Vibration and its Applications", 5th Edition, Prentice Hall, New Delhi, 2001.* 4. *Meirovitch, L., "Elements of Vibration Analysis", Mc Graw – Hill Book Co., New York, 1986.* 5. *Rao.J.S and Gupta.K, "Introductory course on theory and practice of mechanical vibrations", 2nd Edition,New Age International, New Delhi, 2014.* 6. *Ramamurthi.V, "Mechanical Vibration Practice with Basic Theory", 1st edition, Narosa Publishing House, Chennai, 2000.*

Learning Assessment

	Bloom's Level of Thinking	Continuous Learning Assessment (50% weightage)								Final Examination (50% weightage)	
		CLA – 1 (10%)		CLA – 2 (15%)		CLA – 3 (15%)		CLA – 4 (10%)#			
		Theory	Practice	Theory	Practice	Theory	Practice	Theory	Practice	Theory	Practice
Level 1	Remember Understand	40%	-	30%	-	30%	-	30%	-	30%	-
Level 2	Apply Analyze	40%	-	40%	-	40%	-	40%	-	40%	-
Level 3	Evaluate Create	20%	-	30%	-	30%	-	30%	-	30%	-
	Total	100 %		100 %		100 %		100 %		100 %	

CLA – 4 can be from any combination of these: Assignments, Seminars, Tech Talks, Mini-Projects, Case-Studies, Self-Study, MOOCs, Certifications, Conf. Paper etc,

INDUSTRIAL EXPERT	ACADEMIC EXPERT	INTERNAL EXPERT
1. Dr. R. Kalimuthu, ISRO, Mahendragiri, r_kalimuthu@vssc.gov.in, rkpearls@yahoo.com	*Dr. RAJENDRA MACHAVARAM, IIT KHARAGPUR*	*V.N.B PRASAD SODISETTY, SRMIST*
2. Dr. A. Velayutham, DRDO, Avadi, velayudham.a@cvrde.drdo.in	*RAGHAVENDRA BEJGAM ENGINEERING PROJECT LEAD, PENTAIR, NOIDA.*	*Dr. P. Nandakumar, SRMIST*

Course Code	18MEE302T	Course Name	INDUSTRIAL TRIBOLOGY	Course Category	E	Professional Elective	L	T	P	C
							3	0	0	3

Pre-requisite Courses	NIL	Co-requisite Courses	NIL	Progressive Courses	NIL
Course Offering Department	Mechanical Engineering	Data Book / Codes/Standards	PSG Design Data book		

Course Learning Rationale (CLR):	The purpose of learning this course is to:
CLR-1 :	*Understand and analyze thesurfaces and friction*
CLR-2 :	*Understand and analyze the wear mechanisms*
CLR-3 :	*Understand and analyze the film theory*
CLR-4 :	*Understand and analyze the lubricants and lubrication phenomenon*
CLR-5:	*Understand and analyze the surface engineering processes and select suitable materials for bearing*
CLR-6:	*Understand and solve various engineering problems*

Course Learning Outcomes (CLO):	At the end of the course, student will be able to:	Learning 1 Level of Thinking (Bloom)	2 Expected Proficiency (%)	3 Expected Attainment (%)	PLO 1 Engineering Knowledge	2 Problem Analysis	3 Design & Development	4 Analysis, Design, Research	5 Modern Tool Usage	6 Society & Culture	7 Environment & Sustainability	8 Ethics	9 Individual & Team Work	10 Communication	11 Project Mgt. & Finance	12 Life Long Learning	13 PSO - 1	14 PSO - 2	15 PSO - 3
CLO-1 :	*Understand friction and engineering surfaces*	1,&2	100	85	H	H			H		H					H	H		
CLO-2 :	*Apply the knowledge and analyze the failure occurred due to various types of wear*	3&4	100	85	H	H	H	H	H		H					H	H		
CLO-3 :	*Apply the knowledge of lubrication to provide solutions*	3&4	100	85	H	H	H	H	H							H	H		
CLO-4 :	*Analyze various surface conditions and provide new ideas of surface protection techniques*	3&4	100	85	H	H	H	H	H							H	H		
CLO-5:	*Formulate new materials*	5	100	85	H	H										H	H	H	H
CLO-6:	*Investigate the failure of a system*	5	100	85	H	H			H	H						H	H	H	H

		Surfaces and friction	Wear	Film lubrication theory	Lubricants and lubrication	Surface engineering and materials for bearings
Duration (hour)		9	9	9	9	9
S-1	SLO-1	*Introduction to the concept of tribology, Tribological problems*	*Introduction, background of Wear and Types of Wear with applications.*	*Introduction to Viscosity and its importance in lubrication.*	*Types of lubricants and their properties*	*Introduction to surface engineering*
S-2	SLO-1	*Nature of engineering surfaces, Surface topography*	*Abrasive wear*	*Influence of various particles on viscosity of a lubricant.*	*Stribeck Curve and its importance*	*Surface treatments*
S-3	SLO-1	*Surface profilometer, measurement of surface topography; importance of roughness parameters*	*Adhesive wear*	*Fluid film in simple shear, Viscous flow between very close parallel plates.*	*Boundary and Mixed Lubrication regime*	*Coatings and cladded plates*
S-4	SLO-1	*Contact between surfaces, Sources of sliding Friction, Friction characteristics of metals and non-metals*	*Wear due to corrosion*	*Shear variation within the film, Lubricant supply, lubricant low rate.*	*Hydrodynamic lubrication*	*In situ formed tribo films*
S-5	SLO-1	*Friction due to ploughing, Friction due to adhesion*	*Fatigue and fretting wear*	*Cold jacking, Couette flow,*	*Elasto hydrodynamic lubrication(EHL); Problems on EHL*	*Surface Texturing*
S-6	SLO-1	*Sources of rolling friction, Stick slip motion*	*Wear in metals*	*Cavitations, film rupture and oil whirl*	*Importance of film thickness, Lambda ratio*	*Tribo corrosion*
S-7	SLO-1	*Friction of ceramic materials*	*Wear in polymers*	*Petroff's equation*	*Bio degradable lubricants*	*Surface analysis techniques*
S-8	SLO-1	*Friction of polymers*	*Wear of ceramics*	*Reynolds equation*	*Nano lubricants*	*Materials for bearings*
S-9	SLO-1	*Measurement of friction*	*Measurement of wear, Ferrography and oil analysis*	*Sommerfield Number*	*Hertzian contact and problems on Hertizian contacts*	*Condition monitoring*

Learning Resources	*1. Hutchings.I.M and Shipway P, "Tribology, Friction and Wear of Engineering Material, Elsevier Butterworth –Heinemann , UK, 2017.* *2. Bharat Bhushan, "Introduction to tribology", Wiley Publication, 2013.* *3. Williams.J.A, "Engineering Tribology", Oxford University Press, 2005.* *4. GwidonStachowiak, Andrew W Batchelor., "Engineering tribology", Elsevier Butterworth –Heinemann, USA, 2005.* *5. Stolarski.T.A, "Tribology in Machine Design", Industrial Press Inc., 1990.* *6. Cameron.A, "Basic Lubrication Theory", Longman, U.K., 1981.* *7. Neale.M.J., "Tribology Handbook", Newnes Butter worth, Heinemann, U.K., 1975.*

Learning Assessment

	Bloom's Level of Thinking	Continuous Learning Assessment (50% weightage)								Final Examination (50% weightage)	
		CLA – 1 (10%)		CLA – 2 (15%)		CLA – 3 (15%)		CLA – 4 (10%)#			
		Theory	Practice	Theory	Practice	Theory	Practice	Theory	Practice	Theory	Practice
Level 1	Remember Understand	40%	-	30%	-	30%	-	30%	-	30%	-
Level 2	Apply Analyze	40%	-	40%	-	40%	-	40%	-	40%	-
Level 3	Evaluate Create	20%	-	30%	-	30%	-	30%	-	30%	-
	Total	100 %		100 %		100 %		100 %		100 %	

CLA – 4 can be from any combination of these: Assignments, Seminars, Tech Talks, Mini-Projects, Case-Studies, Self-Study, MOOCs, Certifications, Conf. Paper etc,

Course Designers		
Experts from Industry	Experts from Higher Technical Institutions	Internal Experts
1. Dr. R. Kalimuthu, ISRO, Mahendragiri, r_kalimuthu@vssc.gov.in, rkpearls@yahoo.com	*Dr.P. Ramkumar, IITM, ramkumar@iitm.ac.in*	*Mr. ShubrajitBhaumik, SRM IST ,*
2. Dr. A. Velayutham, DRDO, Avadi, velayudham.a@cvrde.drdo.in	*Dr.Chiradeep Ghosh , chiradeep.ghosh@tatasteel.com, Tata Steel*	*Dr. TVVNL Rao, SRMIST*

Course Code	18MEE303T	Course Name	MECHANISM DESIGN, ANALYSIS AND SYNTHESIS	Course Category	E	Professional Elective	L	T	P	C
							3	0	0	3

Pre-requisite Courses	18MEC201T Machines and Mechanisms	Co-requisite Courses	NIL	Progressive Courses	NIL
Course Offering Department	Mechanical Engineering	Data Book / Codes/Standards	NIL		

Course Learning Rationale (CLR):	The purpose of learning this course is to:	Learning			Program Learning Outcomes (PLO)														
		1	2	3	1	2	3	4	5	6	7	8	9	10	11	12	13	14	15
CLR-1 :	*Performthe kinematic analysis of various mechanisms and linkages*	Level of Thinking (Bloom)	Expected Proficiency (%)	Expected Attainment (%)	Engineering Knowledge	Problem Analysis	Design & Development	Analysis, Design, Research	Modern Tool Usage	Society & Culture	Environment & Sustainability	Ethics	Individual & Team Work	Communication	Project Mgt. & Finance	Life Long Learning	PSO - 1	PSO - 2	PSO - 3
CLR-2 :	*Synthesis a linkage or mechanism for the given requirements*																		
CLR-3 :	*Determine the acceleration at any point on the coupler*																		
CLR-4 :	*Perform static and dynamic force analysis of linkages*																		
CLR-5 :	*Perform kinematic analysis and synthesis of spatial mechanisms and Robot linkages*																		
CLR-6 :	*Design a mechanism according to the need and analyze it.*																		
Course Learning Outcomes (CLO):	*At the end of this course, learners will be able to:*																		
CLO-1 :	*Determine the position, velocity and acceleration of simple and complex linkages.*	*1,2 &3*	*75*	*65*	*H*	*H*	*M*	*M*	*H*	-	-	-	-	-	-	*L*			
CLO-2 :	*Synthesize a linkage based on the given working conditions*	*1,2 &3*	*75*	*65*	*H*	*H*	*H*	*H*	*H*	-	-	-	-	-	-	*L*			
CLO-3 :	*Find the conjugate points, radius of curvature and acceleration at any point on the coupler link.*	*1,2 &3*	*75*	*65*	*H*	*H*	*M*	*H*	*H*	-	-	-	-	-	-	*L*			
CLO-4 :	*Find forces/moments in various links with or without considering inertia of links*	*1,2 &3*	*75*	*65*	*H*	*H*	*H*	*M*	*H*	-	-	-	-	-	-	*L*			
CLO-5 :	*Determine the position, velocity and acceleration of spatial linkages and robot linkages*	*1,2 &3*	*75*	*65*	*H*	*H*	*H*	*H*	*H*	-	-	-	-	-	-	*L*			
CLO-6 :	*Do the kinematic and dynamic analysis of mechanisms in addition to its synthesis.*	*1,2 &3*	*75*	*65*	*H*	*H*	*H*	*H*	*H*	-	-	-	-	-	-	*L*			

		Kinematic Analysis of Mechanisms	Kinematic Synthesis of Linkages	Path Curvature Theory	Force Analysis of Mechanisms	Kinematics of Spatial Mechanisms And Robotics
Duration (hour)		9	9	9	9	9
S-1	SLO-1	*Review of fundamentals of kinematics, mobility analysis and classifications of mechanisms*	*Introduction to synthesis, type, number and dimensional synthesis*	*Fixed and moving centrodes*	*Static force analysis of linkages*	*Mobility and description of spatial mechanisms*
S-2	SLO-1	*Kinematic Inversions, Grashoff's law*	*Two position synthesis of four bar and slider crank mechanisms by extreme position and inversion methods*	*Determination of radius of curvature of coupler points by Hartmann's Construction*	*Static force analysis of linkages by graphical method, principle of super position*	*Position, velocity and acceleration analysis of spatial mechanisms by vector algebra method*
S-3	SLO-1	*Mechanical advantage and Transmission angle*	*Three position synthesis of four bar by inversion method*	*Determination of radius of curvature of coupler points by the Euler- Savary equation*		
S-4	SLO-1	*Position analysis of four bar, Slider Crank by complex and vector algebra methods*	*Three position synthesis of slider crank mechanisms by inversion method*	*Inflection Points, The Inflection Circle*	*Dynamics force analysis- D'Alembert's principle*	*Problems on kinematic analysis of spatial mechanisms*
S-5	SLO-1	*Velocity, acceleration and jerk analysis of four bar by complex and vector algebra methods*	*Four position synthesis by point position reduction method and Overlay method.*	*The collineation axis and Bobiller's theorem*	*Combined static and dynamics analysis of four bar linkage, Graphical and analytical methods*	*Kinematic synthesis of spatial mechanisms*
S-6	SLO-1	*Velocity, acceleration and jerk analysis of Slider Crank by complex and vector algebra methods*	*Coupler curve synthesis*	*Determination of radius of curvature of coupler points by Bobiller's Construction*	*Problems on combined static and dynamic analysis*	*Introduction to Robot kinematics, Topological arrangements of robotic arms, Eulerian angles, DH parameters*
S-7	SLO-1	*Velocity analysis of complex and six bar linkages by relative velocity method (Graphical method)*	*Analytical Methods of synthesis by Blotch's Synthesis*	*Problems on Bobiller's Construction*	*Shaking force and shaking couple*	*Kinematic analysis of robot manipulators using transformation matrices*
S-8	SLO-1	*Acceleration analysis of complex and six bar linkages by relative velocity method (Graphical method)*	*Analytical Methods of synthesis by Freudestien's Method*	*Problems on Bobiller's Construction*	*Introduction to force and moment balancing of linkages*	*Inverse kinematics of robot manipulators*

S-9	SLO-1	*Problems on velocity and acceleration of mechanisms by Graphical method*	*Cognate linkages by the Roberts – Chebyshev theorem*	*The cubic Stationary curvature - Ball's Point*	*Problems on Balancing of linkages*	*Robot actuator force analysis*

Learning Resources	1. *Uicker J. J.,Gordon R. Pennock & Joseph E. Shigley John J. Uicker "Theory of Machines and Mechanisms", Oxford Higher education, 2014.* 2. *Rao, J. S., and Dukkipatti, R.V., "Mechanisms and Machine Theory", 2nd Edition, New Age international (P) Ltd., 1995* 3. *Sandor, G. N. and Erdman A. G., Mechanism Design, Analysis and Synthesis Vol: I and Vol: II, Prentice Hall, 1990.* 4. *Norton, R. L., Design of Machinery, McGraw Hill, 1999.* 5. *Hamilton H Mabie and Charles F. Reinhofz, Mechanisms and Dynamics of Machinery, John Wiley & Sons, 1987.* 6. *Amitabha Ghose and Ashok Kumar Malik, Theory of Mechanisms and Machines, EWLP, Delhi, 1999.* 7. *R.S.Hartenberg and J. Denavit, "Kinematic Synthesis of Linkages", Mc. GrawHill Book Company, 1964*

Learning Assessment											
	Bloom's Level of Thinking	Continuous Learning Assessment (50% weightage)								Final Examination (50% weightage)	
		CLA – 1 (10%)		CLA – 2 (15%)		CLA – 3 (15%)		CLA – 4 (10%)#			
		Theory	Practice	Theory	Practice	Theory	Practice	Theory	Practice	Theory	Practice
Level 1	Remember Understand	40%	-	30%	-	30%	-	30%	-	30%	-
Level 2	Apply Analyze	40%	-	40%	-	40%	-	40%	-	40%	-
Level 3	Evaluate Create	20%	-	30%	-	30%	-	30%	-	30%	-
	Total	100 %		100 %		100 %		100 %		100 %	

CLA – 4 can be from any combination of these: Assignments, Seminars, Tech Talks, Mini-Projects, Case-Studies, Self-Study, MOOCs, Certifications, Conf. Paper etc,

Course Designers		
Experts from Industry	Experts from Higher Technical Institutions	Internal Experts
1. Dr.R.Kalimuthu, ISRO, Mahendragiri, r_kalimuthu@vssc.gov.in	*1. Dr. Shankar Krishnapillai, skris@iitm.ac.in, IIT Madras*	*1. Dr P. Nandakumar, SRMIST*
2. Dr.A.Velayutham, DRDO, Avadi, velayudham.a@cvrde.drdo.in	*2. Dr.R.Prabhu sekar, rprabhusekar@mnnit.ac.in, MNNIT Allahabad*	*2. Mr. K.R. Arunprasath, SRMIST*

Course Code	18MEE304T	Course Name	DESIGN FOR MANUFACTURING AND ASSEMBLY	Course Category	E	Professional Elective	L	T	P	C
							3	0	0	3

Pre-requisite Courses	NIL	Co-requisite Courses	NIL	Progressive Courses	NIL
Course Offering Department	Mechanical Engineering	Data Book / Codes/Standards	NIL		

Course Learning Rationale (CLR):	*The purpose of learning this course is to:*
CLR-1 :	*To study how a design can be made suitable for various manufacturing and assembly process requirements*
CLR-2 :	*Application of this study to various Casting and welding.*
CLR-3 :	*Application of this study to various forging, and machining processes*
CLR-4 :	*To study about the various assembly methods and processes*
CLR-5 :	*Know the effect of manufacturing process and assembly operations.*

Course Learning Outcomes (CLO):	*At the end of this course, learners will be able to:*	Learning 1 Level of Thinking (Bloom)	2 Expected Proficiency (%)	3 Expected Attainment (%)	PLO 1 Engineering Knowledge	2 Problem Analysis	3 Design & Development	4 Analysis, Design, Research	5 Modern Tool Usage	6 Society & Culture	7 Environment & Sustainability	8 Ethics	9 Individual & Team Work	10 Communication	11 Project Mgt. & Finance	12 Life Long Learning	13 PSO - 1	14 PSO - 2	15 PSO - 3
CLO-1 :	*Students will demonstrate the ability to identify needs of the customer and convert them in to technical specifications of a product.*	*1& 2*	*90*	*85*	*H*	--	*H*	--	--	--	--	--	--	--	--	--	--	--	--
CLO-2 :	*Know the manufacturing issues that must be considered in the Casting and welding*	*1*	*85*	*80*	*H*	*H*	*H*	*H*	--	--	--	--	--	--	--	--	--	--	--
CLO-3 :	*Know the manufacturing issues that must be considered in the forging and machining processes.*	*1*	*85*	*80*	*H*	*H*	*H*	*H*	--	--	--	--	--	--	--	--	--	--	--
CLO-4 :	*Students will understand the principals used while designing for manufacture, assembly.*	*1&2*	*85*	*80*	*H*	*H*	*H*	*H*	--	--	--	--	--	--	--	--	--	--	--
CLO-5 :	*Students will understand principles of assembly to minimize the assembly time.*	*1&2*	*85*	*80*	*H*	*H*	*H*		--	--	--	--	--	--	--	--	--	--	--

		Learning Unit / Module 1	Learning Unit / Module 2	Learning Unit / Module 3	Learning Unit / Module 4	Learning Unit / Module 5
Duration (hour)		9	9	9	9	9
S-1	SLO-1	*Significance of design- Systematic working plan-The engineering problem to be solved-The basic design*	*Influence of loading, Materials, Production methods on form design*	*Forging Considerations-Hammer forging-Drop forging*	*DFA-Introduction-Distinction between assembly methods and processes*	*Approaches to design for assembly-Introduction*
S-2	SLO-1	*Factors influencing choice of materials-The factors influencing manufacturing*	*Casting considerations-Grey iron castings*	*Requirements and rules for forging.*	*Factors Determining assembly methods and processes-Success and failure-Causes of failure*	*Approaches based on design principles and rules-Example DFA method using Design Principles*
S-3	SLO-1	*Process Capability-Mean, Median, Variance, Mode, Standard Deviation, Normal Distribution- Process capability metrics-*	*Steel castings -Aluminum Casting-Requirements and rules for casting*	*Redesign of components for forging.*	*Product Design factors independent of methods and processes-Introduction-Number of operations in the product*	*DFA Systems employing Quantitative evaluation procedures-IPA Stuttgart Method*
S-4	SLO-1	*Process Capability and Defect Rate, Assumptions, Conditions and Precautions in process capability*	*Form design of pressure die castings*	*Choice between casting, forging and welding.*	*Assembly Precedence-Standardization. Case studies in assembly precedence.*	*DFA Methods employing a Knowledge-based approach-Knowledge Representation*
S-5	SLO-1	*Process Capability-Simple problems*	*Redesign of components for casting-Pattern-Mould-Parting Line*	*Machining Considerations-Drills-Milling-Keyways-Dwells and Dwelling Procedure-Countersunk Head screws*	*Design factors dependent on Assembly methods-Introduction-Single Station Assembly*	*Computer Aided DFA methods-Part model-Feature Processing*
S-6	SLO-1	*Tolerances-symbols and Definition*	*Welding considerations-Welding Processes*	*Requirements and rules for Machining considerations-Reduction of machined areas*	*Line Assembly-Hybrid Systems-Manual Assembly Lines-Flexible Assembly Lines*	*Assembly measures-Qualitative and Quantitative measures*
S-7	SLO-1	*Tolerances relevant to manufacturing, Assembly- Material condition*	*Requirements and rules for welding*	*Redesign of components for Machining.*	*Design factors dependent on Assembly processes-Factors Influencing Production rate to Facility Ratio-Parts Presentation-Manual Assembly*	*Boothroyd and Dewhurst DFA method-Objectives of the method*

S-8	SLO-1	*Tolerance stack- effects on assembly-Examples*	*Redesign of components for welding*	*Simplification by separation-Simplification by Amalgamation*	*Dedicated Assembly-Transportation-Separation-Orientation-Flexible Assembly*	*Redesign of a simple product-Small consumer product-Fastener solution-Redesign using symmetry*
S-9	SLO-1	*Methods of eliminating tolerance stack-Examples*	*Case studies in Form Design-simple problems in form design*	*Case studies- forging and Machining*	*Gripping-Transferring-Part Insertion-Failures-Error Recovery*	*Case Studies-Designing of a disposal valve-Design of a lever-arch file mechanism*

Learning Resources	*1. Harry Peck., Design for Manufacture, Pittman Publications,1983.* *2. Alan Redford and chal, Design for Assembly-Principles and Procedures, McGraw Hill International Europe, London, 1994.* *3. Robert Matousek,Engineering Design-A Systematic Approach,Blackie&sons Ltd.,1963.* *4. James G.Bralla,Hand Book of Product design for Manufacturing,McGraw Hill Co.,1986.* *5. Swift,K.G.,Knowledge Based Design for Manufacture,Kogan Page Ltd.,1987.*

Learning Assessment

	Bloom's Level of Thinking	Continuous Learning Assessment (50% weightage)								Final Examination (50% weightage)	
		CLA – 1 (10%)		CLA – 2 (15%)		CLA – 3 (15%)		CLA – 4 (10%)#			
		Theory	Practice	Theory	Practice	Theory	Practice	Theory	Practice	Theory	Practice
Level 1	Remember Understand	40%	-	30%	-	30%	-	30%	-	30%	-
Level 2	Apply Analyze	40%	-	40%	-	40%	-	40%	-	40%	-
Level 3	Evaluate Create	20%	-	30%	-	30%	-	30%	-	30%	-
	Total	100 %		100 %		100 %		100 %		100 %	

CLA – 4 can be from any combination of these: Assignments, Seminars, Tech Talks, Mini-Projects, Case-Studies, Self-Study, MOOCs, Certifications, Conf. Paper etc,

Course Designers

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1. Dr.R.Kalimuthu, ISRO, Mahendragiri, r_kalimuthu@vssc.gov.in	*Dr. Davidson Jebaseelan, davidson.jd@vit.ac.in* *VIT Chennai.*	*Mr. P.Susai Manickam,* *SRM IST, Chennai*
2. Dr.A.Velayutham, DRDO, Avadi, velayudham.a@cvrde.drdo.in	*Mr. Vignesh Shanmugam.s* *Hyundai Motors Limited, Chennai* *E mail – 273357@hmil.net*	*Dr. P. Nandakumar* *SRM IST, Chennai*

Course Code	18MEE305T	Course Name	FINITE ELEMENT METHOD	Course Category	E	Professional Elective	L	T	P	C
							3	0	0	3

Pre-requisite Courses	18MEC106T Mechanics of Solids, 18MAB202T Numerical methods	Co-requisite Courses	NIL	Progressive Courses	NIL
Course Offering Department	Mechanical Engineering	Data Book / Codes/Standards	NIL		

Course Learning Rationale (CLR):	The purpose of learning this course is to:
CLR-1 :	*Find the approximate solution of boundary value problems*
CLR-2 :	*Know the variationaland Weighted residual approaches to solve differential equations*
CLR-3 :	*Develop basic finite element concepts and solution procedure*
CLR-4 :	*Formulatetheelement stiffness and mass matrices for various one and two dimensional elements*
CLR-5 :	*Formulate the element heat conductance and convection matrices one dimensional element*
CLR-6 :	*To formulate and solve problems in solid mechanics, Eigen Value and heat transfer using finite element method.*

		Learning			Program Learning Outcomes (PLO)														
		1	2	3	1	2	3	4	5	6	7	8	9	10	11	12	13	14	15
Course Learning Outcomes (CLO):	At the end of this course, learners will be able to:	Level of Thinking (Bloom)	Expected Proficiency (%)	Expected Attainment (%)	Engineering Knowledge	Problem Analysis	Design & Development	Analysis, Design, Research	Modern Tool Usage	Society & Culture	Environment & Sustainability	Ethics	Individual & Team Work	Communication	Project Mgt. & Finance	Life Long Learning	PSO - 1	PSO - 2	PSO - 3
CLO-1 :	*Solve the differential equations using weighted residual and variational approaches.*	*1,2&3*	*75*	*65*	*H*	*H*	*L*	*H*	*M*	-	-	*L*	*L*	-	-	*M*			
CLO-2 :	*Solve the structural analysis problems, such as bar, truss and beam using 1D element.*	*1,2 &3*	*70*	*65*	*H*	*H*	*L*	*H*	*M*	-	-	*L*	*L*	-	-	*M*			
CLO-3 :	*Analysis of two-dimensional structural problems on plane triangular and quadrilateral elements.*	*1,2 &3*	*70*	*65*	*H*	*H*	*L*	*H*	*M*	-	-	*L*	*L*	-	-	*M*			
CLO-4 :	*Be able to solve Eigen Value problems in solid mechanics using finite element method.*	*1,2 &3*	*65*	*65*	*H*	*H*	*L*	*H*	*M*	-	-	*L*	*L*	-	-	*M*			
CLO-5 :	*Be able to solve one dimensional heat transfer problems using finite element method*	*1,2 &3*	*70*	*65*	*H*	*H*	*H*	*H*	*H*	-	-	*L*	*L*	-	-	*M*			
CLO-6	*Analyze structural and heat transfer problems using Finite Element*	*1,2 &3*	*65*	*60*	*H*	*H*	*M*	*M*	*M*	-	-	*L*	*L*	-	-	*M*			

		Introduction to FEA	1D Linear Static Analysis	2D Linear Static Analysis	Dynamic Analysis of Structures	1D Heat Transfer Problems
Duration (hour)		9	9	9	9	9
S-1	SLO-1	*Basics of FEA, Historical background, applications of FEA in engineering, modelling of discrete and continuum models*	*Finite element procedure for a continuum problem, discretization, types of elements*	*Introduction to twodimension elasticity, plane stress and strain conditions*	*Dynamic analysis, Formulation-Hamilton's Principle, lumped and consistent mass models*	*Review of fundamentals of heat Transfer*
S-2	SLO-1	*Variational problems, Euler'sequation*	*Selection of interpolation function, shape function, derivation of element stiffness matrix for a one dimensional bar element*	*Constant strain triangular element, Area coordinate system, shape function, strain displacement matrix*	*Derivation of lumped and consistent mass matrices for axial bar element, formulation of eigen value problem*	*Governing equations and boundary conditions for Heat transfer*
S-3	SLO-1	*Rayleigh-Ritz method, minimum potential energy,Example problem, solving differential equation*	*assembly of elements, imposing boundary conditions, calculation of element stress, example problems*		*Determination of natural frequencies and normal mode shapes of axial vibration*	*Derivation of conductance matrix for steady state 1D heat conduction*
S-4	SLO-1	*Weighted residual approaches, collocation method, subdomain method, Galerkinmethod and least square method*	*Tutorial Problems on axial loading of bars*	*Derivation of element stiffness matrix for a CST element*	*Problems onnatural frequencies and normal mode shapes of axial vibration*	*Tutorial on Steady state 1D heat conduction*
S-5	SLO-1	*Example problem, solving differential equations using weighted residual approaches*	*Local and global coordinate systems*	*Tutorial on two dimensional plate problems with CST elements*	*Derivation of lumped and consistent mass matrices for beam element*	
S-6	SLO-1	*Galerkin's Finite Element method for solving differential equations, example problems, comparison of results with different methods*	*Analysis of truss, coordinate transformations, Derivation of the stiffness matrix*	*LST and four noded quadrilateral elements, isoparametric formulation*	*Determination of natural frequencies and normal mode shapes of beam*	*Derivation of element matrix for steady state 1D heat conduction including convection*

S-7	SLO-1	*Spring element, formulation of stiffness matrix, assembly procedure for global stiffness matrix, applying boundary conditions*	*Assembly of stiffness matrix for a truss, Tutorial Problems on Trusses*	*Gaussian quadrature Integration- Derivation of one point and two point formula*	*Determination of natural frequencies and normal mode shapes of beam*	*Tutorial on Steady state 1D heat conduction with convection*
S-8	SLO-1	*Solution of linear algebraic equations, Gauss elimination method, Cholesky decomposition, example problems*	*Beam element, Hermite shape functions, derivation of element stiffness matrix of a beam element.*	*Problems using Gaussian quadrature with one and two points*	*Problemson eigen value problems on beams*	*Solution of simple Heat Transfer 1-D and 2-D steady state problems using a FEA software*
S-9	SLO-1	*Tutorial problems on springs with series and parallel combinations*	*Calculation of load vector for point, uniform distributed and varying loads on beams*	*Lagrange interpolation functions for serendipity family elements*	*Derivation of lumped and consistent mass matrices for a CST element*	*Introduction to transient heat transfer problems*

Learning Resources	*1. Hutton, D.V., "Fundamentals of Finite Element Analysis", McGraw Hill, International Edition, 2004.* *2. Chandrupatla, T.R., Belegundu, A.D., "Introduction to Finite Elements in Engineering", Prentice Hall of India, 1997.* *3. P.Seshu, "Text book of Finite Element Analysis", PHI learning Private Ltd., 2012.* *4. S,S,Rao, "The Finite Element method in Engineering", Elsevier Science &Technology Books, 2004* *5. Cook R.D., Malkus, D.S., Plesha, M.E., Witt, R.J., "Concepts and Applications of Finite Element Analysis", 4th Edition, John Wiley & Sons, 2001.* *6. J.N Reddy, An introduction to the Finite Element Method, 2005, Mcgraw Hill*

Learning Assessment

	Bloom's Level of Thinking	Continuous Learning Assessment (50% weightage)								Final Examination (50% weightage)	
		CLA – 1 (10%)		CLA – 2 (15%)		CLA – 3 (15%)		CLA – 4 (10%)#			
		Theory	Practice	Theory	Practice	Theory	Practice	Theory	Practice	Theory	Practice
Level 1	Remember Understand	40%	-	30%	-	30%	-	30%	-	30%	-
Level 2	Apply Analyze	40%	-	40%	-	40%	-	40%	-	40%	-
Level 3	Evaluate Create	20%	-	30%	-	30%	-	30%	-	30%	-
	Total	100 %		100 %		100 %		100 %		100 %	

CLA – 4 can be from any combination of these: Assignments, Seminars, Tech Talks, Mini-Projects, Case-Studies, Self-Study, MOOCs, Certifications, Conf. Paper etc.,

Course Designers

Experts from Industry	Experts from Higher Technical Institutions	Internal Experts
1. Dr.R.Kalimuthu, ISRO, Mahendragiri, r_kalimuthu@vssc.gov.in	*1. Dr. Atanu Banerjee, atanub@iitg.ac.in, IIT Guwahati*	*1. Dr P. Nandakumar, SRMIST*
2. Dr.A.Velayutham, DRDO, Avadi, velayudham.a@cvrde.drdo.in	*2. Dr.R.Prabhusekar, rprabhusekar@mnnit.ac.in, MNNIT Allahabad*	*2. Mr.P. SusaiManikam, SRMIST*

Course Code	18MEE306T	Course Name	ADVANCED STRENGTH OF MATERIALS	Course Category	E	Professional Elective	L	T	P	C
							3	0	0	3

Pre-requisite Courses	18MEC106T Mechanics of Solids	Co-requisite Courses	NIL	Progressive Courses	NIL
Course Offering Department	Mechanical Engineering	Data Book / Codes/Standards	NIL		

Course Learning Rationale (CLR):	The purpose of learning this course is to:
CLR-1 :	*Be able to Compute the combined effect of deformation/loading arising out of different causes as applied to structural members made of linear, homogeneous, isotropic material so as to be able to predict (as part of a different course) failure of components/sub-systems of a product*
CLR-2 :	*Be able to Compute the effect of deformation/loading in straight and curved beams (a class of primary structural member) subjected to bending (a type of primary loading)*
CLR-3 :	*Be able to Study the effect of bending (a type of primary loading) deformation/load as applied to flat thin plates (a class of primary structural member)*
CLR-4 :	*Be able to Study the use of energy methods in structural analysis as an alternative means of solving a structural mechanics problem*
CLR-5 :	*Be equipped with analytical skills the learning process of which has a bearing in professional practice in understanding difference(s) between exact and approximate solution procedures*
CLR-6 :	*Be able to analyze effects of typical loadings on primary structural members using approximate or exact methods as applicable*

Course Learning Outcomes (CLO):	At the end of this course, learners will be able to:	Learning 1: Level of Thinking (Bloom)	Learning 2: Expected Proficiency (%)	Learning 3: Expected Attainment (%)	PLO 1: Engineering Knowledge	PLO 2: Problem Analysis	PLO 3: Design & Development	PLO 4: Analysis, Design, Research	PLO 5: Modern Tool Usage	PLO 6: Society & Culture	PLO 7: Environment & Sustainability	PLO 8: Ethics	PLO 9: Individual & Team Work	PLO 10: Communication	PLO 11: Project Mgt. & Finance	PLO 12: Life Long Learning	PLO 13: PSO - 1	PLO 14: PSO - 2	PLO 15: PSO – 3
CLO-1 :	*Perform 2D & 3d stress and strain transformation and arrive at maximum values for normal and shear stresses and find the planes on which these stresses act*	*1, 2*	*90*	*75*	*H*	*H*													
CLO-2 :	*Determine i)bending stress in straight beams (due to unsymmetrical bending), ii) transverse shear stresses in straight beams and locate shear center for specified cross-sections, and iii) circumferential (bending) stresses in curved beams*	*1, 2*	*90*	*75*	*H*	*H*													
CLO-3 :	*i)Derive expressions for displacement/strains, stresses, and moments, ii) derive (using these expressions) the governing equation for bending of flat rectangular and axi-symmetric circular plates. Use the expressions for computing these parameters in specified cases*	*1,2*	*90*	*75*	*H*	*H*													
CLO-4 :	*Compute strain energy due to various loadings and using it to determine deflection*	*1,2*	*90*	*75*	*H*	*H*													
CLO-5 :	*Understand the primary difference between theory of elasticity and mechanics of materials approaches and solve plane stress, torsional, and rotating disk problems*	*1,2*	*90*	*75*	*H*	*H*													
CLO-6 :	*Determine displacements, strains, and stresses related to primary structural members*	*1,2*	*90*	*75*															

		Stress & Strain Theory	Bending of Straight & Curved Beams	Bending of flat thin plates	Energy Methods	Theory of Elasticity & Its Applications
Duration (hour)		9	9	9	9	9
S-1	SLO-1	Introduction – course overview, Equilibrium, compatibility, and constitutive relations in macroscopic form, Definition of stress at a point in 3D, representation on an element and sign convention	BendingStresses in beams (initially straight) due to symmetrical loading – review and definition of un-symmetrical bending	Introduction to flat plates – definition of a plate, rectangular and axi-symmetric circular plates, thin vs thick plates, comparison with beams (1D) as a structural member (2D), typical real-world applications. Linear vs non-linear bending – definition. Derivation of governing equation for bending of a flat, thin, rectangular plate – outline of procedure	Work, Strain energy definition for linear, perfectly elastic materials; strain energy due to - uniaxial stress, additional normal stresses in other perpendicular directions, shear stress	Introduction to and comparison with mechanics of materials approach, definition of Plane stress and plane strain linear elastic problems

S-2	SLO-1	concept of a tensor (in relation to a scalar and a vector), 2D stress transformation in Cartesian coordinate system using direction cosines	Bending stresses in beams due to un-symmetrical bending (plane of loading not coinciding with plane of symmetry, even if it exists) – explanation of theory in decoupling the problem into sub-problems using the concept of principal axes and moments of inertia	definition of strains, stresses, and moments and use of these parameters in derivation of governing equation for plate bending (based on Kirchhoff theory) – use of strain-displacement, and stress-strain relations	strain energy due to - general state (3D) of stress, plane stress	Plane stress and plane strain linear elastic problems - Airy's stress function in rectangular coordinates – derivation of the biharmonic equation
S-3	SLO-1	3D stress transformation in Cartesian coordinate system using direction cosines	Application of theory in computing bending stresses and determination and location of neutral axis	Use of equilibrium equations and completion of derivation of governing equation; specification of different boundary conditions generally used – simply supported, clamped, free	Total strain energy in bars with simple loading conditions – axial loading, torsional loading of a solid circular bar, and transverse loading	simple problems related to bending of beams using Airy's stress function in rectangular coordinates
S-4	SLO-1	principal stresses in 3D (after a quick review in 2D)	Deflection due to unsymmetrical bending; Intro to shear center, determination of shear center for a symmetrical channel section	Solution due to sinusoidal bending load on a simply supported plate– step-by-step explanation	Castigliano's 1st theorem, example problems	Additional problems related to bending of beams using Airy's stress function
S-5	SLO-1	Numerical problems (in 2D and 3D based on the above lectures)	determination of shear center for T, unequal I sections	Numerical problems on thin, flat rectangular plates	brief overview of material non-linearity and plasticity;The complementary energy theorem, and Castigliano's 2nd theorem,	overview of torsion of rectangular cross section structural members, Prandtl stress function for torsion, derivation of Poisson's equation (using Prandtl stress function)
S-6	SLO-1	octahedral normal and shear stresses, definition of strain based on small-displacement theory and strain tensor in Cartesian coordinate system	intro to bending of curved beams	Derivation of governing equation for bending of a flat, thin, axi-symmetric circular plate – outline of procedure - definition of strains, stresses, and moments	example problems using Castigliano's 1st& 2ndtheorems (for linear materials)	Membrane analogy, brief discussion of torsion of rectangular cross section
S-7	SLO-1	strain transformation and principal strains in 3D for linear, homogeneous, isotropic material	Derivation of circumferential stress expression	use of strain-displacement, stress-strain, and equilibrium relations in derivation of governing equation (for bending)	Rayleigh's method, example problem of beam bending deflection	torsional stress in hollow closed thin-walled (single cell) tubes – overview and expressions for shear stress and angle of twist
S-8	SLO-1	Numerical problems on 3D strain computation, transformation, and determination of principal strains	Numerical problems on determination of circumferential stresses (rectangular and square sections)	derivation of equations for displacement, support reactions, and maximum stresses for a uniformly loaded, simply supported circular plate	Rayleigh-Ritz method applied to beams in bending	Stresses due to rotation - Radial and tangential stresses in a disc of uniform thickness – derivation of expression for the stresses due to rotation at a constatnt angular speed; maximum stresses
S-9	SLO-1	equilibrium and compatibility relations in differential form, boundary conditions and St. Venant's principle	Additional numerical problems on determination of circumferential stresses (rectangular and square sections); a brief intro (only) to radial stresses in curved beams	Numerical problems on bending of flat, thin, axi-symmetric circular plates	problems based on Rayleigh-Ritz method	Problems related to computation of Radial and tangential stresses in a rotating disc of uniform thickness based on the previous lecture

Learning Resources	1. *Arthur BoresiandRichardh Schmidt, "Advanced Mechanics of Materials," John Wiley & Sons, 6ed, 2009* 2. *Ansel C. Ugural and Saul K. Fenster,"Advanced Mechanics of Materials and Applied Elasticity," Prentice Hall; 5thed.,2011* 3. *Richard G Budynas, "Advanced Strength and Applied Stress Analysis," McGraw Hill International Editions, 1999* 4. *L. S. Srinath, " Advanced Mechanics of Solids," McGraw Hill Education, 3rd edition, 2017* 5. *S. P. Timoshenko and J N Goodier," Theory of Elasticity," McGraw Hill 2017*	6. *G. T. Mase, R, E, Smelser, and G, E, Mase, "Continuum Mechanics for Engineers," 3rd edition, CRC Press, 2004* 7. *Y. C. Fung, "Foundations of Solid Mechanics," Prentice Hall International, 1965* 8. *Stephan H Crandal, Norman C Dahl, Thomas J Lardner," An Introduction to the Mechanics of Solids," McGraw Hill, 2nd edition,1978* 9. *Robert Cook and Warren Young, "Advanced Mechanics of Materials," Pearson, 2nd edition, 1998*

Learning Assessment											
	Bloom's Level of Thinking	Continuous Learning Assessment (50% weightage)								Final Examination (50% weightage)	
		CLA – 1 (10%)		CLA – 2 (15%)		CLA – 3 (15%)		CLA – 4 (10%)#			
		Theory	Practice	Theory	Practice	Theory	Practice	Theory	Practice	Theory	Practice
Level 1	Remember Understand	40%	-	30%	-	30%	-	30%	-	30%	-
Level 2	Apply Analyze	40%	-	40%	-	40%	-	40%	-	40%	-
Level 3	Evaluate Create	20%	-	30%	-	30%	-	30%	-	30%	-
	Total	100 %		100 %		100 %		100 %		100 %	

CLA – 4 can be from any combination of these: Assignments, Seminars, Tech Talks, Mini-Projects, Case-Studies, Self-Study, MOOCs, Certifications, Conf. Paper etc.,

Course Designers		
Experts from Industry	Experts from Higher Technical Institutions	Internal Experts
1. Dr.R.Kalimuthu, ISRO, Mahendragiri, r_kalimuthu@vssc.gov.in	*1. Dr. Joel George, IIT Madras, joel@ae.iitm.ac.in*	*Dr. S. H. Venkatasubramanian, SRMIST*
2. Dr.A.Velayutham, DRDO, Avadi, velayudham.a@cvrde.drdo.in	*2. Dr.Ranjith Mohan,IIT Madras, ranjith.m@iitm.ac.in*	

Course Code	18MEE307T	Course Name	AUTOMOTIVE ENGINEERING	Course Category	E	Professional Elective	L	T	P	C
							3	0	0	3

Pre-requisite Courses	NIL	Co-requisite Courses	NIL	Progressive Courses	NIL
Course Offering Department	Mechanical Engineering	Data Book / Codes/Standards	NIL		

Course Learning Rationale (CLR):	The purpose of learning this course is to:
CLR-1 :	*Be familiar with the understanding of automotive architecture and performance*
CLR-2 :	*Be familiar with the transmission system*
CLR-3 :	*Know the working of wheels, tyres, and braking system*
CLR-4 :	*Be familiar with the suspension and steering system*
CLR-5 :	*Be familiar with the electrical system and advances in automotive engineering.*
CLR-6 :	*Understand the structure, transmission system, suspension system, steering system, electrical system and working of wheels, tyres in automotive Engineering*

Course Learning Outcomes (CLO):	At the end of this course, learners will be able to:	Learning			Program Learning Outcomes (PLO)														
		1	2	3	1	2	3	4	5	6	7	8	9	10	11	12	13	14	15
		Level of Thinking (Bloom)	Expected Proficiency (%)	Expected Attainment (%)	Engineering Knowledge	Problem Analysis	Design & Development	Analysis, Design, Research	Modern Tool Usage	Society & Culture	Environment & Sustainability	Ethics	Individual & Team Work	Communication	Project Mgt. & Finance	Life Long Learning	PSO - 1	PSO - 2	PSO - 3
CLO-1 :	*Broaden the understanding of automotive architecture and performance*	1&2	90	85	H	L	L	L	M	L	L	L	L	L	L	L	L	H	L
CLO-2 :	*Introduce the transmission system*	1,2&3	90	85	H	L	L	L	M	L	L	L	L	L	L	L	L	H	L
CLO-3 :	*Familiarize about the wheels,tyres,and braking system*	1	90	85	H	L	L	L	M	L	L	L	L	L	L	L	L	H	L
CLO-4 :	*Understand the suspension and steering system*	1,2&3	90	85	H	L	L	L	M	L	L	L	L	L	L	L	L	H	L
CLO-5 :	*Familiarize in electrical system in automotive engineering.*	1,2&3	90	85	H	L	L	L	M	L	L	L	L	L	L	L	L	H	L
CLO-6:	*Familiarize all the systems involved in automotive Engineering*	1,2&3	90	85	H	L		L	M	L	L	L	L	L	L	L	L	L	L

		Automobile Architecture and Performance	Transmission Systems	Wheel, Tyres, and Braking system	Suspension and steering System	Electrical System and Advances in Automotive Engineering
Duration (hour)		9	9	9	9	9
S-1	SLO-1	*Automotive components*	*Clutch types, coil spring and diaphragm type clutch.*	*Types of wheels, construction, wired wheels*	*Types front and rear suspension*	*Battery, general electrical circuits*
S-2	SLO-1	*Subsystem and their position of chassis*	*Single and multi-plate clutch*	*Types, construction, radial, bias tires and belted bias tires*	*Conventional and independent type suspension*	*Dash board instrumentation*
S-3	SLO-1	*Frame and body*	*Centrifugal clutch*	*Slip angle, tread patterns*	*Leaf springs, coil springs, dampers*	*Chip formation and its passenger comfort, safety and security*
S-4	SLO-1	*Front, rear and four wheel drives*	*Gear box types, constant mesh, sliding mesh*	*Tyre retreading cold and hot, tubeless tyres*	*Torsion bars, stabilizers bars, arms ,air suspension system*	*Heating, ventilation and air-conditioning(HVAC), seat belts, air bags*
S-5	SLO-1	*Operation and performance*	*Synchromesh gear box*	*Forces on vehicles, tyre grip*	*Types of steering system, Ackermann principle*	*Automotive electronics, Electronic Control Unit(ECU)*
S-6	SLO-1	*Traction force*	*Layout of gear box, Gear selector and shifting mechanism*	*Load transfer, braking distribution between axles, stopping distance*	*Davis steering gear, steering gear boxes, steering linkages*	*Variable Valve Timing(VVT), Active suspension system (ASS)*
S-7	SLO-1	*Traction resistance*	*Overdrive, automatic transmission*	*Types of brakes, mechanical, hydraulic brakes*	*Introduction to sheet metal working and applications*	*Electronic Brake Distribution(EBD)*
	SLO-2		*Rolling air, gradient resistance*		*Power steering , wheel geometry*	
S-8	SLO-1	*Power required for automobile,*	*Propeller shaft, universal joint, slip joint*	*Air brakes, Disc and Drum brakes*	*Caster, camber toe in,toe out*	*Electronic Stability program (ESP), Traction control System(TCS)*
S-9	SLO-1	*Power required for automobile,*	*Differential and real axle arrangement, hydraulic coupling*	*Engine brakes, antilock braking system*	*Wheel Alignment and balancing*	*Global positioning system(GPS), Electric Hybrid Vehicle*

Learning Resources	1. *Kirpal Singh, " Automobile Engineering", standard publishers; Vol-I & II, 2017* 2. *Ramalingam, K. K," Automobile Engineering", SciTech publications, 2014* 3. *Rajput R K, " A Text book of Automobile Engineering", Laxmi Publications., 2015* 4. *Crouse, W.H and Anglia, D.L "Automotive Mechanics", Tata McGraw Hill, 2005* 5. *Narang, G.B , " Automobile Engineering", khanna publishers, 2001* 6. *Kamaraju Ramakrishna, "Automobile Engineering", PHI Learning Pvt Ltd, 2012.*

Learning Assessment											
	Bloom's Level of Thinking	Continuous Learning Assessment (50% weightage)								Final Examination (50% weightage)	
		CLA – 1 (10%)		CLA – 2 (15%)		CLA – 3 (15%)		CLA – 4 (10%)#			
		Theory	Practice	Theory	Practice	Theory	Practice	Theory	Practice	Theory	Practice
Level 1	Remember Understand	40%	-	30%	-	30%	-	30%	-	30%	-
Level 2	Apply Analyze	40%	-	40%	-	40%	-	40%	-	40%	-
Level 3	Evaluate Create	20%	-	30%	-	30%	-	30%	-	30%	-
	Total	100 %		100 %		100 %		100 %		100 %	

CLA – 4 can be from any combination of these: Assignments, Seminars, Tech Talks, Mini-Projects, Case-Studies, Self-Study, MOOCs, Certifications, Conf. Paper etc.,

Course Designers		
Experts from Industry	Experts from Higher Technical Institutions	Internal Experts
1. Dr.R.Kalimuthu, ISRO, Mahendragiri, r_kalimuthu@vssc.gov.in	*DR. K.L.HARIKRISHNA SSN COLLEGE OF ENGINEERING*	*Mr. C. Subramanian, SRMIST*
2. Dr.A.Velayutham, DRDO, Avadi, velayudham.a@cvrde.drdo.in		*Dr.P.Nandakumar, SRMIST*

Course Code	18MEE308T	Course Name	FOUNDATION SKILLS IN INTEGRARTED PRODUCT DEVELOPMENT	Course Category	E	Professional Elective	L	T	P	C
							3	0	0	3

Pre-requisite Courses	NIL	Co-requisite Courses	NIL	Progressive Courses	NIL
Course Offering Department	Mechanical Engineering	Data Book / Codes/Standards	NIL		

Course Learning Rationale (CLR):	*The purpose of learning this course is to:*
CLR-1 :	*Understand the fundamentals of Product Development*
CLR-2 :	*Understand requirement Engineering and System Design*
CLR-3 :	*Understand Conceptual design*
CLR-4 :	*Understand detail design*
CLR-5 :	*Understand Obsolescence management and IPR*

Course Learning Outcomes (CLO):	*At the end of this course, learners will be able to:*	Learning 1 Level of Thinking (Bloom)	Learning 2 Expected Proficiency (%)	Learning 3 Expected Attainment (%)	PLO 1 Engineering Knowledge	PLO 2 Problem Analysis	PLO 3 Design & Development	PLO 4 Analysis, Design, Research	PLO 5 Modern Tool Usage	PLO 6 Society & Culture	PLO 7 Environment & Sustainability	PLO 8 Ethics	PLO 9 Individual & Team Work	PLO 10 Communication	PLO 11 Project Mgt. & Finance	PLO 12 Life Long Learning	PLO 13 PSO - 1	PLO 14 PSO - 2	PLO 15 PSO - 3
CLO-1 :	*Do global trend and PESTEL analysis*	*1 2&3*	*90*	*85*	*H*		*H*			*H*	*H*		*H*						
CLO-2 :	*Perform requirement Engineering*	*1 2&3*	*90*	*85*	*H*		*H*			*H*	*H*		*H*						
CLO-3 :	*Develop conceptsfor products as solution to engineering problem*	*1 2&3*	*90*	*85*	*H*		*H*			*H*	*H*		*H*						
CLO-4 :	*Perform verification and validation*	*1 2&3*	*90*	*85*	*H*		*H*			*H*	*H*		*H*						
CLO-5 :	*Perform maintenance requirement*	*1 2&3*	*90*	*85*	*H*		*H*			*H*	*H*		*H*						

Duration (hour)		09	09	09	09	09s
S-1	SLO-1	*Global Trends Analysis and Product decision: Types of various trends affecting product decision -Social Trends(Demographic, Behavioral, Psychographic ,*	*Requirement Engineering: Types of Requirements (Functional, Performance, Physical ,Regulatory, Economical, Behavioral);*	*Conceptualization: Industrial Design and User Interface Design*	*System Integration, Testing, Certification and Documentation: Manufacturing/Purchase and Assembly of Systems*	*Sustenance: Maintenance*
S-2	SLO-1	*Economical Trends(Market, Economy, GDP, Income Levels,Spending Pattern, target cost, TCO), Technical Trends(Technology,Applications, Tools, Methods)*	*Types of Requirements (, Technical, Stakeholder, Environmental, Industry specific, Internal-Company Specific)*	*Introduction to Concept generation Techniques*	*Integration of Mechanical, Embedded and S/W systems;*	*Sustenance: Repair; Enhancements.*
S-3	SLO-1	*Environmental Trends(Environmental Regulations and Compliance), Political/Policy Trends,(Regulations, Political Scenario, IP Trends and Company Policies);PESTLE Analysis*	*Requirement Engineering (Gathering (VOC)*	*Concept Screening & Evaluation - Concept Design*	*Introduction to Product verification processes and stages - Industry specific (DFMEA)*	*Product EoL: Obsolescence Management*
S-4	SLO-1	*Introduction to Product Development Methodologies and Management: Overview of Products and Services (Consumer product, Industrial product, Specialty products etc)*	*Analysis (QFD)*	*S/W Architecture, Hardware Schematics and simulation*	*Introduction to Product verification processes and stages - Industry specific (FEA, CFD)*	*Configuration Management; EoL Disposal.*
S-5	SLO-1	*Types of Product Development (NPD/ Re-Engineering (Enhancements, Cost Improvements)/ Reverse Engineering*	*Design Specification*	*Detailed Design: Component Design and Verification*	*Introduction to Product validation processes and stages Industry specific (Sub-system Testing/ Integration Testing*	*The Industry: Engineering Services Industry - overview; PLM,Product development in Industry versus Academia*
S-6	SLO-1	*Design Porting & Homologation);*	*Traceability Matrix and Analysis*	*High Level Design/Low Level Design of S/W Programs, S/W testing;*	*Introduction to Product validation processes and stages Industry specific (Functional Testing/ Performance Testing / Compliance Testing*	*The IPD Essentials: Introduction to vertical specific product development processes*

S-7	SLO-1	*Overview of Product Development methodologies (Over the Wall/ Waterfall/ V-Model/ Stage-Gate Process/ Spiral/Systems Engineering/ Agile)*	*Requirement Management*	*Hardware Schematic, Component design, Layout and Hardware Testing.*	*Product Testing standards and Certification - Industry specific;*	*Product development Trade-offs*
S-8	SLO-1	*Product Life Cycle (S-Curve, Reverse Bathtub Curve)*	*Introduction to System Modeling,System Optimization*	*Prototyping: Types of Prototypes (Mockups, Engineering Assessment Prototype, Alpha, Beta, Gama)*	*Product Documentation (Compliance Documentation, Catalogue, Brochures, user manual)*	*Intellectual Property Rights and Confidentiality*
S-9	SLO-1	*Product Development Planning and Management (Budgeting, Risk, Resources and Design Collaboration) Product Development Planning and Management (Scheduling, Change Management, Product Cost Management)*	*System Specification; Sub-System Design; Interface Design.*	*Introduction to Rapid Prototyping and Rapid Manufacturing*	*Product Documentation (maintenance Manual, Spares Parts List, Warranty, Disposal Guide, IETMS, Web Tools)*	*Security and configuration management.*

Learning Resources	*1. Foundation Skills in Integrated Product Development (FSIPD),Ist Edition,2013, Published by NASSCOM.* *2 .Ulrich, Karl T. and Eppinger, Steven D (2004) Product Design and Development, 5th Edition, McGraw-Hill, 2012.* *3. Kevin N. Otto, "product design – techniques in reverse engineering and new product development", PEARSON, New Delhi, 2011*

Learning Assessment

	Bloom's Level of Thinking	Continuous Learning Assessment (50% weightage)								Final Examination (50% weightage)	
		CLA – 1 (10%)		CLA – 2 (15%)		CLA – 3 (15%)		CLA – 4 (10%)#			
		Theory	Practice	Theory	Practice	Theory	Practice	Theory	Practice	Theory	Practice
Level 1	Remember Understand	40 %	-	30 %	-	30 %	-	30 %	-	30%	-
Level 2	Apply Analyze	40 %	-	40 %	-	40 %	-	40 %	-	40%	-
Level 3	Evaluate Create	20 %	-	30 %	-	30 %	-	30 %	-	30%	-
	Total	100 %		100 %		100 %		100 %		100 %	

CLA – 4 can be from any combination of these: Assignments, Seminars, Tech Talks, Mini-Projects, Case-Studies, Self-Study, MOOCs, Certifications, Conf. Paper etc.,

Course Designers

Experts from Industry	Experts from Higher Technical Institutions	Internal Experts
1. Dr.R.Kalimuthu, ISRO, Mahendragiri, r_kalimuthu@vssc.gov.in	*Dr.R.Prabhusekar, rprabhusekar@mnnit.ac.in, MNNIT Allahabad*	*1. Mr. N. arun, SRM IST*
2. Dr.A.Velayutham, DRDO, Avadi, velayudham.a@cvrde.drdo.in	*Dr. Shanmugam. P, Shanmugam.p@sfl.co.in, Sundaram fasteners, Chennai*	*2. Dr. P. Nandakumar, SRMIST*

Course Code	18MEE309T	Course Name	MODELING SYSTEMS	Course Category	E	Professional Elective	L	T	P	C
							3	0	0	3

Pre-requisite Courses	Nil	Co-requisite Courses	Nil	Progressive Courses	Nil
Course Offering Department	Mechanical Engineering	Data Book / Codes/Standards	Nil		

Course Learning Rationale (CLR):	The purpose of learning this course is to:
CLR-1 :	*Acquire knowledge to model systems seen in reality*
CLR-2 :	*Understand the use of mathematics in modeling*
CLR-3 :	*Understand the basic principles of modeling systems*
CLR-4 :	*Understand and develop simple models*
CLR-5 :	*Understand and recognize that modeling as an interdisciplinary requirement*
CLR-6 :	*Understand and correlate real time problems with mathematical forms*

Course Learning Outcomes (CLO):	At the end of this course, learners will be able to:	Learning 1: Level of Thinking (Bloom)	2: Expected Proficiency (%)	3: Expected Attainment (%)	PLO 1: Engineering Knowledge	2: Problem Analysis	3: Design & Development	4: Analysis, Design, Research	5: Modern Tool Usage	6: Society & Culture	7: Environment & Sustainability	8: Ethics	9: Individual & Team Work	10: Communication	11: Project Mgt. & Finance	12: Life Long Learning	13: PSO - 1	14: PSO - 2	15: PSO - 3
CLO-1 :	*Understand and correlate engineering systems seen in real time environment with the modeling systems*	1&2	90	85	H	H	-	-	-	-	H	-	-	-	-	-	-	-	-
CLO-2 :	*Understand and realize the use of mathematics in modeling engineering systems*	1&2	90	85	H	H	-	-	-	-	-	-	-	-	-	-	-	-	-
CLO-3 :	*Understand and able to convert real time problems into mathematical form*	1&2	90	85	H	H	-	-	-	-	-	-	-	-	-	-	-	-	-
CLO-4 :	*Understand and model various components of engineering systems*	1,2,&3	90	85	H	H	H	H	H	-	-	-	-	-	-	-	-	-	-
CLO-5 :	*Modeling engineering systems such as mechanical systems and thermal systems*	1,2&3	90	85	H	H	H	H	H	-	-	-	-	-	-	-	-	-	-
CLO-6 :	*Understand and recognize that modeling is an interdisciplinary requirement*	1,2	90	85	H	H	-	-	-	-	-	-	-	-	-	-	-	-	-

Duration (hour)		9	9	9	9	9
S-1	SLO-1	*Introduction: Model – Definition, Nature and necessity*	*Use of Modeling Mathematics: Principles of modeling – common aspects of all mechanical systems*	*Generate Simple Models: Introductions to system identification*	*Understanding the Mathematics in Response: Characteristic equation*	*Project: Identify a system*
S-2	SLO-1	*History of modeling*	*Given a simple system – create a model*	*Model mechanical systems - Rectilinear*	*Solution of characteristic equation*	*Objectives of modeling and simulation of a system*
S-3	SLO-1	*Different type of modeling*	*Assessment of reality of the model – degree of accuracy*	*Model mechanical systems - Torsional*	*Introduction to Eigen values – natural frequencies - eigen vectors – mode shapes*	*Identify components*
S-4	SLO-1	*Impact of computers on modeling*	*Quadratic oscillator system and need for this model*	*Model a thermal system*	*Use of Laplace transforms for stability analysis*	*Model components – test each component*
S-5	SLO-1	*Different areas of application – Design, Thermodynamics, Mechanics, Controls etc.*	*Spring mass damper system and need for such a system*	*Response analysis – the reverse engineered explanation*	*Different type of representation of systems*	*Assemble the model*
S-6	SLO-1	*Modeling in software*	*Linearity of springs – modeling*	*Study of response for different inputs – modeling inputs*	*How to analyze for controllability*	*Identify suitable inputs – model them*
S-7	SLO-1	*Introduction to Discrete and continuous systems*	*Modeling damping – different type*	*Time driven models*	*How to analyze for observability, stabilizability*	*Analyze the response to that input*
S-8	SLO-1	*Components of systems*	*Modeling systems – assemble - quadratic*	*Event driven models*	*Conditions for the same*	*Submit a report*
S-9	SLO-1	*Areas of applications*	*Relate mathematics to real system – ODEs, Transforms – solutions*	*Numerical experimentation*	*Relevance of these tests to modeling*	*Presentation and viva voce*

Learning Resources	*1.G. J. Olsder, J. W. van der Woude, J. G. Maks, D. Jeltsema, "Mathematical Systems Theory", VSSD, Leeghwaterstraat, Deelft, Netherlands; 4th Edition, 2011* *2. Polderman J. W., Willems J. C., "Introduction to mathematical theory of systems and control", Springer, 1997*	*. 3 Frank L Severence, "Systems modeling and simulation – An introduction", student edition, 2012.*

Learning Assessment

	Bloom's Level of Thinking	Continuous Learning Assessment (50% weightage)								Final Examination (50% weightage)	
		CLA – 1 (10%)		CLA – 2 (15%)		CLA – 3 (15%)		CLA – 4 (10%)#			
		Theory	Practice	Theory	Practice	Theory	Practice	Theory	Practice	Theory	Practice
Level 1	Remember Understand	40 %	-	30 %	-	30 %	-	30 %	-	30%	-
Level 2	Apply Analyze	40 %	-	40 %	-	40 %	-	40 %	-	40%	-
Level 3	Evaluate Create	20 %	-	30 %	-	30 %	-	30 %	-	30%	-
	Total	100 %		100 %		100 %		100 %		100 %	

CLA – 4 can be from any combination of these: Assignments, Seminars, Tech Talks, Mini-Projects, Case-Studies, Self-Study, MOOCs, Certifications, Conf. Paper etc.,

Course Designers		
Experts from Industry	Experts from Higher Technical Institutions	Internal Experts
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2. Dr.A.Velayutham, DRDO, Avadi, velayudham.a@cvrde.drdo.in		*Dr. P. Nandakumar, SRMIST*

Course Code	18MEE310T	Course Name	HUMAN BODY MECHANICS	Course Category	E	Professional Elective	L	T	P	C
							3	0	0	3

Pre-requisite Courses	Nil	Co-requisite Courses	Nil	Progressive Courses	Nil
Course Offering Department	Mechanical Engineering	Data Book / Codes/Standards	Nil		

Course Learning Rationale (CLR):	*The purpose of learning this course is to:*
CLR-1 :	*Upon learning the students shall understand the fundamentals of biomechanics, joints, tissue overall anatomical structure and their importance.*
CLR-2 :	*Upon learning the students shall understandthe mechanism of the different parts of the human body.*
CLR-3 :	*Upon learning the students shall understandthe musculoskeletal system with tissue loads and responses and neuromuscular control.*
CLR-4 :	*Upon learning the students shall understand kinematics, is the accurate description of motion and is essential to understanding the biomechanics of human motion. Kinematics can range from anatomical descriptions of joint rotations to precise mathematicalmeasurements of musculoskeletal motions.*
CLR-5 :	*Upon learning the students shall understand, the Newton's Laws of Motion in the human body and how these laws can be applied to human motion in the biomechanical principles of Force–Motion, Force–Time, and Coordination ContinuumPrinciples*
CLR-6 :	*Enableunderstanding of the concepts of human body mechanics that illustrate the application of biomechanics principles. These principles are the application for the biomechanical concepts used to improve movement or reduce injury risk*

Course Learning Outcomes (CLO):	*At the end of this course, learners will be able to:*	Learning			Program Learning Outcomes (PLO)														
		1	2	3	1	2	3	4	5	6	7	8	9	10	11	12	13	14	15
		Level of Thinking (Bloom)	Expected Proficiency (%)	Expected Attainment (%)	Engineering Knowledge	Problem Analysis	Design & Development	Analysis, Design, Research	Modern Tool Usage	Society & Culture	Environment & Sustainability	Ethics	Individual & Team Work	Communication	Project Mgt. & Finance	Life Long Learning	PSO - 1	PSO - 2	PSO - 3
CLO-1 :	*Upon learning the students shall understand the fundamentals of biomechanics, joints, tissue overall anatomical structure and their importance.*	*1,2,3*	*90*	*85*	*H*	*H*				*H*		*H*							
CLO-2 :	*Upon learning the students shall understand the mechanism of the different parts of the human body.*	*1,2*	*95*	*90*	*H*	*H*			*H*	*H*	*H*	*H*							
CLO-3 :	*Upon learning the students shall understand themusculoskeletal system with tissue loads and responses and neuromuscular control.*	*1,2,3*	*90*	*85*	*H*	*H*			*H*	*H*	*H*	*H*	*H*			*H*			
CLO-4 :	*Upon learning the students shall understand kinematics, is the accurate description of motion and is essential to understanding the biomechanics of human motion. Kinematics can range from anatomical descriptions of joint rotations to precise mathematicalmeasurements of musculoskeletal motions.*	*1,2,3*	*90*	*85*	*H*	*H*	*H*	*H*	*H*	*H*	*H*		*H*			*H*			
CLO-5 :	*Upon learning the students shall understand, the Newton's Laws of Motion in the human body and how these laws can be applied to human motion in the biomechanical principles of Force–Motion, Force–Time, and Coordination Continuum Principles*	*1,2,3*	*85*	*80*	*H*	*H*		*H*	*H*	*H*	*H*	*H*				*H*			

		Introduction to Biomechanics of Human Movement and Anatomy of Human Body.	Equilibrium and Human Movement	Mechanics of the Musculoskeletal System	Kinematics of Human Movement	Angular Kinetics of Human Movement.
Duration (hour)		9	9	9	9	9
S-1	SLO-1	*Introduction to biomechanics,Importance of Biomechanics, Improving Performance Preventing and Treating Injury*	*Equilibrium and Torque*	*General introduction of tissue and its classifications.*	*Kinematic convention, Proximal, Flexion, Anterior*	*Introduction to angular kinematics in arms for the biceps femoris muscle*
S-2	SLO-1	*Quantitative versus qualitative problems*	*Resultant Joint Torques*	*Response of Tissues to Forces, Stress, Strain, Stiffness and Mechanical Strength, Viscoelasticity*	*absolute spatial reference system for human gait*	*Sample problems on applying forces in optimal direction for maximum torque output*
S-3	SLO-1	*Structure, movements and loads on the shoulder*	*Levers, Anatomical levers*	*Biomechanics of the Passive Muscle–Tendon Unit (MTU)*	*Total description of a body segmentation in space*	*Moment of inertia of a skeleton about a specific axis*
S-4	SLO-1	*Structure, movements and loads on the elbow and wrist*	*Equations of static and dynamic equilibrium*	*Biomechanics of Bone*	*Direct measurement techniques*	*Newton's laws to calculate the net forces and torques acting on body segments.*
S-5	SLO-1	*Structure, movements and loads on the hip*	*Center of gravity and locating the center of gravity*	*Biomechanics of Ligaments*	*Goniometers Eletro goniometer*	*static equilibrium and a reaction board to calculate whole body center of gravity*
S-6	SLO-1	*Structure, movements and loads on the knee*	*Locating the human body Center of Gravity, Stability and balance.*	*Three Mechanical Characteristics*	*Image measurement techniques*	*whole body center of gravity of a high jumper using the*

				of Muscle, Force–Velocity Relationship, Force–Length Relationship, Force–Time Relationship		*segmental method and a three-segment model of the body. Most*
S-7	SLO-1	*Structure, movements and loads on the spine*	*Properties of Bone, Maxwell &Voight Models of bone*	*Stretch-Shortening Cycle (SSC)*	*Cinematography*	*PRINCIPLE OF BALANCE*
S-8	SLO-1	*Structure, movements and loads on the foot*	*Biomechanics of human skeletal muscle.*	*Force–Time Principle*	*Optoelectic techniques*	*two-dimensional area within all supporting Biomechanical system.*
S-9	SLO-1	*Common injuries in shoulder, elbow wrist, hip knee, spine and foot.*	*Biomechanics of human Skeletal Articulations*	*Neuromuscular Control, The Functional Unit of Control: Motor Units, Regulation of Muscle Force, Proprioception of Muscle Action and Movement.*	*Problems on calculating velocities and accelerations*	*The position of the line of gravity relative to the limits of the base of support*

Learning Resources	*1. Susan .J. Hall, "Basic biomechanics", Tata Mcgraw Hill, Sixth edition, 2011.* *2. Y. C. Fung, "Biomechanics", Springer Verlang, 2nd Edition, 1997.* *3. D. J. Schneck and J. D. Bronzino, "Biomechanics- Principles and Applications", CRC Press, Second Edition, 2000* *4. Kreighbaum, E. and Barthels, K., "Biomechanics: A Qualitative Approach for Studying HumanMovement", Pearson, 1996.*	*5. Boston: Allyn and Bacon Alexander. R. Mc. Neill, "Biomechanics", Chapman and Hall, 1975* *6. Fundamentals of Biomechanics by Duane Knudson (Springer)* *7 .Biomechanics and Motor Control of Human Movement By David A. Winter*

Learning Assessment											
	Bloom's Level of Thinking	Continuous Learning Assessment (50% weightage)								Final Examination (50% weightage)	
		CLA – 1 (10%)		CLA – 2 (15%)		CLA – 3 (15%)		CLA – 4 (10%)#			
		Theory	Practice	Theory	Practice	Theory	Practice	Theory	Practice	Theory	Practice
Level 1	Remember Understand	40 %	-	30 %	-	30 %	-	30 %	-	30%	-
Level 2	Apply Analyze	40 %	-	40 %	-	40 %	-	40 %	-	40%	-
Level 3	Evaluate Create	20 %	-	30 %	-	30 %	-	30 %	-	30%	-
	Total	100 %		100 %		100 %		100 %		100 %	

Industrial Expert	Academic expert	Internal Expert
1. Dr.R.Kalimuthu, ISRO, Mahendragiri, r_kalimuthu@vssc.gov.in	*Dr. Amit Roy Roy Chowdhury, IISER Shibpur, amit@aero.iiests.ac.in*	*Dr. Sandipan Roy,SRMIST*
2. Dr.A.Velayutham, DRDO, Avadi, velayudham.a@cvrde.drdo.in		*Dr. P. Nandakumar, SRMIST*

Course Code	18MEE401T	Course Name	DESIGN OF TRANSMISSION SYSTEMS	Course Category	E	Professional Elective	L	T	P	C
							3	0	0	3

Pre-requisite Courses	18MEC308T	Co-requisite Courses	Nil	Progressive Courses	//Course code
Course Offering Department	Department of Mechanical Engineering	Data Book / Codes/Standards		Approved Design Data Book	

Course Learning Rationale (CLR):	*The purpose of learning this course is to:*
CLR-1 :	*Selection of flexible drives*
CLR-2 :	*Design the Parallel gears*
CLR-3 :	*Design the Non-Parallel gears*
CLR-4 :	*Design the gear box*
CLR-5 :	*Selection of bearings*

Course Learning Outcomes (CLO):	*At the end of this course, learners will be able to:*	Learning 1: Level of Thinking (Bloom)	2: Expected Proficiency (%)	3: Expected Attainment (%)	Program Learning Outcomes (PLO) 1: Engineering Knowledge	2: Problem Analysis	3: Design & Development	4: Analysis, Design, Research	5: Modern Tool Usage	6: Society & Culture	7: Environment & Sustainability	8: Ethics	9: Individual & Team Work	10: Communication	11: Project Mgt. & Finance	12: Life Long Learning	13: PSO - 1	14: PSO - 2	15: PSO - 3
CLO-1 :	*Select the flat belt, V-belt, chain and wire ropes*	*1,2,3*	*90*	*85*	*H*	*H*	*H*	*M*	*M*	*L*	*H*	*L*	*M*	*L*	*M*	*M*	*L*	*H*	*L*
CLO-2 :	*Design the spur gear and helical gear*	*1,2,3*	*90*	*85*	*H*	*H*	*H*	*M*	*M*	*L*	*H*	*L*	*M*	*L*	*M*	*M*	*L*	*H*	*L*
CLO-3 :	*Design the bevel gear and worm gear*	*1,2,3*	*90*	*85*	*H*	*H*	*H*	*M*	*M*	*L*	*H*	*L*	*M*	*L*	*M*	*M*	*L*	*H*	*L*
CLO-4 :	*Design the multi speed gear box for machine tool applications*	*1,2,3*	*90*	*85*	*H*	*H*	*H*	*M*	*M*	*L*	*H*	*L*	*M*	*L*	*M*	*M*	*L*	*H*	*L*
CLO-5 :	*Select the journal bearing, ball bearings, roller bearings and deep grove bearings*	*1,2,3*	*90*	*85*	*H*	*H*	*H*	*M*	*M*	*L*	*H*	*L*	*M*	*L*	*M*	*M*	*L*	*H*	*L*

		Flexible Drives	Parallel Gears	Non-Parallel Gears	Gear Boxes	Bearings
Duration (hour)		9	9	9	9	9
S-1	SLO-1	*Belt drives: types, selection of belt drives*	*Review of gear fundamentals, Forces and stresses in geartooth*	*Straight bevel gear: Terminology*	*Geometric progression, standard step ratio,structural andray diagrams Number of teeth calculation*	*Introduction of Hydrodynamic journal bearings*
	SLO-2	*Belt materials and applications*	*Equivalent number of teeth, gear tooth failures, Selection of gear materials*	*Forces and stresses on gear tooth*		*Sommerfeld Number, Raimondi and Boyd graphs*
S-2	SLO-1	*Selection of flat belt drives using fundamental equations*	*Design procedure on spur gear based on strength consideration*	*Design procedure on bevel gear based on strength consideration*	*Design procedure on sliding mesh gear box*	*Bearing materials, properties required for bearing materials, System of lubrication*
	SLO-2	*problems on flat belt drives using fundamental equations*	*Problems on spur gear based onstrength consideration*	*Problems on bevel gear based onstrength consideration*	*problems on sliding mesh gear box*	
S-3	SLO-1	*Selection procedure for flat belt drives using manufacturer's data*	*Problems on spur gear based onstrength consideration*	*Problems on bevel gear based onstrength consideration*	*problems on sliding mesh gear box*	*Selection procedure for journal bearing*
	SLO-2	*Problems on flat belt drives using manufacturer's data*				
S-4	SLO-1	*Selection procedure for V-belt drives using fundamental equations*	*Design procedure on spur gear based on wear consideration*	*Design procedure on bevel gear based on wear consideration*	*Design procedure on constant mesh gear box*	*Problems injournal bearings*
	SLO-2	*Problemson V-belt drives using fundamental equations*	*Problems on spur gear based onwear consideration*	*Problems on bevel gear based onwear consideration*	*Problems on constant mesh gearbox*	
S-5	SLO-1	*Selection procedure for V-belt drives using manufacturer's data*	*Problems on spur gear based onwear consideration*	*Problems on bevel gear based onwear consideration*	*Design of Multi speed gear box for machine toolapplications*	*Introduction to Roller contact bearings*
	SLO-2	*Problems on V-belt drives usingmanufacturer's data*				
S-6	SLO-1	*Wire ropes: types, construction and Selection of wire ropes*	*Design procedure on helical gear based on strength consideration*	*Worm gear: Thermal capacity, efficiency, forces andstresses*	*Design of Multi speed gear box for machine toolapplications*	*Types of bearing, Load rating, bearing materials and bearing failure*

	SLO-2	*Stresses in wire ropes*	*Problems on helical gear based onstrength consideration*	*Design procedure on worm gear based onstrength consideration*		
S-7	SLO-1	*Selection procedure for wire ropes*	*Problems on helical gear based onstrength consideration*	*problems on worm gear based onstrength consideration*	*Variable speed gear box*	*Selection of bearing*
	SLO-2	*Problems on wire ropes*				
S-8	SLO-1	*Power transmission chains: types and applications*	*Design procedure on helical gear based on wear consideration*	*Design procedure on worm gear based on wear consideration*	*Fluid couplings*	*Problems in ball bearing*
	SLO-2		*Problems on helical gear based onwear consideration*	*Problems on worm gear based onwear consideration*		
S-9	SLO-1	*Selection procedure on power transmission chains and sprockets*	*Problems on helical gear based onwear consideration*	*Problems on worm gear based onwear consideration*	*Torque convertor for automotive applications*	*Problems in roller bearing*
	SLO-2	*Problems on power transmission chains and sprockets*				

Learning Resources	*1. Robert. C. Juvinall, Kurt. M. Marshek, "Fundamentals of Machine Component Design", John Wiley&sons, 6th Edition, 2017.* *2. Joseph Edward Shigley and Charles R. Mischke, "Mechanical Engineering Design", McGraw –HillInternational Editions, New York, 10th Edition, 2014.* *3. Spotts, M.F., Shoup, T.E., Hornberger, L.E., "Design of Machine Elements", Prentice Hall of IndiaEighth Edition, 2004.* *4. Paul H Black and O. E. Adams, P., "Machine Design", 3rd edition, Mc Graw Hill Book Company, Inc.,New York, USA, 2007.* *5. Bernard Hamrock, Steven Schmid, Bo Jacobson, "Fundamentals of Machine Elements", 2nd Edition,Tata McGraw-Hill Book Co., 2006.* *6. Dr. Sadhu Singh, "Design of Machine Elements (Machine Design)", Khanna Publishers; Fifth edition (1987).* *7. KhurmiR.S ,Gupta J.M., "A text book of machine design", S.Chand&Company Ltd, 25th revised edition, 2005.* *8. P.S.G Tech..,"Design Data Book", KalaikathirAchchagam, 2012*

Learning Assessment

	Bloom's Level of Thinking	Continuous Learning Assessment (50% weightage)								Final Examination (50% weightage)	
		CLA – 1 (10%)		CLA – 2 (15%)		CLA – 3 (15%)		CLA – 4 (10%)#			
		Theory	Practice	Theory	Practice	Theory	Practice	Theory	Practice	Theory	Practice
Level 1	Remember Understand	40 %	-	30 %	-	30 %	-	30 %	-	30%	-
Level 2	Apply Analyze	40 %	-	40 %	-	40 %	-	40 %	-	40%	-
Level 3	Evaluate Create	20 %	-	30 %	-	30 %	-	30 %	-	30%	-
	Total	100 %		100 %		100 %		100 %		100 %	

CLA – 4 can be from any combination of these: Assignments, Seminars, Tech Talks, Mini-Projects, Case-Studies, Self-Study, MOOCs, Certifications, Conf. Paper etc.,

Course Designers

Experts from Industry	Experts from Higher Technical Institutions	Internal Experts
1. Dr.R.Kalimuthu, ISRO, Mahendragiri, r_kalimuthu@vssc.gov.in	*Mr. Vignesh Shanmugam.s Hyundai Motors India Limited, Irungattukottai – 602117.E mail – 273357@hmil.net*	*Mr. D. Raja, SRM IST*
2. Dr.A.Velayutham, DRDO, Avadi, velayudham.a@cvrde.drdo.in	*Dr. Davidson Jebaseelan, davidson.jd@vit.ac.in VIT, Chennai*	*Dr. P. Nandakumar, SRMIST*

Course Code	18MEE402T	Course Name	OPTIMIZATION IN ENGINEERING DESIGN	Course Category	E	Professional elective	L	T	P	C
							2	1	0	3

Pre-requisite Courses	NIL	Co-requisite Courses	NIL	Progressive Courses	NIL
Course Offering Department	Mechanical Engineering	Data Book / Codes/Standards	Approved design data book		

Course Learning Rationale (CLR):	*The purpose of learning this course is to:*
CLR-1 :	*Be familiar with principles of optimization and its need*
CLR-2 :	*Be familiar with various conventional optimization techniques*
CLR-3 :	*Be familiar with Solving multivariable problems techniques*
CLR-4 :	*Be familiar with Solving problems using unconventional optimization techniques*
CLR-5 :	*Be familiar with Application of optimization to design of machine elements.*

Course Learning Outcomes (CLO):	*At the end of this course, learners will be able to:*	Learning			Program Learning Outcomes (PLO)														
		1	2	3	1	2	3	4	5	6	7	8	9	10	11	12	13	14	15
		Level of Thinking (Bloom)	Expected Proficiency (%)	Expected Attainment (%)	Engineering Knowledge	Problem Analysis	Design & Development	Analysis, Design, Research	Modern Tool Usage	Society & Culture	Environment & Sustainability	Ethics	Individual & Team Work	Communication	Project Mgt. & Finance	Life Long Learning	PSO - 1	PSO - 2	PSO - 3
CLO-1 :	*understand optimization principles and its need*	*1& 2*	*90*	*85*	*H*														
CLO-2 :	*understand and apply the concept of conventional optimization techniques*	*1&2*	*90*	*85*	*H*	*H*													
CLO-3 :	*understand and apply the concept of constrained in single variable as well as multivariable*	*1&2*	*90*	*85*	*H*	*H*													
CLO-4 :	*understand and apply the concept unconventional optimization techniques*	*1&2,3*	*90*	*85*	*H*	*H*		*H*											
CLO-5 :	*apply the methods of optimization in real life situation*	*1&2,3*	*90*	*85*	*H*	*H*	*H*	*H*											

		Introduction to optimization	Unconstrained optimization techniques	Constrained optimization techniques	Modern Methods of Optimization	Applications
Duration(hour)		9	9	9	9	9
S-1	SLO-1	*Introduction to optimization: adequate and optimum design*	*Techniques of unconstrained optimization*	*Direct search methods: Random jumping method, Random walk method*	*Genetic Algorithm Introduction*	*Design optimizationof springs*
S-2	SLO-1	*Principles of optimization,design vector, design constraints*	*Golden section method.*	*Tutorials on Random Jumping Method*	*Basic elements of natural genetics—reproduction, crossover, and mutation*	*Design vector for springs*
S-3	SLO-1	*Statement of an optimization problem*	*Fibonacci method*	*Tutorials on Random Walk Method*	*The computational procedure involved in optimizing the fitness function in genetic algorithm*	*Objective function for springs*
S-4	SLO-1	*Formulation of objective function*	*Random search*	*Direct search methods: conjugate gradient method, quasi-Newton methods*	*Tutorials on Genetic Algorithm*	*Design optimizationof shafts and torsionally loaded members.*
S-5	SLO-1	*Design constraints*	*Random search*	*Tutorial on conjugate gradient method*	*Simulated Annealing: Introduction*	*Design vectors for torsionally loaded members*
S-6	SLO-1	*Classical optimization techniques: single variable*	*Pattern search*	*Indirect methods –Penalty function method*	*Simulated Annealing - Steps involved*	*Objective function fortorsionally loaded members*
S-7	SLO-1	*Classical optimization techniques: single variable*	*Gradient search*	*Indirect methods –Penalty function method problems*	*Ant colony optimization: Basic Concept*	*Design optimization of simple truss members*
S-8	SLO-1	*Classical optimization techniques: multivariable*	*Quadratic interpolation method*	*Interior penalty function method*	*Ant colony optimization: Ant Searching Behavior*	*Design vectors forsimple truss members*
S-9	SLO-1	*Classical optimization techniques multivariable*	*Cubic interpolation method*	*Exterior penalty function method*	*Graphical representation of the Ant colonyoptimization process*	*Objective function for simple truss members*

Learning Resources	1. *Rao Singaresu.S, "Engineering Optimization – Theory & Practice", New Age International (P) Limited, New Delhi, 2009.* 2. *Kalyanamoy Deb, "Optimization for Engineering design algorithms and Examples", Prentice Hall of India Pvt. Ltd., 2006.* 3. *Johnson Ray C, "Optimum design of mechanical elements", Wiley, John & Sons, Digitized 2007* 4. *Goldberg .D.E, "Genetic algorithms in search, optimization and machine", Barnen, AddisonWesley, New York, 1989.* 5. *William Orthwein, "Machine Component Design", Vol. I and II, Jaico Publishing house, New Edition, 2006.* 6. *Rao.C.S, "Optimization Techniques", DhanpatRai& Sons, New Delhi* 7. *Fox.R.L, "Optimization methods for Engineering Design", Addison Wesley Pub, Digitized 2007.* 8. *Garret N. Vanderplaats, "Numerical optimization techniques for engineering", McGraw-Hill Ryerson, Limited, 1984.*

Learning Assessment

	Bloom's Level of Thinking	Continuous Learning Assessment (50% weightage)								Final Examination (50% weightage)	
		CLA – 1 (10%)		CLA – 2 (15%)		CLA – 3 (15%)		CLA – 4 (10%)#			
		Theory	Practice	Theory	Practice	Theory	Practice	Theory	Practice	Theory	Practice
Level 1	Remember Understand	40 %	-	30 %	-	30 %	-	30 %	-	30%	-
Level 2	Apply Analyze	40 %	-	40 %	-	40 %	-	40 %	-	40%	-
Level 3	Evaluate Create	20 %	-	30 %	-	30 %	-	30 %	-	30%	-
	Total	100 %		100 %		100 %		100 %		100 %	

CLA – 4 can be from any combination of these: Assignments, Seminars, Tech Talks, Mini-Projects, Case-Studies, Self-Study, MOOCs, Certifications, Conf. Paper etc.,

Course Designers		
Experts from Industry	Experts from Higher Technical Institutions	Internal Experts
1. Dr.R.Kalimuthu, ISRO, Mahendragiri, r_kalimuthu@vssc.gov.in	*DR. SUBHAS GANGULY, sganguly.met@nitrr.ac.in* *NIT Raipur*	*Vamsi krishna dommeti SRMIST*
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Course Code	18MEE403T	Course Name	TOOL ENGINEERING DESIGN	Course Category	E	Professional Elective	L	T	P	C
							3	0	0	3

Pre-requisite Courses	Nil	Co-requisite Courses	Nil	Progressive Courses	Nil
Course Offering Department	Mechanical Engineering	Data Book / Codes/Standards	Nil		

Course Learning Rationale (CLR):	*The purpose of learning this course is to:*
CLR-1 :	*Be familiar with tool materials and their properties*
CLR-2 :	*Be familiar with the design of single point cutting tools and twist drills*
CLR-3 :	*Be familiar with the design of various types of dies*
CLR-4 :	*Be familiar with the blank development for different components*
CLR-5 :	*Be familiar with the design of jigs and fixtures for simple components*

Course Learning Outcomes (CLO):	*At the end of this course, learners will be able to:*	Learning 1: Level of Thinking (Bloom)	Learning 2: Expected Proficiency (%)	Learning 3: Expected Attainment (%)
CLO-1 :	*Identify suitable tool materials for the specific manufacturing applications*	*1&2*	*85*	*80*
CLO-2 :	*Design single point cutting tools and twist drill for different machining requirements*	*2&3*	*85*	*80*
CLO-3 :	*Design various types of dies for manufacturing components*	*2&3*	*85*	*80*
CLO-4 :	*Develop the blank for cylindrical and non-cylindrical shells*	*2&3*	*85*	*80*
CLO-5 :	*Design and develop the jigs and fixtures for simple mechanical components*	*2&3*	*85*	*80*

Program Learning Outcomes (PLO)

	1 Engineering Knowledge	2 Problem Analysis	3 Design & Development	4 Analysis, Design, Research	5 Modern Tool Usage	6 Society & Culture	7 Environment & Sustainability	8 Ethics	9 Individual & Team Work	10 Communication	11 Project Mgt. & Finance	12 Life Long Learning	13 PSO - 1	14 PSO - 2	15 PSO - 3
CLO-1	*H*	*L*	*M*	*M*	-	-	-	-	*M*	-	-	-	*H*	*L*	*H*
CLO-2	*H*	*M*	*M*	*M*	-	-	-	-	*M*	-	-	-	*H*	*L*	*H*
CLO-3	*H*	*H*	*H*	*M*	-	-	-	-	*M*	-	-	-	*H*	*L*	*H*
CLO-4	*H*	*H*	*H*	*L*	-	-	-	-	*M*	-	-	-	*H*	*L*	*H*
CLO-5	*H*	*H*	*H*	*H*	-	-	-	-	*M*	-	-	-	*H*	*L*	*H*

Duration (hour)		9	9	9	9	9
S-1	SLO-1	*Different types of tool materials: cemented carbides, coatedcarbides, cermets,*	*Press working terminology*	*Principles of jigs and fixtures*	*Design principles of fixtures*	*Case study in jigs*
S-2	SLO-1	*ceramics and polycrystalline and new tool materials*	*Different types of Presses and press accessories*	*Locating principles and different locating elements*	*Design of fixtures for milling operation*	*Case study in jigs*
S-3	SLO-1	*Composition and properties of tool materials*	*Computation of capacities and tonnage requirements ofpresses*	*Clamping principles, clamping devices and types in jigs*	*Design of fixtures for boring operation*	*Case study in jigs*
S-4	SLO-1	*Cutting tool selection and treatments*	*Various types of Strip layout*	*Analysis of clamping force*	*Design of fixtures for broaching & grinding operation*	*Case study in fixture*
S-5	SLO-1	*Design of single point turning tools and multipoint tools*	*Different types of dies, Progressive dies, Combination diesand compound dies*	*Function of drill bush, types drill bushes*	*Design of fixture for assembly*	*Case study in fixture*
S-6	SLO-1	*Problems on the design of single point cutting tool alone*	*Design and development of various types of cutting, forming,bending and drawing dies*	*Different types of jigs , Plate jig, latch jig, channel jig,*	*Design of fixture for inspection*	*Case study in fixture*
S-7	SLO-1	*Selection of tool holders and inserts for turning*	*Design and development of various types of cutting, forming,bending and drawing dies*	*Different types of jigs Post jig, angle plate jig, turn over jig, and pot jigs*	*Design of fixture for welding*	*Case study in press tools*
S-8	SLO-1	*Function of Chip breaker, types of chip breaker*	*Blank development for cylindrical and non-cylindrical shells, blank size calculation*	*Design and development of jigs for given components*	*Design and development of fixtures for given components*	*Case study in press tools*
S-9	SLO-1	*Design of twist drill and reamers*	*Forging dies basics and materials for forging dies*	*Design and development of jigs for given components*	*Design and development of fixtures for given components*	*Case study in press tools*

Learning Resources	1. *Sadasivan.T.A, and Sarathy.D, "Cutting tools for Productive machining", 1st edition, Widia (India) Ltd, Bangalore, 1999.* 2. *Donaldson.C, Lecain.G.H and Goold.V.C, "Tool Design", Tata McGraw Hill publishing company limited, New Delhi, 2002* 3. *Edward G. Hoffman, "Jigs and Fixture design", 2nd edition, Galgotia publication Pvt. Ltd., New Delhi,1987* 4. *Hiram E. Grant, "Jigs and Fixtures - Nonstandard clamping device", Tata McGraw Hill, New Delhi, 1971.* 5. *Prakash H. Joshi, "Press tool design and construction", 1st edition, Wheeler Publishing, New Delhi, 2000.* 6. *Kempster.M.H.A, "An Introduction to Jig and tool design", 3rd edition, ELBS, 1987* 7. *Prakash H. Joshi, "Cutting tools", 1st edition, Wheeler Publishing, New Delhi, 1997.* 8. *Prakash H. Joshi, "Tooling Data", 1st edition, Wheeler Publishing, New Delhi, 2000.*

Learning Assessment

	Bloom's Level of Thinking	Continuous Learning Assessment (50% weightage)								Final Examination (50% weightage)	
		CLA – 1 (10%)		CLA – 2 (15%)		CLA – 3 (15%)		CLA – 4 (10%)#			
		Theory	Practice	Theory	Practice	Theory	Practice	Theory	Practice	Theory	Practice
Level 1	Remember Understand	40 %	-	30 %	-	30 %	-	30 %	-	30%	-
Level 2	Apply Analyze	40 %	-	40 %	-	40 %	-	40 %	-	40%	-
Level 3	Evaluate Create	20 %	-	30 %	-	30 %	-	30 %	-	30%	-
	Total	100 %		100 %		100 %		100 %		100 %	

CLA – 4 can be from any combination of these: Assignments, Seminars, Tech Talks, Mini-Projects, Case-Studies, Self-Study, MOOCs, Certifications, Conf. Paper etc.,

Course Designers

Experts from Industry	Experts from Higher Technical Institutions	Internal Experts
1. Mr. S.Bhargav, GM,Rane Brake, Trichy	*1. Dr. V.Srinivasan,Annamalai University, srinivraghavan@yahoo.com*	*1. Mr.V.G.Umasekar, SRMIST*
2. Dr. Muthumanikkam, Jt. Director, CVRDE, DRDO,Avadi,Chennai.	*2.Dr.Assaithambi, Govn. Col.of. Eng,sengipatti,Thanjavur, basaithambi@gcetj.edu.in*	*Dr. U. M. Iqbal, SRMIST*

Course Code	18MEE404T	Course Name	COMPUTER GRAPHICS	Course Category	E	Professional Elective	L	T	P	C
							3	0	0	3

Pre-requisite Courses	NIL	Co-requisite Courses	NIL	Progressive Courses	NIL
Course Offering Department	Mechanical Engineering	Data Book / Codes/Standards	NIL		

Course Learning Rationale (CLR):	*The purpose of learning this course is to:*
CLR-1 :	*Be familiar with the basics of computer graphics and transformations*
CLR-2 :	*Be familiar with the special curvesand their parametric representation*
CLR-3 :	*Be familiar with the surface modeling techniques and their mathematical representation*
CLR-4 :	*Be familiar with the three dimensional graphics techniques*
CLR-5 :	*Be familiar with the graphics and Communication standards*
CLR-6 :	*Be familiar with the computer graphics and various modeling techniques*

Course Learning Outcomes (CLO):	*At the end of this course, learners will be able to:*	Learning 1: Level of Thinking (Bloom)	Learning 2: Expected Proficiency (%)	Learning 3: Expected Attainment (%)	PLO 1: Engineering Knowledge	PLO 2: Problem Analysis	PLO 3: Design & Development	PLO 4: Analysis, Design, Research	PLO 5: Modern Tool Usage	PLO 6: Society & Culture	PLO 7: Environment & Sustainability	PLO 8: Ethics	PLO 9: Individual & Team Work	PLO 10: Communication	PLO 11: Project Mgt. & Finance	PLO 12: Life Long Learning	PLO 13: PSO - 1	PLO 14: PSO - 2	PLO 15: PSO - 3
CLO-1 :	*Understand about computer graphics and basic transformations*	*1*	*90*	*85*	*H*	*L*	*M*	*L*	*L*	*L*	*L*	*L*	*L*	*L*	*L*	*L*	*L*	*L*	*L*
CLO-2 :	*Acquire knowledge on special curves and their parametric representation*	*1&2*	*90*	*85*	*H*	*L*	*H*	*M*	*L*	*L*	*L*	*L*	*L*	*L*	*L*	*L*	*L*	*L*	*L*
CLO-3 :	*Understand the various surface modeling techniques and their mathematical representation*	*1&2*	*90*	*85*	*H*	*M*	*H*	*M*	*M*	*L*	*L*	*L*	*L*	*L*	*L*	*L*	*L*	*L*	*L*
CLO-4 :	*Understand the three dimensional modeling techniques and apply these techniques to develop new products*	*1&2*	*90*	*85*	*H*	*M*	*H*	*M*	*M*	*L*	*L*	*L*	*L*	*L*	*L*	*L*	*L*	*L*	*L*
CLO-5 :	*Acquire knowledge on data exchange and Communication standards*	*1&3*	*90*	*85*	*H*	*M*	*L*	*M*	*L*	*L*	*L*	*L*	*L*	*L*	*L*	*L*	*L*	*L*	*L*
CLO-6 :	*Understand about computer graphics and various modeling techniques*																		

		Introduction to Computer Graphics	Special Curves	Surface modeling	Three Dimensional computer graphics	Graphics and Communication standards
Duration (hour)		9	9	9	9	9
S-1	SLO-1	*Origin of computer Graphics*	*Introduction of Curve representation*	*Introduction of Surface modeling techniques*	*Boundary representation (B-rep)*	*Graphics and data exchange standards*
S-2	SLO-1	*Interactive graphics display*	*Introduction to Bezier curve*	*Coonspatch*	*Basic elements and building operations*	*Graphical Kernel System*
S-3	SLO-1	*Video Display devices*	*Parametric representation of Bezier curve*	*Mathematical representation and boundaries of Coons patch*	*Constructive solid geometry (CSG)*	*Bit maps*
S-4	SLO-1	*Types of Display devices*	*Introduction toCubic spline curve*	*Bi-Cubic patch*	*Basic elements and Building operations*	*open GL (graphics library)*
S-5	SLO-1	*Algorithm for line, circle*	*Parametric representation of Cubic spline curve*	*Mathematical representation of Bi-Cubic patch*	*Viewing transformations*	*Data exchange standards (IGES)*
S-6	SLO-1	*2D transformation (scaling, rotation, translation)*	*Introduction toB-Spline curve*	*Bezier surface*	*Clipping operations*	*STEP and CALLS*
S-7	SLO-1	*3D transformation scaling &rotation*	*Parametric representation of B-Spline curve*	*Mathematical representation of Bezier surface*	*Hidden line removal for curved surfaces*	*DXF Standard and STL*
S-8	SLO-1	*3D transformation Translation*	*Introduction toRotational curves*	*B-Spline surface*	*Algorithms for shading*	*Communication standards, LAN*
S-9	SLO-1	*Concatenation transformations*	*Parametric representation of Rotational curves*	*Mathematical representation of B spline surface*	*Algorithms for rendering*	*Communication standards, WAN*

Learning Resources	1. Donald Hearn and Pauline Baker M. "Computer Graphics", Prentice Hall, Inc., 2009 2. Ibrahim Zeid"CAD/Cam Theory and Practice", McGraw Hill, International Edition, 2010. 3. Harington, Stevan, "Computer Graphics: A Programming Approach", McGraw Hill, 1983 4. Plastock, Roy A., &Kally, "Theory and Problems of Computer Graphics", McGraw Hill, 1986

Learning Assessment

	Bloom's Level of Thinking	Continuous Learning Assessment (50% weightage)								Final Examination (50% weightage)	
		CLA – 1 (10%)		CLA – 2 (15%)		CLA – 3 (15%)		CLA – 4 (10%)#			
		Theory	Practice	Theory	Practice	Theory	Practice	Theory	Practice	Theory	Practice
Level 1	Remember Understand	40 %	-	30 %	-	30 %	-	30 %	-	30%	-
Level 2	Apply Analyze	40 %	-	40 %	-	40 %	-	40 %	-	40%	-
Level 3	Evaluate Create	20 %	-	30 %	-	30 %	-	30 %	-	30%	-
	Total	100 %		100 %		100 %		100 %		100 %	

CLA – 4 can be from any combination of these: Assignments, Seminars, Tech Talks, Mini-Projects, Case-Studies, Self-Study, MOOCs, Certifications, Conf. Paper etc.,

Course Designers		
Experts from Industry	Experts from Higher Technical Institutions	Internal Experts
1. Dr.R.Kalimuthu, ISRO, Mahendragiri, r_kalimuthu@vssc.gov.in	*Dr. Davidson Jebaseelan, davidson.jd@vit.ac.in, VIT Chennai*	*Mr.S.ArunPrasath, SRMIST*
2. A. Don Bosco, Valeo, Chennai	*S.DineshBabu, Renault Nissan Technology, Chennai*	*Mr.R.Yogeswaran, SRMIST*

Course Code	18MEE405T	Course Name	FATIGUE, FRACTURE MECHANICS AND CREEP	Course Category	E	Professional Elective	L	T	P	C
							3	0	0	3

Pre-requisite Courses	NIL	Co-requisite Courses	NIL	Progressive Courses	NIL
Course Offering Department	Mechanical Engineering	Data Book / Codes/Standards	NIL		

Course Learning Rationale (CLR):	*The purpose of learning this course is to:*
CLR-1 :	*Be familiar with fatigue crack propagation and micromechanisms of fatigue*
CLR-2 :	*Be familiar with the concepts of environmentally assisted cracking in metals*
CLR-3 :	*Know about fracture mechanics and stress intensity factors*
CLR-4 :	*Know about deformation at crack tip, crack tip opening displacement, crack initiation and growth*
CLR-5 :	*Be familiar with characteristics, mechanisms, effects and considerations of creep*

		Learning			Program Learning Outcomes (PLO)														
		1	2	3	1	2	3	4	5	6	7	8	9	10	11	12	13	14	15
Course Learning Outcomes (CLO):	*At the end of this course, learners will be able to:*	Level of Thinking (Bloom)	Expected Proficiency (%)	Expected Attainment (%)	Engineering Knowledge	Problem Analysis	Design & Development	Analysis, Design, Research	Modern Tool Usage	Society & Culture	Environment & Sustainability	Ethics	Individual & Team Work	Communication	Project Mgt. & Finance	Life Long Learning	PSO - 1	PSO - 2	PSO - 3
CLO-1 :	*Recognize and analyze fatigue crack propagation, crack closure, fatigue threshold, variable amplitude loading and retardation and micromechanisms of fatigue*	*1&2*	*90*	*85*	*H*	*H*	-	-	-	-	-	-	-	-	-	-	-	-	-
CLO-2 :	*Appreciate the knowledge on environmentally assisted cracking,stress corrosion, hydrogen embrittlement and corrosion fatigue in metals*	*1&2*	*90*	*85*	*H*	-	-	-	-	-	*H*	-	-	-	-	-	-	-	-
CLO-3 :	*Understand fracture mechanics and acquire knowledge on energy release rate, stress intensity factors of simple and complex cases*	*1& 2*	*90*	*85*	*H*	*H*	-	-	-	-	-	-	-	-	-	-	-	-	-
CLO-4 :	*Acquire knowledge onanelastic deformation at the crack tip, J-integral, crack tip opening displacement and mixed mode crack initiation and growth*	*1&2*	*90*	*85*	*H*	*H*	-	-	-	-	-	-	-	-	-	-	-	-	-
CLO-5 :	*Understand characteristics of creep and acquire knowledge on mechanisms, tests, interactions, temperature effects, materials and design considerations of creep*	*1&2*	*90*	*85*	*H*	*H*	-	-	-	-	-	-	-	-	-	-	-	-	-

Duration (hour)		9	9	9	9	9
S-1	SLO-1	*Fatigue crack propagation, similitude in Fatigue*	*Introduction to environmentally assisted cracking in metals, Corrosion principles: electrochemical reactions*	*Introduction to fracture mechanics: Kinds of failure, brittle and ductile fracture, modes of fracture failure*	*Anelastic deformation at crack tip: approximate shape and size of plastic zone*	*Introduction to creep, characteristics of creep*
S-2	SLO-1	*Empirical fatigue crack growth equations*	*Corrosion current and polarization, electrode potential and passivity, cathodic protection*	*Energy release rate: Griffith's dilemma, surface energy, Griffith's analysis, mathematical formulation, compliance approach, strain energy approach*	*Anelastic deformation at crack tip: effective crack length, effect of plate thickness*	*Mechanisms of creep: dislocation creep, diffusion creep, grain boundary sliding, Creep deformation mechanism maps*
S-3	SLO-1	*Crack closure, closer look at crack-wedging mechanisms, loading variables on closure*	*Environmentally assisted cracking (EAC) overview: Cracking mechanisms*	*Energy release rate: anelastic deformation at crack tip, thin plate vs thick plate*	*Definition of J-Integral, path independence, stress-strain relation*	*Creep under multiaxial loading, combined stresses, stress relaxation*
S-4	SLO-1	*The fatigue threshold: a two-criterion model, threshold behavior in inert environments*	*Crack growth rate vs applied stress intensity, threshold for EAC, small crack effects*	*Energy release rate: crack resistance, stable and unstable crack growth, critical energy release rate*	*Further discussion on J-integral from a designer's point of view, critical J-integral, safety or failure*	*Creep-fatigue interaction, creep fractures*
S-5	SLO-1	*Variable amplitude loading and retardation: reverse plasticity at crack tip, the effect of overloads and underloads*	*Static, cyclic and fluctuating loads, cracking morphology, life prediction*	*Introduction to Stress intensity factors, Investigations closer to crack tip, LEFM*	*J-Integral: engineers approach, simplified relation, applications*	*Creep test, stress rupture test, representation of creep rupture data*
S-6	SLO-1	*Models for retardation and variable amplitude fatigue*	*Stress corrosion cracking, film rupture model*	*Stress intensity factor: Stress and displacement fields in isotropic elastic materials, field equations*	*Introduction to CTOD, relationship between CTOD, K_I and G_I, Equivalence between CTOD and J*	*Creep and Stress Rupture: Deformation and fracture at Elevated Temperature*
S-7	SLO-1	*Growth of short cracks: microstructural and mechanical*	*Crack growth rate in stage II, corrosion product wedging*	*Stress intensity factor: Westergaard's approach, Mode I (opening mode), Mode II (sliding mode), Mode III (tearing mode)*	*Introduction to mixed mode crack initiation and growth*	*Theories of low and high temperature creep*

S-8	SLO-1	*Micromechanisms of fatigue: Fatigue in region II, micromechanisms near the threshold*	*Hydrogen embrittlement, cracking mechanisms, Variables that effect cracking behavior: load, hydrogen, temperature*	*SIF of more complex cases: Other applications of Westergaard approach, applications of principle of superposition*	*Mixed mode crack propagation: maximum tangential stress criteria, Strain energy density criterion*	*Prediction of longtime properties, effect of metallurgical variables, Creep resistant materials, hightemperature alloys*
S-9	SLO-1	*Damage tolerance methodology*	*Corrosion fatigue, time dependent and cycle dependent behavior, Mechanisms of corrosion fatigue, effect of corrosion product wedging on fatigue*	*Edge cracks, embedded cracks, critical stress intensity factor*	*Mixed mode examples, crack growth*	*Design considerations to avoid creep*

Learning Resources	*T. L. Anderson, "Fracture Mechanics Fundamentals and Applications", CRC Press Taylor & Francis; 4th edition, 2017* *Prashant Kumar, " Elements of Fracture Mechanics" Tata McGraw-Hill; 2009* *C. T. Sun, Z. -H. Zin, " Fracture Mechanics ", Elsevier; 2012* *G. E. Dieter, "Mechanical Metallurgy ", McGraw-Hill; 2017*

Learning Assessment

	Bloom's Level of Thinking	Continuous Learning Assessment (50% weightage)								Final Examination (50% weightage)	
		CLA – 1 (10%)		CLA – 2 (15%)		CLA – 3 (15%)		CLA – 4 (10%)#			
		Theory	Practice	Theory	Practice	Theory	Practice	Theory	Practice	Theory	Practice
Level 1	Remember Understand	30%	-	30%	-	40%	-	40%	-	30%	-
Level 2	Apply Analyze	50%	-	50%	-	40%	-	40%	-	50%	-
Level 3	Evaluate Create	20%	-	20%	-	20%	-	20%	-	20%	-
	Total	100 %		100 %		100 %		100 %		100 %	

CLA – 4 can be from any combination of these: Assignments, Seminars, Tech Talks, Mini-Projects, Case-Studies, Self-Study, MOOCs, Certifications, Conf. Paper etc.,

Course Designers

Experts from Industry	Experts from Higher Technical Institutions	Internal Experts
1. Dr.R.Kalimuthu, ISRO, Mahendragiri, r_kalimuthu@vssc.gov.in	*Dr. Sudheesh Kumar, sudheeshkumar3@gmail.com, GCE, Kannur*	*Dr T V V L N Rao, SRMIST*
2. Dr.A.Velayutham, DRDO, Avadi, velayudham.a@cvrde.drdo.in	*Dr.R.Prabhusekar, rprabhusekar@mnnit.ac.in, MNNIT Allahabad*	*Dr P Nandakumar, SRMIST*

Course Code	18MEE406T	Course Name	LINEAR ELASTICITY	Course Category	E	Professional Elective	L	T	P	C
							3	0	0	3

Pre-requisite Courses	Advanced calculus and complex Analysis, mechanics of solids	Co-requisite Courses	Nil	Progressive Courses	Nil
Course Offering Department	Department of Mechanical Engineering	Data Book / Codes/Standards	Nil		

Course Learning Rationale (CLR):	*The purpose of learning this course is to:*
CLR-1 :	*To studyConcept of Stress- Strains and Deformation*
CLR-2 :	*To ApplyBoundary Conditions for different kind of problems*
CLR-3 :	*To solve the problem using different solution method*
CLR-4 :	*To solve the plane elasticity problems using different solution method*
CLR-5 :	*To solvetorsion and elastic cylinders problems*
CLR-6 :	*To studyConcept of Stress- Strains and Deformation*

		Learning			Program Learning Outcomes (PLO)														
		1	2	3	1	2	3	4	5	6	7	8	9	10	11	12	13	14	15
Course Learning Outcomes (CLO):	*At the end of this course, learners will be able to:*	Level of Thinking (Bloom)	Expected Proficiency (%)	Expected Attainment (%)	Engineering Knowledge	Problem Analysis	Design & Development	Analysis, Design, Research	Modern Tool Usage	Society & Culture	Environment & Sustainability	Ethics	Individual & Team Work	Communication	Project Mgt. & Finance	Life Long Learning	PSO - 1	PSO - 2	PSO - 3
CLO-1 :	*understand the basics of Tensors, Index Notation, Coordinate Transformations, Deformation and Strain, Strain Transformation, Principal Strains, StrainCompatibility,*	1,2			*H*	*H*													
CLO-2 :	*apply boundary conditions and can get the general result*	1,2			*H*	*H*	*H*												
CLO-3 :	*solve the problem using different solution method*	1,2,3			*H*	*H*	*H*												
CLO-4 :	*solve the plane elasticity problems using different solution method*	1,2,3			*H*	*H*	*H*												
CLO-5 :	*Solve torsion and elastic cylinders problems*	1,2,3			*H*	*H*		*H*								*H*			
CLO-6 :	*Able to understand the basics of Tensors, Index Notation, Coordinate Transformations, Deformation and Strain, Strain Transformation, Principal Strains, StrainCompatibility,*	1,2			*H*	*H*													

		Foundations	General Results	System Response	Plane Elasticity Problems	Torsion And Flexure Of Elastic Cylinders
Duration (hour)		9	9	9	9	9
S-1	SLO-1	*Mathematical Preliminaries-Scalar, Vector, Matrix, and Tensor Definitions*	*Review of Field Equations*	*Anti-plane Strain*	*Plane Stress and Plane Strain*	*General solution of the torsion problem*
S-2	SLO-1	*Index notation*	*Field equations and boundary conditions, Navier equations*	*Field Equations and Boundary Conditions*	*Introduction to Airy Stress Function*	*Prandtl Stress Function*
S-3	SLO-1	*Concept of Stress- Strains and Deformation*	*Stress Formulation-Beltrami-Michell compatibility equations*	*Complex Variable Solutions to Anti-plane Strain Problems*	*Stress function, stress function for plane stress and plane strain cases*	*Torsion Solutions Derived from Boundary Equation*
S-4	SLO-1	*Coordinate Transformations -Strain Transformation*	*Displacement Formulation Principle of Superposition*	*Solution using Taylor Series*	*Introduction to Cartesian Coordinate Using Polynomials*	*Torsion Solutions Using Fourier Methods*
S-5	SLO-1	*Principal Strains, Strain Compatibility*	*2D approximations (plane stress and plane strain) and solution strategies*	*Solution using Laurent Series*	*Cartesian Coordinate Solutions Using Polynomials*	*Torsion of Hollow Cylinders*
S-6	SLO-1	*TractionVector*	*Uniqueness Theorems-Reciprocal Theorem*	*Solution using Cauchy Integral Formula*	*Introduction to Cartesian Coordinate Using Fourier Methods*	*Torsion of Circular Shafts of Variable Diameter*
S-7	SLO-1	*Stress Transformation*	*Principle of Virtual Work*	*Solution using Cauchy Integral Formula*	*Cartesian Coordinate Solutions Using Fourier Methods*	*Torsion of elliptic cross sections*
S-8	SLO-1	*Equilibrium Equations&Generalized Hooke's law.*	*Principle of Minimum Potential and Complementary Energy*	*Solution using Conformal Mapping*	*Introduction to Solutions in Polar Coordinates*	*Flexure Formulation*
S-9	SLO-1	*Review of Continuum Mechanics Concepts*	*Saint-Venant's Principle*	*Solution using Conformal Mapping*	*Axisymmetric problems, thick-walled cylinders, rotating disks of uniform thickness, stress concentration, effect of circular holes on stress distribution in plates.*	*Flexure Problems without Twist*

Learning Resources	1. *Martin H. Sadd, Elasticity: Theory, "Applications and Numeric's", Elsevier India, 2005* 2. *Timoshenko.S.P, Goodier.J.N, "Theory of Elasticity", Tata McGraw-Hill Education, 2010.* 3. *England.A.H, "Complex Variable Methods in Elasticity", Dover Publications, 2003.* 4. *Malvern.L.E, "Introduction to the Mechanics of a Continuous Medium", Prentice Hall, 1977.* 5. *Love.A.E.H, "The Mathematical Theory of Elasticity", Dover, 2011.* 6. *Landau.L.D and Lifshitz.E.M, "Theory of Elasticity, Butterworth-Heinemann", 1986.* 7. *Atkin.R.J and Fox.N, "An Introduction to the Theory of Elasticity", Dover,2005.* 8. *Barber.J.R, "Elasticity", Springer, 2009.*

Learning Assessment

	Bloom's Level of Thinking	Continuous Learning Assessment (50% weightage)								Final Examination (50% weightage)	
		CLA – 1 (10%)		CLA – 2 (15%)		CLA – 3 (15%)		CLA – 4 (10%)#			
		Theory	Practice	Theory	Practice	Theory	Practice	Theory	Practice	Theory	Practice
Level 1	Remember Understand	30%	-	30%	-	40%	-	40%	-	30%	-
Level 2	Apply Analyze	50%	-	50%	-	40%	-	40%	-	50%	-
Level 3	Evaluate Create	20%	-	20%	-	20%	-	20%	-	20%	-
	Total	100 %		100 %		100 %		100 %		100 %	

CLA – 4 can be from any combination of these: Assignments, Seminars, Tech Talks, Mini-Projects, Case-Studies, Self-Study, MOOCs, Certifications, Conf. Paper etc.,

Course Designers

Experts from Industry	Experts from Higher Technical Institutions	Internal Experts
1. Dr.R.Kalimuthu, ISRO, Mahendragiri, r_kalimuthu@vssc.gov.in	*Dr. R. Damodaram, SSN College of Engineering, Chennai, damodaramr@ssn.edu.in*	*Mr. K. Jegadheesan, SRMIST*
2. Dr.A.Velayutham, DRDO, Avadi, velayudham.a@cvrde.drdo.in	*Dr.R.Prabhusekar, rprabhusekar@mnnit.ac.in, MNNIT Allahabad*	*Dr. M. Iqbal, SRMIST*

Course Code	18MEE407T	Course Name	DESIGN OF PRESSURE VESSEL AND PIPING	Course Category	E	Professional Elective	L	T	P	C
							3	0	0	3

Pre-requisite Courses	18MEC206T	Co-requisite Courses	NIL	Progressive Courses	NIL
Course Offering Department	Mechanical Engineering	Data Book / Codes/Standards	ASME Pressure Vessel and Boiler Code; Section VIII Div. 1&2; 2003.American Standard Code for Pressure Piping; B 31.1.		

Course Learning Rationale (CLR):	*The purpose of learning this course is to:*
CLR-1:	*Familiarize with basics of Pressure vessel design*
CLR-2:	*Familiarize with different types of stresses and their effects in Pressure vessel.*
CLR-3:	*Equip with Pressure vessel design.*
CLR-4:	*Expose to failuremechanisms in Pressure vessel.*
CLR-5:	*Expose to the concept of piping layout and the stresses acting on it.*
CLR-6	*Analyse and design of pressure vessel and piping.*

Course Learning Outcomes (CLO):	*At the end of this course, learners will be able to:*	Learning			Program Learning Outcomes (PLO)														
		1	2	3	1	2	3	4	5	6	7	8	9	10	11	12	13	14	15
		Level of Thinking (Bloom)	Expected Proficiency (%)	Expected Attainment (%)	Engineering Knowledge	Problem Analysis	Design & Development	Analysis, Design, Research	Modern Tool Usage	Society & Culture	Environment & Sustainability	Ethics	Individual & Team Work	Communication	Project Mgt. & Finance	Life Long Learning	PSO - 1	PSO - 2	PSO - 3
CLO-1:	*understand the basics of pressure vessel design*	*1&2*	*90*	*85*	*H*	*H*	*H*	*M*										*L*	
CLO-2:	*determine various stresses, and their effects in pressure vessel.*	*12&3*	*90*	*85*	*H*	*H*	*H*											*L*	
CLO-3:	*design pressure vessel.*	*12&3*	*90*	*85*	*H*	*H*	*H*											*L*	
CLO-4:	*know the various types of failures in pressure vessel.*	*12&3*	*90*	*85*	*H*	*H*	*H*											*L*	
CLO-5:	*know the concepts of piping layout and the stresses acting on it*	*12&3*	*90*	*85*	*H*	*H*	*H*											*L*	
CLO-6	*Know the design concepts of pressure vessel and piping*	*1 2&3*	*90*	*85*	*H*	*H*	*H*											*L*	

		Overview of Pressure Vessel and stresses	Stresses in Pressure Vessels	Design of Pressure Vessels	Failure Analysis of vessels	Fundamentals of piping design
Duration (hour)		09	09	09	09	09
S-1	SLO-1	*Introduction, construction and design procedure.*	*Stresses in cylinder, Dilation of pressure vessels, Intersecting spheres.*	*Stress concentration at a variable thickness transition section in a cylindrical vessel, circular hole, Elliptical Openings*	*Buckling phenomenon, vessels under external pressure.*	*Introduction to piping, definition,codes, standards and specifications.,*
S-2	SLO-1	*. Design approach, design by rule, design by analysis.*	*Membrane stresses in vessel under internal pressure, cylindrical vessel, spherical, conical vessel.*	*Stress concentration factor for superposition, Dynamic and thermal transient condition.*	*Elastic buckling of circular ring, deflectioncurve, buckling.*	*Piping components, pipe, pipe fittings, flanges, valves, bolt and gaskets.*
S-3	SLO-1	*Introduction, Stress intensity, Stresses in a circular ring.*	*Thermal stresses in long hollow cylinder, logarithmic, thermal gradient.*	*Design of tall cylindrical self-supporting process columns for short vertical vessels.*	*Buckling of long cylinder or tubes, inelastic collapse, initial non-circularity.*	*Flow diagram, piping layout*
S-4	SLO-1	*Stress significance, stress pattern.*	*Linear thermal gradient, Steady state Thermal stresses.*	*Design of supports for short vertical vessel.*	*Collapse of thick walled cylinder, fully plastic wall,*	*underground, above ground pipelines*
S-5	SLO-1	*Residual stress, shape of a member*	*Thermal stresses due to thermal gradients.*	*Theory of reinforced openings.*	*Collapse of the wall of a cylinder.*	*Piping stress analysis, Forces and moments*
S-6	SLO-1	*Methods for determining stresses, strain gauge, Photo elastic, Moiré.*	*Ultra-high-pressure vessel -design principle, wedge, segment principle.*	*Nozzle reinforced placement shape, single nozzles, Multiple nozzles, Nonradical nozzles.*	*Effect of supports on elastic buckling, buckling, collapse coefficient.*	*Piping specifications, static and dynamic loads*
S-7	SLO-1	*Thermal stresses, thermal strains and their significance.*	*Cascade principle, yoke Beam and ties, Anvil principle, Bridge man massive conical anvils.*	*Pressure vessel design, welded joints, strength of weldments.*	*Buckling under combined external pressure and axial loading*	*nomenclature of pipe supports, guided cantilever method*

S-8	SLO-1	*Terminology of vessel, vessel Ligament.*	*Discontinuity stresses in pressure vessels, Cylindrical vessels with various heads, Infinite long beam, semidefinite beam.*	*Bolted joints and gaskets, thread and nut design, bolt head, shank design.*	*interaction method, interaction equations in design.*	*Design of piping system, pressure components design*
S-9	SLO-1	*Ligament efficiency, Longitudinal, circumferential ligaments in a cylindrical and spherical shape.*	*Stresses in a bimetallic joint, deformation and stresses in flanges.*	*Introduction to ASME pressure vessel codes.*	*Safety factors in design, Imperfection sensitivity*	*minimum wall thickness of pipe, pipe span calculations, Ansi piping codes.*

Learning Resources	1. *John F. Harvey, "Theory and Design of Pressure vessels", CBS publishers and Distributors, 1987.* 2. *Henry H Bedner, " Pressure Vessels, Design Hand Book ", CBS publishers and Distributors ,1987.* 3. *Somnath Chattopadhyay," Pressure vessels: Design and practice ", CRC Press ,2004.* 4. *Smith P., "Fundamentals of piping design", Elsevier Gulf Publishing Company 2007.* 5. *William. J. Bees"Approximate Methods in the design and analysis of pressure vessels and piping ", Pre ASME-pressure vessels and piping conference ,1997.* 6. *ASME Pressure Vessel and Boiler code, section viii Div. 1&2,2003 American standard code for pressure piping, B31.1* 7. *Brownell. L E & Young E.D," Process equipment design ", Wiley Eastern Ltd, India.*

Learning Assessment

	Bloom's Level of Thinking	Continuous Learning Assessment (50% weightage)								Final Examination (50% weightage)	
		CLA – 1 (10%)		CLA – 2 (15%)		CLA – 3 (15%)		CLA – 4 (10%)			
		Theory	Practice	Theory	Practice	Theory	Practice	Theory	Practice	Theory	Practice
Level 1	Remember Understand	40%	-	30%	-	30%	-	30%	-	30%	-
Level 2	Apply Analyze	40%	-	40%	-	40%	-	40%	-	40%	-
Level 3	Evaluate Create	20%	-	30%	-	30%	-	30%	-	30%	-
	Total	100 %		100 %		100 %		100 %		100 %	

CLA – 4 can be from any combination of these: Assignments, Seminars, Tech Talks, Mini-Projects, Case-Studies, Self-Study, MOOCs, Certifications, Conf. Paper etc.,

Course Designers

Experts from Industry	Experts from Higher Technical Institutions	Internal Experts
1. Dr.R.Kalimuthu, ISRO, Mahendragiri, r_kalimuthu@vssc.gov.in	*Dr V.MARIAPPAN, vmari@nitt.edu, NIT Trichy*	*Dr. P.Nandakumar, SRMIST*
2. Dr.A.Velayutham, DRDO, Avadi, velayudham.a@cvrde.drdo.in		*Mr.R.Harris Samuel, SRMIST*

Course Code	18MEE408T	Course Name	KINEMATICS AND DYNAMICS OF ROBOTS	Course Category	E	Professional Elective	L	T	P	C
							3	0	0	3

Pre-requisite Courses	Nil	Co-requisite Courses	Nil	Progressive Courses	Nil
Course Offering Department	Mechanical Engineering	Data Book / Codes/Standards	Nil		

Course Learning Rationale (CLR):	*The purpose of learning this course is to:*
CLR-1 :	*Acquire the fundamental concepts of Robot Transformation*
CLR-2 :	*Impart the Knowledge about the concepts of Direct kinematics of Robot*
CLR-3 :	*Impart the Knowledge about the concepts of Inverse kinematics of Robot*
CLR-4 :	*Acquire fundamental knowledge about theplanning trajectories on workspace of robot*
CLR-5 :	*Enable students withthe basic knowledge of Robot Dynamics*
CLR-6 :	*Understand the kinematics and dynamics models of robots*

		Learning			Program Learning Outcomes (PLO)														
		1	2	3	1	2	3	4	5	6	7	8	9	10	11	12	13	14	15
Course Learning Outcomes (CLO):	*At the end of this course, learners will be able to:*	Level of Thinking (Bloom)	Expected Proficiency (%)	Expected Attainment (%)	Engineering Knowledge	Problem Analysis	Design & Development	Analysis, Design, Research	Modern Tool Usage	Society & Culture	Environment & Sustainability	Ethics	Individual & Team Work	Communication	Project Mgt. & Finance	Life Long Learning	PSO - 1	PSO - 2	PSO - 3
CLO-1 :	*Understanding rigid body transformations, homogeneous transformation matrices of Robot.*	*1 &2*	*85*	*75*	*H*	*H*	*M*	*M*	*M*	*L*	*L*	*L*	*M*	*M*	*M*	*M*	*M*	*M*	*M*
CLO-2 :	*Derive the direct kinematics equation for robot manipulators.*	*2*	*80*	*70*	*H*	*H*	*M*	*M*	*M*	*L*	*L*	*L*	*M*	*M*	*M*	*M*	*M*	*M*	*M*
CLO-3 :	*Derive the inverse kinematics equation for robot manipulators.*	*1 &2*	*80*	*70*	*H*	*H*	*H*	*M*	*M*	*L*	*L*	*L*	*M*	*M*	*M*	*M*	*M*	*M*	*M*
CLO-4 :	*Generate workspace and trajectory planning in Cartesian and joint spaces.*	*1 &2*	*75*	*70*	*H*	*H*	*H*	*M*	*M*	*L*	*L*	*L*	*M*	*M*	*M*	*M*	*M*	*M*	*M*
CLO-5 :	*Understand the equations of motion (dynamics model) of manipulators using Lagrange-Euler and Newton-Euler methods.*	*1 &2*	*75*	*70*	*H*	*H*	*H*	*M*	*M*	*L*	*L*	*L*	*M*	*M*	*M*	*M*	*M*	*M*	*M*
CLO-6 :	*Analyze the kinematic and dynamic model of robot*	*2*	*75*	*70*	*H*	*H*	*M*	*M*	*M*	*L*	*L*	*L*	*M*	*M*	*M*	*M*	*M*	*M*	*M*

Duration (hour)		9	9	9	9	9
S-1	SLO-1	*Introduction about machines and mechanisms – Robot anatomy*	*Link coordinates for D-H representation*	*Inverse Kinematics of transformation*	*Introduction & analysis of work space*	*Introduction to manipulator dynamics*
	SLO-2					
S-2	SLO-1	*Arm and wrist configuration of Robot*	*Arm matrix and Arm equation – DH representation of Kinematics model*	*General properties of solution*	*Workspace analysis for 4 axis SCARA robot*	*Lagrange's equation - kinetic and potential energy*
	SLO-2					
S-3	SLO-1	*Position and orientation of objects, descriptions: Positions, Orientations and Frames*	*Direct Kinematics of 2 DOF Planar Manipulator arm*	*Inverse Kinematics for 2 DOF planar robot*	*Work space fixtures*	*Link inertia tensor*
	SLO-2					*Link jacobian manipulator inertia tensor*
S-4	SLO-1	*Coordinate transformation / Mapping in fixed angle rotation*	*Direct Kinematics of 3 axis articulated robot – Link*	*Inverse kinematics – 3 DOF articulated robot – Guide lines, solution techniques*	*Trajectory planning - Terminology*	*Gravity and generalized forces*
	SLO-2				*Trajectory planning – pick and place motion*	
S-5	SLO-1	*Mappings: Changing descriptions from Frame to Frame*		*Inverse kinematics – 3 DOF articulated robot – Derivation of equations*	*Continuous path motion – Joint space technique and Cartesian space technique*	*Lagrange – Euler Dynamic model formulation*
	SLO-2					
S-6	SLO-1	*Operators: Translations, Rotations and Transformations, Transformation Arithmetic*	*Direct Kinematics of 3 DOF wrist*	*Inverse kinematics of RPY wrist*	*Trajectory planning – Interpolated motion*	*Kinetic and Potential Energy Formulation for Two axis planar robot*
	SLO-2					
S-7	SLO-1	*Transformation of Vectors for Rotation, translation and composite*		*Inverse kinematics of – 4 axis SCARA robot – General solution*	*Trajectory planning – straight line motion*	*L-E Dynamics model for Two axis planar robot*
	SLO-2					

S-8	SLO-1	*Inverting Transformation*	*Direct Kinematics Analysis of 4 axis SCARA Robot*	*Tool Configuration*	*Trajectory planning for 3 DOF Manipulator*	*Newton – Euler formulation*
	SLO-2					
S-9	SLO-1	*Rotation Matrix – fixed and Euler angle representation*		*Tool configuration of a 4 axis SCARA robot*	*Trajectory planning for 4 DOF SCARA Manipulator*	*N-E Dynamics model for Two axis planar robot*
	SLO-2					

Learning Resources	1. *1.Robert J. Schilling, Fundamentals of Robotics Analysis and Control, Prentice Hall of India Pvt. Ltd., 2003* 2. *Richard D. Klafter, Thomas. A, Chmielewski, Michael Negin, Robotics Engineering an Integrated Approach, Prentice Hall of India Pvt. Ltd., 1993* 3. *P.A. Janaki Raman, Robotics and Image Processing An Introduction, Tata Mc Graw Hill Publishing company Ltd., 1995* 4. *John J. Craig, Introduction to Robotics Mechanics and Control, Fourth Edition, Pearson Education International, 2018.* 5. *Mittal RK, Nagrath IJ, Robotics and Controls, Tata McGraw Hill Publications, 2003*

Learning Assessment

	Bloom's Level of Thinking	Continuous Learning Assessment (50% weightage)								Final Examination (50% weightage)	
		CLA – 1 (10%)		CLA – 2 (15%)		CLA – 3 (15%)		CLA – 4 (10%)#			
		Theory	Practice	Theory	Practice	Theory	Practice	Theory	Practice	Theory	Practice
Level 1	Remember Understand	40%	-	30%	-	30%	-	30%	15%	30%	-
Level 2	Apply Analyze	40%	-	40%	-	40%	-	40%	20%	40%	-
Level 3	Evaluate Create	20%	-	30%	-	30%	-	30%	15%	30%	-
	Total	100 %		100 %		100 %		100 %		100 %	

CLA – 4 can be from any combination of these: Assignments, Seminars, Tech Talks, Mini-Projects, Case-Studies, Self-Study, MOOCs, Certifications, Conf. Paper etc.,

Course Designers

Experts from Industry	Experts from Higher Technical Institutions	Internal Experts
1. Dr.R.Kalimuthu, ISRO, Mahendragiri, r_kalimuthu@vssc.gov.in	*Dr. Yogesh Singh, Yogesh@mech.nits.ac.in, NIT Silchar*	*Mr. KR. Arun prasad, SRMIST*
2. Dr.A.Velayutham, DRDO, Avadi, velayudham.a@cvrde.drdo.in	*Dr.R.Prabhu sekar, rprabhusekar@mnnit.ac.in, MNNIT Allahabad*	*Dr. P. Nandakumar, SRMIST*

Course Code	18MEE409T	Course Name	COMPUTER APPLICATIONS IN DESIGN	Course Category	E	Professional Elective	L	T	P	C
							3	0	0	3

Pre-requisite Courses	NIL	Co-requisite Courses	NIL	Progressive Courses	NIL
Course Offering Department	Mechanical Engineering	Data Book / Codes/Standards	NIL		

Course Learning Rationale (CLR):	*The purpose of learning this course is to:*
CLR-1 :	*understand the overall design process and the types of three-dimensional modeling schemes.*
CLR-2 :	*write programs in MATLAB for Mechanical Engineering Design problems*
CLR-3 :	*understand in applying CAD model for design*
CLR-4 :	*know how the model data is stored, retrieved and to organize for CIM applications*
CLR-5 :	*know uses of parametric modeling. Uses of Rapid prototyping and Artificial Intelligence*
CLR-6 :	*understand the overall design process and the types of three-dimensional modeling schemes.*

		Learning			Program Learning Outcomes (PLO)														
		1	2	3	1	2	3	4	5	6	7	8	9	10	11	12	13	14	15
Course Learning Outcomes (CLO):	*At the end of this course, learners will be able to:*	Level of Thinking (Bloom)	Expected Proficiency (%)	Expected Attainment (%)	Engineering Knowledge	Problem Analysis	Design & Development	Analysis, Design, Research	Modern Tool Usage	Society & Culture	Environment & Sustainability	Ethics	Individual & Team Work	Communication	Project Mgt. & Finance	Life Long Learning	PSO - 1	PSO - 2	PSO - 3
CLO-1 :	*understand the overall design process and can able to apply on any projects.*	*1&2*	*90*	*85*	*H*	-	-	-	-	-	-	-	-	-	-	-	-	-	-
CLO-2 :	*write interactive programs in MATLAB for design problems.*	*1*	*90*	*85*	*H*	*H*	-	-	-	-	-	-	-	-	-	-	-	-	-
CLO-3 :	*understand in applying CAD model in design*	*1*	*90*	*85*	*H*	-	*M*	-	-	-	-	-	-	-	-	-	-	-	-
CLO-4 :	*organize data for CIM applications and various aspects of data storage and manipulation*	*1&2*	*90*	*85*	*H*	-	*M*	-	-	-	-	-	-	-	-	-	-	-	-
CLO-5 :	*understand the uses of parametric modelling and artificial intelligence.*	*1&2*	*90*	*85*	*H*	-	*M*	-	-	-	-	-	-	-	-	-	-	-	-

		Introduction to CAD	Writing design programs in MATLAB for Machine Elements	Applying the CAD model in design	Entity Manipulation and Data Storage:	Expanding the capability of CAD
Duration (hour)		9	9	9	9	9
S-1	SLO-1	*The design process*	*Introduction to Machine Drawing*	*Applications to draughting*	*Manipulation of the model*	*Parametric modeling*
S-2	SLO-1	*Different types of design process*	*Introduction to Machine Drawing*	*The use of 3D modeling for 2D representation*	*Model storage*	*Variation modeling*
S-3	SLO-1	*Role of CAD in Design*	*Introduction to MATLAB software*	*Approaches to 3D modelling*	*Data structures*	*Feature based modeling*
S-4	SLO-1	*Types and applications of design models*	*Introduction for Writing interactive programs to solve design problems in MATLAB*	*Direct assessment for the geometric model*	*Database consideration*	*Feature recognition*
S-5	SLO-1	*Computer representation of drawings*	*Design problems using MATLAB for Shafts*	*Generation of new models from the geometric model*	*Object oriented representations*	*Design by features*
S-6	SLO-1	*Three-dimensional modeling schemes*	*Design problems using MATLAB for Gears*	*The scope of customization and design automation*	*CIM*	
S-7	SLO-1	*Wire frame model*	*Design problems using MATLAB for Pulleys*	*Typical facilities for system customization*	*Organizing data for CIM application*	*Rapid prototyping*
S-8	SLO-1	*Surface representation model*	*Design problems using MATLAB for flywheel*	*The graphics Kernel System*	*ERP (Enterprise Resource planning)*	
S_9	SLO-1	*Solid modeling*	*Design problems using MATLAB for connecting rods*	*Standard for exchanging images*	*Design information system*	*Artificial intelligence in design*

Learning Resources	1. *Charles. S. Knox, "Organising data for CIM Applications", Marcel Dekker Inc. New York 1987.* 2. *Ibrahim Zeid, "CAD/ CAM - Theory and Practice" - McGraw Hill, International Edition, 1998.* 3. *Chris McMahon and Jimmi Browne, "CAD CAM Principles, practice and Manufacturing Management", Pearson Education Asia, 2002.* 4. *Kr. Gopalakrishna, "Machine Drawing" , Subhas Stores, 2007* 5. *Chandupatla and Belagundu, "Introduction to Finite Element Methods in Engineering", Prentice Hall of India Private Limited, New Delhi, 1997.* 6. *http://www.machinedesign.com* 7. *MATLAB: Easy Way of Learning,S. Swapna Kumar and S. V. B. Lenina,2016*

Learning Assessment											
	Bloom's Level of Thinking	Continuous Learning Assessment (50% weightage)								Final Examination (50% weightage)	
		CLA – 1 (10%)		CLA – 2 (15%)		CLA – 3 (15%)		CLA – 4 (10%)#			
		Theory	Practice	Theory	Practice	Theory	Practice	Theory	Practice	Theory	Practice
Level 1	Remember Understand	20%	-	15%	-	15%	-	15%	-	15%	-
Level 2	Apply Analyze	20%	-	20%	-	20%	-	20%	-	20%	-
Level 3	Evaluate Create	10%	-	15%	-	15%	-	15%	-	15%	-
	Total	100 %		100 %		100 %		100 %		100 %	

CLA – 4 can be from any combination of these: Assignments, Seminars, Tech Talks, Mini-Projects, Case-Studies, Self-Study, MOOCs, Certifications, Conf. Paper etc.,

Course Designers		
Experts from Industry	Experts from Higher Technical Institutions	Internal Experts
1. Dr.R.Kalimuthu, ISRO, Mahendragiri, r_kalimuthu@vssc.gov.in	*Dr. Davidson Jebaseelan, davidson.jd@vit.ac.in* *VIT Chennai.*	*Mr. S. Balamurugan,SRM IST*
2. Dr.A.Velayutham, DRDO, Avadi, velayudham.a@cvrde.drdo.in	*Mr. Vignesh Shanmugam.S, 273357@hmil.net* *Hyundai Motors Limited, Chennai*	*Dr. P. Nandakumar, SRMIST*

Course Code	18MEE321T	Course Name	ELEMENTS OF MECHATRONICS	Course Category	E	Professional Elective	L	T	P	C
							3	0	0	3

Pre-requisite Courses	Nil	Co-requisite Courses	Nil	Progressive Courses	Nil
Course Offering Department	Mechanical Engineering	Data Book / Codes/Standards	Nil		

Course Learning Rationale (CLR):	*The purpose of learning this course is to:*
CLR-1 :	*Acquire the fundamental knowledge of mechatronics systems*
CLR-2 :	*Understand the sensors and transducers.*
CLR-3 :	*Understand the actuation systems, signal processing and controllers.*
CLR-4 :	*Acquire knowledge about the PLC.*
CLR-5 :	*Know mechatronics system design and its applications.*
CLR-6 :	*Knowledge about the concept and components of mechatronics systems.*

Course Learning Outcomes (CLO):	*At the end of this course, learners will be able to:*	Learning 1 Level of Thinking (Bloom)	2 Expected Proficiency (%)	3 Expected Attainment (%)	PLO 1 Engineering Knowledge	2 Problem Analysis	3 Design & Development	4 Analysis, Design, Research	5 Modern Tool Usage	6 Society & Culture	7 Environment & Sustainability	8 Ethics	9 Individual & Team Work	10 Communication	11 Project Mgt. & Finance	12 Life Long Learning	13 PSO - 1	14 PSO - 2	15 PSO - 3
CLO-1 :	*Differentiate the basic key elements of mechatronics systems*	1	90	85	M	-	M	-	-	-	-	-	-	-	-	-	L	L	L
CLO-2 :	*Have cognizance on performance of sensors and transducers.*	1	90	85	H	M	M	L	L	-	-	-	-	-	-	-	H	H	L
CLO-3 :	*Differentiate and utilize actuation systems, signal processing and controllers.*	1	90	85	H	M	M	M	-	-	-	-	-	-	-	-	H	M	L
CLO-4 :	*program the PLC.*	2	90	85	H	H	M	M	-	-	-	-	-	-	-	-	H	H	L
CLO-5 :	*Design of mechatronics system and its applications.*	3	90	85	H	M	H	H	-	-	-	-	-	-	-	-	H	M	L
CLO-6 :	*Differentiate, analysis and design mechatronics systems.*	3	90	85	H	M	M	M	L	-	-	-	-	-	-	-	H	M	L

		Introduction to Mechatronics	Sensors and Transducers	Electrical Drives and Controllers	Programmable Logic Controllers	Mechatronics System Design and Application
Duration (hour)		9	10	10	8	8
S-1	SLO-1	*Introduction to Mechatronics systems*	*Introduction to sensors and transducers, classification and Static and dynamic characteristics.*	*Introduction, Electromagnetic Principles, Solenoids and Relays*	*Basic structure, Programming units and Memory of Programmable logic controller*	*Mechatronics in Engineering Design, Traditional and mechatronics design*
S-2	SLO-1	*Mechatronics system components and Measurement Systems, Control Systems.*		*Electrical drives of stepper motors, servo motors.*		*Car park barriers using PLC*
S-3	SLO-1	*Open and Closed Loops Systems temperature control*	*Principle and working of Resistive, capacitive, inductive transducer.*		*Input and Output Modules, Mnemonics for programming*	*Pick and Place robots and Bar code reader*
S-4	SLO-1		*Resonant transducer and Optical measurement systems for absolute and incremental encoders*	*Operational amplifier*	*Latching and Internal relays*	
S-5	SLO-1	*Water level controller and Shaft speed control*	*Photo electric sensor and vision system*	*A/D converters*	*Timers, Counters and Shift Registers*	*Automotive control systems*
S-6	SLO-1		*Fibre optic transducers*	*D/A converters*		*Robotics Applications*
S-7	SLO-1	*Sequential Controllers : Washing machine control*	*Solid state sensors and transducers for magnetic measurements*	*Signal processing, Multiplexer and Introduction to Data acquisition system*	*Master relay and Jump Controls*	*Case studies for Coin counters, Robot walking and Boiler control using PID.*
S-8	SLO-1	*Sequential Controllers : Digital camera*	*Temperature measurements*	*Proportional, Integral, Derivative and PID controller*	*Programming the PLC using Ladder diagram for Simple applications.*	
S-9	SLO-1	*MEMS and the automobile airbag*	*Chemical measurements, piezoelectric sensor and accelerometers*	*Introduction to Micro controller : M68HC11 and ATMEGA328*		
S-10	SLO-1		*Ultrasonic sensors and transducers for flow and distance*			

Learning Resources	TEXT BOOKS	REFERENCES
	Bolton.W, "Mechatronics", Pearson, 6th Edition, 2015.	*James Harter, "Electromechanics, Principles and Concepts and Devices", Prentice Hall, New Delhi, 1995.*
	Bradley.D.A, Dawson.DBurdN.C.and Loader A.J, "Mechatronics", CRC Press, 1993, First Indian Print 2010.	*David W. Pessen, "Industrial Automation Circuit Design and Components", Wiley India, 2011.*
	Jacob Fraden, "Handbook of Modern Sensors Physics, Designs, and Applications", 5th Edition, Springer International Publishing, 2016.	*Bolton.W, "Programmable Logic Controllers", Elsevier, 2015.*
		Brian Morris, "Automatic Manufacturing Systems Actuators, Controls and Sensors", McGraw Hill, New York, 1994
		Godfrey C. Onwubolu, "Mechatronics Principles and applications", Butterworth-Heinemann, New Delhi, 2006.

Learning Assessment

	Bloom's Level of Thinking	Continuous Learning Assessment (50% weightage)								Final Examination (50% weightage)	
		CLA – 1 (10%)		CLA – 2 (15%)		CLA – 3 (15%)		CLA – 4 (10%)#			
		Theory	Practice	Theory	Practice	Theory	Practice	Theory	Practice	Theory	Practice
Level 1	Remember / Understand	40 %	-	30 %	-	30 %	-	30 %	-	30%	-
Level 2	Apply / Analyze	40 %	-	40 %	-	40 %	-	40 %	-	40%	-
Level 3	Evaluate / Create	20 %	-	30 %	-	30 %	-	30 %	-	30%	-
	Total	100 %		100 %		100 %		100 %		100 %	

CLA – 4 can be from any combination of these: Assignments, Seminars, Tech Talks, Mini-Projects, Case-Studies, Self-Study, MOOCs, Certifications, Conf. Paper etc.,

Course Designers

Experts from Industry	Experts from Higher Technical Institutions	Internal Experts
Mr. B. Sriram, WABCO INDIA LTD, sriram.b@wabco-auto.com	*DR J.Prasanna, CEG, Anna University, pras_me@yahoo.com*	*1. Mr.N. Karthikeyan, SRMIST*
Dr.R.Kalimuthu, ISRO, Mahendragiri, r_kalimuthu@vssc.gov.in	*Dr.R.Sivaramakrishnan, MIT, Anna University, srk@mitindia.edu, srk@annauniv.edu*	*2. Mr.V.Manojkumar, SRMIST*

Course Code	18MEE322T	Course Name	FLUID POWER CONTROL	Course Category	E	Professional Elective	L	T	P	C
							3	0	0	3

Pre-requisite Courses	NIL	Co-requisite Courses		Progressive Courses	NIL
Course Offering Department	Mechanical Engineering	Data Book / Codes/Standards	NIL		

Course Learning Rationale (CLR):	*The purpose of learning this course is to:*
CLR-1 :	*Be familiar with the construction and working of hydraulic power generating and utilizing elements*
CLR-2 :	*Know the working of various control valves and familiar with accessories in hydraulic systems*
CLR-3 :	*Be familiar with the construction and working of pneumatic systems and fluidic control*
CLR-4 :	*Be familiar with designing of fluid power circuits for given applications*
CLR-5 :	*Know the maintenance procedures and trouble shooting*
CLR-6 :	*understand the fluid power systems and to develop circuits for industrial applications*

Course Learning Outcomes (CLO):	*At the end of this course, learners will be able to:*	Learning 1: Level of Thinking (Bloom)	Learning 2: Expected Proficiency (%)	Learning 3: Expected Attainment (%)
CLO-1 :	*Recognize the use of power generating elements, and acquire knowledge the principles and characteristics of hydraulic components*	1&2	90	85
CLO-2 :	*Acquire knowledge on working of various control valves and familiar with accessories in hydraulic systems*	1	90	85
CLO-3 :	*Acquire knowledge on the principles and working of pneumatic components.*	1	90	85
CLO-4 :	*Design the circuit for given applications*	1,2&3	90	85
CLO-5 :	*Acquire knowledge on maintenance and analyze the trouble shooting of fluid power systems*	1&2	90	85
CLO-6 :	*Understand fluid power systems and apply knowledge to develop fluid power circuits for industrial applications*	1,2&3	90	85

Program Learning Outcomes (PLO)	1 Engineering Knowledge	2 Problem Analysis	3 Design & Development	4 Analysis, Design, Research	5 Modern Tool Usage	6 Society & Culture	7 Environment & Sustainability	8 Ethics	9 Individual & Team Work	10 Communication	11 Project Mgt. & Finance	12 Life Long Learning	13 PSO - 1	14 PSO - 2	15 PSO - 3
CLO-1	H	-	-	-	-	-	-	-	-	-	-	-	L	L	L
CLO-2	H	-	-	-	-	-	-	-	-	-	-	-	M	L	L
CLO-3	H	-	-	-	-	-	-	-	-	-	-	-	M	L	L
CLO-4	H	H	H	-	M	-	-	-	-	-	-	-	H	H	H
CLO-5	H	-	-	-	-	-	M	-	-	-	-	M	H	H	H
CLO-6	H	H	H	-	-	-	M	-	-	-	-	-	M	M	M

Duration (hour)		Hydraulic Power Generating And Utilizing Systems	Hydraulic Valves And Accessories	Pneumatic Systems	Design Of Fluid Power Systems	Applications, Maintenance And Trouble Shooting
		10	9	9	9	8
S-1	SLO-1	*Introduction to fluid power system, Hydraulic fluids functions, types, properties, selection and application.*	*Construction and working of manually, pilot and solenoid operated 2/2, 3/2, 4/2,4/3, directional control valves*	*Introduction, comparison with hydraulic systems and electrical systems*	*Fluid power actuators: Speed and force calculations in fluid power systems*	*Industrial hydraulic circuits for riveting machine.*
S-2	SLO-1	*POWER GENERATING ELEMENTS: Construction, operation, characteristics of External Gear pump, internal Gear pump*	*Construction and working of pressure relief, compound pressure relief, pressure sequence valves*	*Construction, operation, characteristics and symbols of reciprocating and rotary compressors*	*Pump performance calculations, Sizing of reservoirs. Calculation of pressure and pressure drop across components in fluid power circuits*	*Hydraulic circuits for grinding and shaping machine.*
S-3	SLO-1	*Construction, operation, characteristics of Lobe, Gerotor and Screw pumps*	*Construction and working of pressure reducing, counter balance valves*	*Construction, operation, characteristics and symbols of 3/2, 5/2, 5/3 manual operated, pilot operated and solenoid operated DCVs*	*Finding the capacity of accumulators required for hydraulic systems.*	*Working of hydraulic press and pump unloading circuits*
S-4	SLO-1	*Construction, operation, characteristics of Un balanced and balanced vane pump*	*Working principle of check valve, throttle valve, one way FCV.*	*Need for air treatment, Filter, Regulator, Lubricator, Muffler and Dryers*	*Selection of different components such as reservoir, various valves, actuators, filters, pumps for a practical application.*	*Hydraulic / pneumatic circuits for material handling Systems*
S-5	SLO-1	*Construction, operation, characteristics of pressure compensated vane pump*	*Working principle of pressure compensated FCV, and their applications.*	*Introduction to fluidic devices, working of Bi-stable, monostable devices*	*Design of hydraulic/pneumatic circuits for simplereciprocation, regenerative, speed control of actuators*	*Preventive and breakdown, maintenance procedures in fluid power systems*
S-6	SLO-1	*Construction, operation, characteristics of bent axis piston pump, swash plate piston pump and Radial Piston Pump*	*Importance of proportional valves, Servo valves and its applications*	*Fluidic application circuits – continuous reciprocation and sequencing*	*Design of hydraulic/pneumatic circuits for sequencing, synchronization*	*Trouble shooting of fluid power systems : problems, causes and remedies-hydraulics*

S-7	SLO-1	*Construction and working of single acting, double acting hydraulic linear actuators*	*Need for intensifier in hydraulic systems, applications*	*Pneumatic Sensors types and applications*	*Cascading circuit for trapped signals : two cylinders*	*Trouble shooting of fluid power systems : problems, causes and remedies-pneumatics*
S-8	SLO-1	*Special cylinders: Tandem, Rodless, Telescopic*	*Different switches, filters, seals, fittings and other accessories used in hydraulic systems*	*Introduction to Electro Pneumatics – switches, relays, solenoids*	*Cascading circuit for trapped signals : three cylinders*	*Safety aspects involved fluid power systems*
S-9	SLO-1	*Cushioning arrangement for cylinders to reduce the impact on the cylinders, Various cylinder mountings*	*Functions, types and applications of accumulators in hydraulics*	*Constructing electrical ladder diagrams for various fluid power applications.*	*Fail-safe circuit, counter balance circuit, actuator locking*	
S-10	SLO-1	*Construction and working of Gear, Vane, Piston motors to obtain rotary motion*				

Learning Resources	1. *Anthony Esposito, "Fluid Power with applications", Pearson Education Inc, 2015.* 2. *Majumdar.S.R, "Oil Hydraulic Systems: Principles and Maintenance", Tata McGraw Hill Publishing company Ltd, New Delhi, 2006.* 3. *Majumdar.S.R, "Pneumatic systems – principles and maintenance", Tata McGraw Hill Publishing company Ltd, New Delhi, 2006* 4. *Ilango Sivaraman, "Introduction to Hydraulics and Pneumatics", PHI Learning Pvt. Ltd, New Delhi, 2017.* 5. *Joji Parambath "Industrial Hydraulic Systems: Theory and Practice", Universal Publishers, USA, 2016.* 6. *EurIng Ian C. Thrner, "Engineering Applications of Pneumatics and Hydraulics", Routledge, Taylor & Francis group, London and Newyork, 2011.* 7. *Andrew Parr, "Hydraulics and Pneumatics: A technician's and engineer's guide", Elsevier Ltd, 2011.* 8. *Anton H Hehn, "Fluid Power Trouble Shooting", Marcel Dekker Inc., NewYork, 1995*

Learning Assessment

	Bloom's Level of Thinking	Continuous Learning Assessment (50% weightage)								Final Examination (50% weightage)	
		CLA – 1 (10%)		CLA – 2 (15%)		CLA – 3 (15%)		CLA – 4 (10%)#			
		Theory	Practice	Theory	Practice	Theory	Practice	Theory	Practice	Theory	Practice
Level 1	Remember Understand	40 %	-	30 %	-	30 %	-	30 %	-	30%	-
Level 2	Apply Analyze	40 %	-	40 %	-	40 %	-	40 %	-	40%	-
Level 3	Evaluate Create	20 %	-	30 %	-	30 %	-	30 %	-	30%	-
	Total	100 %		100 %		100 %		100 %		100 %	

CLA – 4 can be from any combination of these: Assignments, Seminars, Tech Talks, Mini-Projects, Case-Studies, Self-Study, MOOCs, Certifications, Conf. Paper etc.,

Course Designers

Experts from Industry	Experts from Higher Technical Institutions	Internal Experts
1. Dr. R. Kalimuthu, ISRO, Mahendragiri, r_kalimuthu@vssc.gov.in, rkpearls@yahoo.com	*1. Dr. P. Hariharan, Anna University, hari@annauniv.edu, hariharan2311@gmail.com*	*Dr. M. R. Stalin John, SRMIST*
Mr. S. Sendilkumar- Festo India Pvt Ltd	*2. Dr.N.Arunachalam, IIT Madras, chalam@iitm.ac.in*	*Mr. R. Murugesan, SRMIST*

Course Code	18MEE323T	Course Name	PROCESS PLANNING AND COST ESTIMATION	Course Category	E	Professional Elective	L	T	P	C
							3	0	0	3

Pre-requisite Courses	18MEC103T	Co-requisite Courses	Nil	Progressive Courses	Nil
Course Offering Department	Mechanical Engineering	Data Book / Codes/Standards	Nil		

Course Learning Rationale (CLR):	The purpose of learning this course is to:
CLR-1 :	*Acquire knowledge about Process planning*
CLR-2 :	*Understand Different Cost and its components*
CLR-3 :	*Learn about cost estimation of products manufactured in foundry and forging shops*
CLR-4 :	*Acquire knowledge about various cost involved in welding and sheet metal shops*
CLR-5 :	*Calculate Machining time for different process*
CLR-6 :	*Impart clear knowledge about process planning, costing, and estimation of machining time*

Course Learning Outcomes (CLO):	At the end of this course, learners will be able to:	Learning 1: Level of Thinking (Bloom)	2: Expected Proficiency (%)	3: Expected Attainment (%)	PLO 1: Engineering Knowledge	2: Problem Analysis	3: Design & Development	4: Analysis, Design, Research	5: Modern Tool Usage	6: Society & Culture	7: Environment & Sustainability	8: Ethics	9: Individual & Team Work	10: Communication	11: Project Mgt. & Finance	12: Life Long Learning	13: PSO - 1	14: PSO - 2	15: PSO - 3
CLO-1 :	*Design and plan for various process and various manufacturing methodologies*	1,2	90	85	H	L	H	M	H	-	-	-	-	-	-	M	H	L	H
CLO-2 :	*Estimate various cost involved in a product*	1,2	90	85	H	M	-	M	-	-	-	-	-	-	M	H	H	L	M
CLO-3 :	*Estimate cost in different manufacturing shops*	1,2	90	85	H	H	-	H	-	-	-	-	-	-	M	M	M	L	H
CLO-4 :	*Estimate cost in different fabrication shops*	1,2	90	85	H	H	-	H	-	-	-	-	-	-	M	M	M	L	H
CLO-5 :	*Estimate machining time of various metal removal operations*	1,2	90	85	H	H	-	H	-	-	-	-	-	-	M	M	M	L	H
CLO-6 :	*Familiarize in process planning, costing and estimation of machining time*	1,2	90	85	H	H	M	M	M	-	-	-	-	-	M	M	M	L	H

		Process Planning	Costing and Estimation	Estimation of costs in different shops	Estimation of costs in fabrication shops	Estimation of machining times and costs
Duration (hour)		8	9	9	9	10
S-1	SLO-1	*Production system and Types of production*	*Objectives of costing and estimation*	*Estimation in foundry shop*	*Welding, Types of weld joints, Gas welding*	*Machine shop operations, Estimation of Machining time*
S-2	SLO-1	*Standardization and Simplification*	*costing and estimation: Functions and procedure*	*Pattern cost, Casting cost*	*Estimation of Gas welding cost, Gas cutting*	*Estimation of machining time for turning, knurling and facing operations : Tutorials*
S-3	SLO-1	*Production design and selection*	*Introduction to costs, Computing material cost*	*Cost estimation in Foundry shop: Tutorials-1*	*Arc welding: Equipments, Cost Estimation*	*Estimation of machining time for reaming, threading and tapping operations : Tutorials*
S-4	SLO-1	*Process planning, Selection and analysis*	*Direct labor cost, Analysis of overhead costs*	*Cost estimation in Foundry shop: Tutorials-2*	*Cost estimation in Welding shop: Tutorials-1*	*Estimation of machining time for drilling: Tutorials*
S-5	SLO-1	*Manual/Experience based planning, Variant type CAPP*	*Expenses: Factory expenses*	*Forging: Types, Operations*	*Cost estimation in Welding shop: Tutorials-2*	*Estimation of machining time for boring : Tutorials*
S-6	SLO-1	*Generative type CAPP*	*Administrative expenses, Selling and distributing expenses*	*Estimation of Losses and time in forging*	*Estimation in sheet metal shop*	*Estimation of machining time for shaping Tutorials*
S-7	SLO-1	*Economics of process planning, case studies*	*Cost ladder ,Cost of product*	*Estimation of Forging cost*	*Shearing and forming*	*Estimation of machining time for planning Tutorials*
S-8	SLO-1	*Processes analysis, Break even analysis*	*Depreciation, Analysis of depreciation*	*Cost estimation in Forging shop: Tutorials -1*	*Cost estimation in Sheet metal shop: Tutorials - 1*	*Estimation of machining time for milling operations : Tutorials*
S-9	SLO-1		*Problems in depreciation method*	*Cost estimation in Forging shop: Tutorials -2*	*Cost estimation in Sheet metal shop: Tutorials - 2*	*Estimation of machining time for grinding operations : Tutorials*
S-10	SLO-1					*Case studies: Estimation of cost for a product*

Learning Resources	1. Banga.T.R and Sharma.S.C, "MechanicalEstimating and Costing", Khanna publishers, New Delhi, 17th Edition, 2015. 2. Adithan.M.S and Pabla, "Estimating and Costing", Konark Publishers Pvt., Ltd, 2013. 3. Nanua Singh, "System Approach to Computer Integrated Design and Manufacturing", John Wiley & Sons, New York, 2011. 4. Joseph G. Monks, "Operations Management, Theory and Problems", McGraw Hill Book Company, New Delhi, 2008. 5. Narang.G.B.S and Kumar.V, "Production and Planning", Khanna Publishers, New Delhi, 2014. 6. Chitale.A.K and Gupta.R.C, "Product Design and manufacturing", Prentice Hall of India, New Delhi, 2014. 7. Peter Scalon, Process planning, Design/Manufacture Interface, Elsevier Sci. & Tech. 2002.

Learning Assessment

	Bloom's Level of Thinking	Continuous Learning Assessment (50% weightage)								Final Examination (50% weightage)	
		CLA – 1 (10%)		CLA – 2 (15%)		CLA – 3 (15%)		CLA – 4 (10%)#			
		Theory	Practice	Theory	Practice	Theory	Practice	Theory	Practice	Theory	Practice
Level 1	Remember Understand	40 %	-	30 %	-	30 %	-	30 %	-	30%	-
Level 2	Apply Analyze	40 %	-	40 %	-	40 %	-	40 %	-	40%	-
Level 3	Evaluate Create	20 %	-	30 %	-	30 %	-	30 %	-	30%	-
	Total	100 %		100 %		100 %		100 %		100 %	

CLA – 4 can be from any combination of these: Assignments, Seminars, Tech Talks, Mini-Projects, Case-Studies, Self-Study, MOOCs, Certifications, Conf. Paper etc.,

Course Designers

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2. Dr. A. Velayutham, DRDO, Avadi, velayudham.a@cvrde.drdo.in	*2. Dr.N.Arunachalam, IIT Madras, chalam@iitm.ac.in*	*Mr.M.Dhanasekaran, SRMIST*

Course Code	18MEE324T	Course Name	FOUNDRY ENGINEERING	Course Category	E	Professional Elective	L T P C	
							3 0 0 3	

Pre-requisite Courses	NIL	Co-requisite Courses	NIL	Progressive Courses	NIL
Course Offering Department	Mechanical Engineering	Data Book / Codes/Standards	NIL		

Course Learning Rationale (CLR):	*The purpose of learning this course is to:*
CLR-1 :	*Understand the basics of foundry, castings, limitations, patterns, materials, allowances*
CLR-2 :	*Learn design, types of mold, materials, equipment's, sand mold, core, runner, raiser air vents, gatings, methods of solidification.*
CLR-3 :	*Be familiar with the casting process, permanent mold, gravity, pressure die casting, centrifugal casting, precision, shell molding.*
CLR-4 :	*Melting, pouring, qualities issues, types of furnaces, remelting, molten metal treatment, pouring temperature, casting inspection, rectification, cause and remedies for casting defects, destructive testing, NDT, dye penetrant, magnetic particle, X-ray, elimination of dissolved gasses, use of statistical quality control in foundry.*
CLR-5 :	*Understand the Need and area for automation material handling, of raw, molten metal, storage and dispatch, overhead crane, trolley, pollution control, computers in castings and foundry.*
CLR-6 :	*Understand about castings, patterns, molds, quality control, modernization in foundry*

Course Learning Outcomes (CLO):	*At the end of this course, learners will be able to:*	Learning 1 Level of Thinking (Bloom)	2 Expected Proficiency (%)	3 Expected Attainment (%)	Program Learning Outcomes (PLO) 1 Engineering Knowledge	2 Problem Analysis	3 Design & Development	4 Analysis, Design, Research	5 Modern Tool Usage	6 Society & Culture	7 Environment & Sustainability	8 Ethics	9 Individual & Team Work	10 Communication	11 Project Mgt. & Finance	12 Life Long Learning	13 PSO - 1	14 PSO - 2	15 PSO - 3
CLO-1 :	*Understand the process in foundry, patterns, allowances*	*1&2*	*90*	*85*	*H*	*L*	*M*	*M*	*H*	*L*			*L*	*M*		*M*	*H*	*H*	*M*
CLO-2 :	*Learn the mold types, core making, methods of solidification*	*1&2*	*90*	*85*	*H*	*H*	*M*	*M*	*H*					*M*		*M*	*H*	*H*	*M*
CLO-3 :	*Study the various casting process*	*1*	*90*	*85*	*H*	*L*	*L*	*M*	*H*					*M*		*M*	*H*	*H*	*M*
CLO-4 :	*Gain knowledge about furnaces, and quality control in castings.*	*1&2*	*90*	*85*	*H*	*L*	*L*	*M*	*H*							*M*	*H*	*H*	*M*
CLO-5 :	*Understand the automation in foundry, for handling raw, molten metal finished products,*	*1&2*	*90*	*85*	*H*	*L*	*M*	*M*	*H*	*M*	*M*					*M*	*H*	*H*	*M*
CLO-6 :	*Learn the foundry techniques in broader sense and able to implement.*	*1&2*	*90*	*85*	*H*	*L*	*M*	*M*	*H*	*M*						*M*	*H*	*H*	*M*

		Foundry, patterns, materials, allowances.	Mold types, core making, runner and raisers,	– Different casting types, second operations, rework	Melting of metal and testing of casting and quality control	Modernization economic way of producing castings
Duration (hour)		9	9	9	9	9
S-1	SLO-1	*Introduction to foundry technology, ,*	*Types of mold*	*Types of casting process*	*Types of furnace*	*Need for modernization in foundry*
S-2	SLO-1	*Over view of Casting, patterns*	*Mold equipment's*	*Permanent molds, gravity casting*	*Selection of furnace*	*Materials handling*
S-3	SLO-1	*Patterns materials,*	*Mold and core preparation*	*Co2 process*	*Melting and remelting*	*In house metal melting and handling*
S-4	SLO-1	*allowances*	*Gatings*	*Image sharpening, Butterworth filters*	*Inspection of castings*	*Storage of raw materials,* .
S-5	SLO-1	*Castings limitations*	*Runner and raiser*	*Generation of spatial masks from frequency domain specification,*	*Defects analysis and remedies, molten metal purification.*	*work in process,* *Finished products*
S-6	SLO-1	*Tupes of patterns*	*Air vents and its importance*	*Basic steps in frequency domain filtering*	*Destructive testing, nondestructive testings.* *Magnetic particle testings, ultrasonic cell*	*Types of materials handling*
S-7	SLO-1	*Advantages of castings*	*So[idification,typesof solidification*	*Nonlinear filters, function, Max filter, Min filter*	*Quality control of castings, techniques.*	*Electric cranes and trolleys*
S-8	SLO-1	*Limitations of castings*	*Defects related to solidifications*	*Homomorphic filtering, False color, Pseudo color and its approaches and*	*Application of statistical quality control methods*	*pollution control*
S-9	SLO-1	*Assignment on casting, patterns and allowances*	*Assignment on molds, runner, riser, solidification*	*Assignments on image filtering in MATLAB/Open CV/Python*	*Assignment in furnace, casting defects* *Quality control*	*Assignment on automation,* *Materials handling,* *Materials handling equipments, pollution control*

Learning Resources	TEXT BOOKS 1. Complete casting handbook: Metal casting process, metallurgy., techniques and design-john Campbell. 2. Banga.T.R. and Agelhiarwal.R.I. Foundry engineering, Khanna publishers. New Delhi.1992. 3. Jain.P.L. Principles of foundry technology, Dhanpat rai & sons. New Delhi.1996 REFERRENCE BOOKS 4. Taylor.H.F.Flemings.M.C.and Wulff.J. Foundry engineering, WILEY EASTERN LTD. New Delhi.1989 5. Gupta.R.B. Foundry engineering, SATHYA PRAKASAM, New Delhi.1989. 6. ASM Metals, Hand book on castings, vol .15,14 th edition. 2002.

Learning Assessment

	Bloom's Level of Thinking	Continuous Learning Assessment (50% weightage)								Final Examination (50% weightage)	
		CLA – 1 (10%)		CLA – 2 (15%)		CLA – 3 (15%)		CLA – 4 (10%)#			
		Theory	Practice	Theory	Practice	Theory	Practice	Theory	Practice	Theory	Practice
Level 1	Remember Understand	40 %	-	30 %	-	30 %	-	30 %	-	30%	-
Level 2	Apply Analyze	40 %	-	40 %	-	40 %	-	40 %	-	40%	-
Level 3	Evaluate Create	20 %	-	30 %	-	30 %	-	30 %	-	30%	-
	Total	100 %		100 %		100 %		100 %		100 %	

CLA – 4 can be from any combination of these: Assignments, Seminars, Tech Talks, Mini-Projects, Case-Studies, Self-Study, MOOCs, Certifications, Conf. Paper etc.,

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2. Dr. A. Velayutham, DRDO, Avadi, velayudham.a@cvrde.drdo.in	*2. Dr.N.Arunachalam, IIT Madras, chalam@iitm.ac.in*	*2. Mr.V.Manojkumar, SRMIST*

Course Code	18MEE325T	Course Name	THEORY OF METAL FORMING	Course Category	E	Professional Elective	L	T	P	C
							3	0	0	3

Pre-requisite Courses	Nil	Co-requisite Courses	Nil	Progressive Courses	Nil
Course Offering Department	Mechanical Engineering	Data Book / Codes/Standards	Nil		

Course Learning Rationale (CLR):	*The purpose of learning this course is to:*
CLR-1 :	*Impart knowledge about various metal forming process*
CLR-2 :	*Be familiar with the stress criterion for plastic deformation*
CLR-3 :	*Attain the ability to identify the process parameters responsible for metal forming*
CLR-4 :	*Provide good exposure towards recent trends in metal forming process*
CLR-5 :	*Understand the defects and overcome with remedies*
CLR-6 :	*Be familiar with the basic science of metal forming, plastic deformation of bulk and sheet metals, in addition to acquire knowledge about the modern processes such as high velocity & super plastic forming.*

Course Learning Outcomes (CLO):	*At the end of this course, learners will be able to:*	Learning 1	2	3
		Level of Thinking (Bloom)	Expected Proficiency (%)	Expected Attainment (%)
CLO-1 :	*Apply & analyze the theories involved in plastic behavior of metals*	*1&2*	*90*	*85*
CLO-2 :	*Estimate the metal working process under various conditions*	*1,2&3*	*90*	*85*
CLO-3 :	*Appreciate the types of plastic forming and equipment's used.*	*1&2*	*90*	*85*
CLO-4 :	*Utilize the various processes of sheet metal forming.*	*1&2*	*90*	*85*
CLO-5 :	*Appreciate the importance of modern metal forming processes.*	*1&2*	*90*	*85*
CLO-6 :	*Apply the theories of plasticity and inspecting methods in various metal forming processes and produce engineering components*	*1,2&3*	*90*	*85*

Program Learning Outcomes (PLO)

	1	2	3	4	5	6	7	8	9	10	11	12	13	14	15
	Engineering Knowledge	Problem Analysis	Design & Development	Analysis, Design, Research	Modern Tool Usage	Society & Culture	Environment & Sustainability	Ethics	Individual & Team Work	Communication	Project Mgt. & Finance	Life Long Learning	PSO - 1	PSO - 2	PSO - 3
CLO-1	*H*	*M*	*L*	*L*									*H*	*H*	*H*
CLO-2	*H*	*M*	*L*	*L*									*H*	*M*	*H*
CLO-3	*H*				*M*								*H*	*L*	*H*
CLO-4	*H*				*M*								*H*	*L*	*H*
CLO-5	*H*				*M*								*H*	*L*	*H*
CLO-6	*H*	*M*	*L*	*L*	*M*								*H*	*H*	*H*

Duration (hour)		9	9	9	9	9
S-1	SLO-1	*Theory of plasticity: State of stress*	*Mechanics of metal working -Flow stress determination*	*Classification of rolling process, Types of rolling mills, Hot and cold rolling*	*Introduction to Sheet metal forming processes*	*Comparison with conventional forming methods*
S-2	SLO-1	*Components of Stress- Stress tensor*	*Effect of temperature in metal working*	*Forces and geometric relationship in rolling*	*Rod and wire drawing equipment*	*High Energy Rate Forming, fine blanking*
S-3	SLO-1	*Engineering stress strain relationship*	*Strain rate effects*	*Rolling of bars and shapes, Rolling defects, causes and remedies*	*Shearing, blanking, bending, stretch forming,*	*P/M forging-Isothermal forging*
S-4	SLO-1	*Flow curve and flow rules*	*Hot, cold and warm working*	*Classification of Forging process, Forging Equipment, Open and closed die forging*	*Explosive and press brake forming*	*Electrohydraulic forming*
S-5	SLO-1	*True stress and true strain*	*Metallurgical structure, Anisotropy*	*Forging defects, residual stresses*	*Deep drawing & tube drawing*	*Magnetic pulse forming*
S-6	SLO-1	*Yield criteria*	*Effects of hardening ,friction and lubrication*	*Classification of extrusion process, Variables affecting extrusion*	*Principles and process parameters*	*Rubber pad forming*
S-7	SLO-1	*Slip line field theory*	*Hydrostatic pressure*	*Hydrostatic extrusion, Production of seamless pipe and tubing*	*Sheet metal formability*	*Superplastic forming*
S-8	SLO-1	*Plastic work, Plastic anisotropy*	*Workability, Spring back*	*Deformation, lubrication and defects in extrusion*	*Formability limit diagram*	*Types of Severe plastic forming: ECAP*
S-9	SLO-1	*Plastic deformation of crystals*	*Residual stresses, Deformation processing system*	*Basics of Severe plastic deformation and its approaches*	*Defects in formed parts*	*Accumulative Roll Bonding*

Learning Resources	1. *George E Dieter, "Mechanical Metallurgy", Tata McGraw-Hill Education Pvt. Ltd, 2014.* 2. *Iuzalec, Andrzej, "Theory of Metal Forming Plasticity", Springer Berlin Heidelberg, 2010* 3. *A.Rosochowski, "Severe Plastic Deformation Technology", Whittles Publishing, 2017.* 4. *Z. R. Wang, Weilong Hu, S. J. Yuan, Xiaosong Wang, "Engineering Plasticity: Theory and Applications in Metal Forming", Wiley, 2018, ISBN: 978-1-119-23730-3* 5. *Serope Kalpakjian and Stevan R Schmid, "Manufacturing Process for Engineering Materials", Pearson Education, 2007*	6. *Surendar Kumar, "Technology of Metal Forming Processes", PHI Learning Pvt Ltd, 2008* 7. *William F Hasford, Robert M Caddell "Metal Forming: Mechanics and Metallurgy", Cambridge University Press, 2011* 8. *ASM "Metals Handbook, Volume 14, Forming and Forging", ASM Metals Park, Ohio, USA, 1998*

Learning Assessment											
	Bloom's Level of Thinking	Continuous Learning Assessment (50% weightage)								Final Examination (50% weightage)	
		CLA – 1 (10%)		CLA – 2 (15%)		CLA – 3 (15%)		CLA – 4 (10%)#			
		Theory	Practice	Theory	Practice	Theory	Practice	Theory	Practice	Theory	Practice
Level 1	Remember Understand	40 %	-	30 %	-	30 %	-	30 %	-	30%	-
Level 2	Apply Analyze	40 %	-	40 %	-	40 %	-	40 %	-	40%	-
Level 3	Evaluate Create	20 %	-	30 %	-	30 %	-	30 %	-	30%	-
	Total	100 %		100 %		100 %		100 %		100 %	

CLA – 4 can be from any combination of these: Assignments, Seminars, Tech Talks, Mini-Projects, Case-Studies, Self-Study, MOOCs, Certifications, Conf. Paper etc.,

Course Designers		
Experts from Industry	Experts from Higher Technical Institutions	Internal Experts
R.GNANAKARAN AGM-Human Resources Super Auto Forge Pvt.Ltd Kolapakkam.Mobile:98849 06001, Email: gnanakaran@superautoforge.net Tel:044 40753611	*Dr. Uday Chakkingal, IITM*	*Mr.S.Sasikumar , SRMIST*
2. Dr. A. Velayutham, DRDO, Avadi, velayudham.a@cvrde.drdo.in	*Dr.V..S. Sethilkumar,CEG,Anna University*	*Dr.U. Mohammed Iqbal , SRMIST*

Course Code	18MEE326T	Course Name	WELDING TECHNOLOGY	Course Category	E	Professional Elective	L	T	P	C
							3	0	0	3

Pre-requisite Courses	Nil	Co-requisite Courses	Nil	Progressive Courses	Nil
Course Offering Department	Mechanical Engineering	Data Book / Codes/Standards	Nil		

Course Learning Rationale (CLR):	*The purpose of learning this course is to:*
CLR-1 :	*Be familiar with the welding power sources and welding fundamentals*
CLR-2 :	*Be familiar with the fusion welding processes*
CLR-3 :	*Be familiar with the solid-state welding processes*
CLR-4 :	*attain the knowledge about welding metallurgy*
CLR-5 :	*attain the knowledge about brazing and soldering technology*
CLR-6 :	*Understand the concept of weldability, weld quality, welding defects and welding inspection*

Course Learning Outcomes (CLO):	*At the end of this course, learners will be able to:*	Learning 1: Level of Thinking (Bloom)	2: Expected Proficiency (%)	3: Expected Attainment (%)	PLO 1: Engineering Knowledge	2: Problem Analysis	3: Design & Development	4: Analysis, Design, Research	5: Modern Tool Usage	6: Society & Culture	7: Environment & Sustainability	8: Ethics	9: Individual & Team Work	10: Communication	11: Project Mgt. & Finance	12: Life Long Learning	13: PSO - 1	14: PSO - 2	15: PSO - 3
CLO-1 :	*Understand the fundamentals of welding processes and to recognize the importance of arc physics , weld protection*	1 & 2	90	85	H	M	L	M	-	-	M	M	-	-	-	-	H	L	M
CLO-2 :	*Understand the fusion welding processes and to recognize the various types of fusion techniques and be able to apply those techniques for any work*	1, 2 &3	90	85	H	M	M	H	M	-	H	M	-	-	-	-	H	M	H
CLO-3 :	*Understand the solid-state welding processes and to recognize the various types of solid-state techniques and be able to apply those techniques for any work*	1, 2 &3	90	85	H	M	M	H	M	-	H	M	-	-	-	-	H	H	H
CLO-4 :	*Obtained the knowledge about welding metallurgy and be able to apply the principle of metallurgy to recognize weld joint microstructure*	1, 2 &3	90	85	H	H	-	H	-	-	H	M	-	-	-	-	H	M	M
CLO-5 :	*Understand the concept of brazing and soldering techniques and able to apply the concept to critical welding aspects*	1 & 2	90	85	H	L	L	L	-	-	M	M	-	-	-	-	H	L	M
CLO-6 :	*Understand the concept of weldability, weld quality, and welding defects, acquire the knowledge of welding inspection and testing and be able to apply the concept to identify any weld defects*	1, 2 &3	90	85	H	H	M	H	L	-	M	M	-	-	-	-	H	M	H

		Welding Fundamentals & Basic Fusion Welding Processes	Advanced Fusion Welding Processes	Solid-State Welding Processes	Welding Metallurgy	Weld Quality & Inspection
Duration (hour)		9	9	9	9	9
S-1	SLO-1	*Manufacturing and Joining, Welding, Need for welding, Applications, Advantages and Disadvantages*	*Fundamentals of gas metal arc welding, process variables, effect of filler metals on weld*	*Fundamental aspects of solid state processes, common process variables, bonding mechanism*	*Basic solidification concepts, solidification modes and constitutional supercooling, dendrite and cell spacing*	*Design of weldments, Concept of weldability*
S-2	SLO-1	*Fundamental Mechanisms of welding, Classifications of welding process*	*Fundamentals of gas tungsten arc welding, process variables, flux*	*Fundamentals of forge welding, characteristics, application*	*Epitaxial and nonepitaxial growth, effect of welding parameters, weld metal nucleation mechanisms*	*Weldability of ferrous and nonferrous alloys, Weldability test method*
S-3	SLO-1	*Heat Input and Power density of different welding processes, Cooling rate effect*	*Pulsed TIG Welding process, process variables*	*Fundamentals of roll bonding, characteristics, application*	*Dissimilar welds: issues and solutions*	*Fundamental concepts of residual stress and distortion,*
S-4	SLO-1	*Weld protection, Shielding gas, Flux, Types of flux coatings*	*Cold metal transfer welding process , Process Variables*	*Fundamentals of ultrasonic welding, characteristics, application*	*Weld Thermal Cycle*	*Welding defects, classification and characteristics*
S-5	SLO-1	*Principle of Fusion welding process, Gas welding process, Types of flames in gas welding process*	*Fundamentals of flux cored arc welding, process variables, electrode classification*	*Fundamentals of friction welding, characteristics, application*	*Heat affected zone thermal cycle*	*Solidification crack, Hydrogen induced crack*
S-6	SLO-1	*Shielded Metal arc welding process, welding variables, electrode classification, Physics of welding arc, polarity*	*Fundamentals of submerged arc welding, process variables, flux*	*Fundamentals of friction stir welding, process variables, application*	*Post weld heat treatment of weldments: Need and selection of PWHT parameters*	*Destructive testing of welded joints, tensile and hardness*

S-7	SLO-1	*Volt - Ampere Characteristics: Constant current, constant voltage and alternating current*	*Fundamentals of plasma arc welding, process variables, Hybrid Plasma TIG process.*	*Friction stir welding tools, effect of tool geometry*	*Formation of heat affected zone, recrystallization and grain growth*	*Destructive testing of welded joints, toughness, fatigue and creep*
S-8	SLO-1	*Arc characteristics: Arc plasma, effect of temperature, Arc distribution, Arc blow*	*Fundamentals of resistance welding, process variables, types*	*Fundamentals of explosive welding, characteristics, application*	*Fundamental concepts of brazing, characteristics, applications*	*Concept of non-destructive testing, classification*
S-9	SLO-1	*Fundamentals of weld bead geometry, Types of welded joints, Welding positions and welding processes*	*Fundamentals of laser beam welding, process variables, Hybrid laser welding process*	*Fundamentals of diffusion bonding process, process variables, applications*	*Fundamental concepts of soldering, characteristics, applications*	*Concept of Radiography, dye penetration and Ultrasonic test*

Learning Resources	1. *John C. Lippold, Welding Metallurgy and Weldability, John Wiley & Sons, Inc., publication, 2015.*
	2. *A.C. Davies, The science and practice of welding, Vol. 1 and 2, Tenth Edition, Cambridge University Press, 2010.*
	3. *Welding Handbook – 9th Edition, Volume 1 to volume 5, American Welding Society, 2007.*
	4. *Sindo Kou, Welding Metallurgy, 2nd edition, John Wiley & Sons, Inc., publication, 2003.*
	5. *Robert W. Messler, Jr., Principles of Welding-Processes, Physics, Chemistry, and Metallurgy, John Wiley & Sons, Inc., publication, 1999.*
	6. *R S Parmar, Welding Engineering and Technology, Khanna Publisher, 2008*
	7. *O. P. Khanna, Welding Technology, Dhanpat Rai Publications; 2013 edition (2011)*
	8. *Richard L. Little, Welding and Welding Technology, McGraw Hill Education (1 July 2017)*

Learning Assessment

	Bloom's Level of Thinking	Continuous Learning Assessment (50% weightage)								Final Examination (50% weightage)	
		CLA – 1 (10%)		CLA – 2 (15%)		CLA – 3 (15%)		CLA – 4 (10%)#			
		Theory	Practice	Theory	Practice	Theory	Practice	Theory	Practice	Theory	Practice
Level 1	Remember Understand	40 %	-	30 %	-	30 %	-	30 %	-	30%	-
Level 2	Apply Analyze	40 %	-	40 %	-	40 %	-	40 %	-	40%	-
Level 3	Evaluate Create	20 %	-	30 %	-	30 %	-	30 %	-	30%	-
	Total	100 %		100 %		100 %		100 %		100 %	

CLA – 4 can be from any combination of these: Assignments, Seminars, Tech Talks, Mini-Projects, Case-Studies, Self-Study, MOOCs, Certifications, Conf. Paper etc.,

Course Designers

Experts from Industry	Experts from Higher Technical Institutions	Internal Experts
Dr. B. Arivazhagan *Scientific Officer- E* *Materials Technology Division* *Metallurgy and Materials Group* *IGCAR, Kalpakkam 603 102*	*Dr. P. Sathiya, Professor, Department of Production Engineering, NIT Trichy*	*Dr. Madhavan S, SRMIST*
Dr. Manidipto Mukherjee *Sr. Scientist* *Advanced Manufacturing Centre,* *Design and Manufacturing Research Group,* *CSIR-Central Mechanical Engineering Research Institute,* *Mahatma Gandhi Rd., City Centre, Durgapur 713209, West Bengal, India*	*Dr.S.Aravindan, Professor, Department of Mechanical Engineering, IIT Delhi*	*Dr. Shashi Kumar, SRMIST*

Course Code	18MEE327T	Course Name	MECHANICAL HANDLING SYSTEMS AND EQUIPMENT	Course Category	E	Professional Elective	L	T	P	C
							3	0	0	3

Pre-requisite Courses	NIL	Co-requisite Courses	NIL	Progressive Courses	NIL
Course Offering Department	Mechanical Engineering	Data Book / Codes/Standards	PSG Tech "Design Data Book" Kalaikathir Achchagam Coimbatore		

Course Learning Rationale (CLR):	*The purpose of learning this course is to:*
CLR-1 :	*Be familiar with Fundamentals of material handling and intraplant transporting facilities*
CLR-2 :	*Be familiar with Common material handling systems*
CLR-3 :	*Be familiar with automated feeding mechanism and design*
CLR-4 :	*Be familiar with Unit Built Machines (UBM), Automated systems in transfer lines*
CLR-5 :	*Be familiar with Transfer mechanisms, conveyors, part feeding devices*
CLR-6 :	*Be familiar with material handling equipments,and their automated systems*

Course Learning Outcomes (CLO):	*At the end of this course, learners will be able to:*	Learning 1: Level of Thinking (Bloom)	Learning 2: Expected Proficiency (%)	Learning 3: Expected Attainment (%)	PLO 1: Engineering Knowledge	PLO 2: Problem Analysis	PLO 3: Design & Development	PLO 4: Analysis, Design, Research	PLO 5: Modern Tool Usage	PLO 6: Society & Culture	PLO 7: Environment & Sustainability	PLO 8: Ethics	PLO 9: Individual & Team Work	PLO 10: Communication	PLO 11: Project Mgt. & Finance	PLO 12: Life Long Learning	PLO 13: PSO - 1	PLO 14: PSO - 2	PLO 15: PSO - 3
CLO-1 :	*Understand about Fundamentals of material handling and intraplant transporting facilities*	1	90	85	H	M	L	L	L							M	H	H	M
CLO-2 :	*Acquire knowledge on Common material handling systems*	1&2	90	85	H	M	M	M	H							M	H	L	M
CLO-3 :	*Acquire knowledge on automated feeding mechanism and design*	1&2	90	85	H	L	M	M	H							M	H	L	M
CLO-4 :	*Understand the Automated systems in transfer lines*	1&2	90	85	H	L	M	M	H							M	H	H	M
CLO-5 :	*Understand Transfer mechanisms, conveyors, part feeding devices*	1	90	85	H	L	M	M	H							M	H	L	H
CLO-6 :	*Understand material handling equipments, and their automated systems*	1&2&3	90	85	H	L	M	M	H							M	H	H	H

		Introduction	Common Material Handling Equipment	Automation of Material Handling	Classification of Automated System	Automated Material Handling Equipment
Duration (hour)		9	9	9	9	9
S-1	SLO-1	*Introduction to work handling concepts - types of intraplant transporting facility*	*Concepts of Unit Loads, Material handling and Storage*	*Automated feeding arrangements for discrete parts*	*Concepts of Unit Built Machines (UBM)*	*Automated handling and storage systems in manufacturing environment*
S-2	SLO-1	*Principles of material handling-manual and mechanical handling*	*Equipments operation and selection*	*Design based in work piece requirements, orienting methods*	*Gain lean and green endorsement, collaboration to achieve lean and green goals*	*Rail Guided Vehicles (rgvs), Automated Guided Vehicles (agvs)*
S-3	SLO-1	*Principle groups of material handling*	*Containers, Pallets, Conveyor systems, Industrial trucks, Wagon tipplers*	*One by one feeding, agonizing, stapling etc*	*Classification and elements, Power Units, self-contained and separate feed type, Change over UBM*	*Applications of rgvs and agvs, Automated Storage and Retrieval Systems (AS / RS)*
S-4	SLO-1	*Choice of material handling equipment, hoisting equipment*	*Transporters, stackers, reclaimers*	*Feeding continuous material liquids, granules etc*	*Transfer lines – classification and their components*	*AS / RS in the Automated factory*
S-5	SLO-1	*Surface and overhead equipment-General characteristics of overhead equipments and their application*	*Silos & hoppers and their accessories, Ropeways, Ship loaders, Cable cranes*	*Automated assembly system, elements,*	*Automated systems for handling and transfer of prismatic, axis symmetric parts and asymmetric parts in transfer lines*	*Considerations for planning an AS /RS system, Applications of AS / RS*
S-6	SLO-1	*Introduction to control of hoisting equipments*	*Container handling systems, Electric lifts*	*Automated assembly system ,configuration design, details and control*	*Case studies on transfer lines – interlocked*	*Principles of work holding devices – Modular fixturing*
S-7	SLO-1	*Storage – open and closed storage systems*	*Hoists, EOT cranes, Elevators*	*Special feeding mechanisms*	*Case studies on palletized and flexible inter linkage transfer lines*	*Flexible fixturing systems*
S-8	SLO-1	*Bulk loading, Unloading, Shipping*	*Material handling equipments in Steel mills, Power plants, Mines, Automobile and Transport Industries*	*Automated inspection and their design*	*Control systems for flexible inter linkage transfer lines*	*Fixturing for FMS*
S-9	SLO-1	*Receiving systems and operations-First in first out(FIFO),last in first out(LIFO)*	*Large scale Constructions etc. Case Study for All Above Mentioned Handling systems.*	*Case study for automated material handling.*	*SWARF handling and disposal systems*	*Robots and their applications in handling and storage*

Learning Resources	1. *Groover. M. P., "Automation, Production Systems and CIM", Prentice hall India, 2007.* 2. *Morris A. Cohen, Uday M. Apte., "Manufacturing Automation", Irwin, Chicago,* 3. *James A. Tompkins., "Facilities planning", John wiley& Sons Inc, 1984.* 4. *James. M. Apple, "Principles of layout and material handling", Ronald press, 1977* 5. *N.Rudenko" Materials Handling equipment" Envee publisher,New Delhi*

Learning Assessment

	Bloom's Level of Thinking	Continuous Learning Assessment (50% weightage)								Final Examination (50% weightage)	
		CLA – 1 (10%)		CLA – 2 (15%)		CLA – 3 (15%)		CLA – 4 (10%)#			
		Theory	Practice	Theory	Practice	Theory	Practice	Theory	Practice	Theory	Practice
Level 1	Remember Understand	40 %	-	30 %	-	30 %	-	30 %	-	30%	-
Level 2	Apply Analyze	40 %	-	40 %	-	40 %	-	40 %	-	40%	-
Level 3	Evaluate Create	20 %	-	30 %	-	30 %	-	30 %	-	30%	-
	Total	100 %		100 %		100 %		100 %		100 %	

CLA – 4 can be from any combination of these: Assignments, Seminars, Tech Talks, Mini-Projects, Case-Studies, Self-Study, MOOCs, Certifications, Conf. Paper etc.,

Course Designers

Experts from Industry	Experts from Higher Technical Institutions	Internal Experts
1. Dr. R. Kalimuthu, ISRO, Mahendragiri, r_kalimuthu@vssc.gov.in, rkpearls@yahoo.com	*1. Dr. P. Hariharan, Anna University, hari@annauniv.edu, hariharan2311@gmail.com*	*1. Mr. C. Balasuthagar, SRMIST*
2. Dr. A. Velayutham, DRDO, Avadi, velayudham.a@cvrde.drdo.in	*2. Dr.N.Arunachalam, IIT Madras, chalam@iitm.ac.in*	*Dr. M. Iqbal, SRMIST*

Course Code	18MEE328T	Course Name	NON-TRADITIONAL MACHINING TECHNIQUES	Course Category	E	Professional Elective	L	T	P	C
							3	0	0	3

Pre-requisite Courses	Nil	Co-requisite Courses	Nil	Progressive Courses	Nil
Course Offering Department	Mechanical Engineering	Data Book / Codes/Standards	Nil		

Course Learning Rationale (CLR):	*The purpose of learning this course is to:*
CLR-1 :	*Be familiar with the concept of Non-traditional machining techniques and their need and advantages over traditional machining techniques*
CLR-2 :	*Be familiar with the classification of Non-traditional machining techniques*
CLR-3 :	*Be familiar with the Mechanical energy based Non-traditional machining techniques*
CLR-4 :	*Be familiar with the Electro-chemical energy based Non-traditional machining techniques*
CLR-5 :	*Be familiar with the Thermal energy based Non-traditional machining techniques*
CLR-6 :	*Be familiar with the latest developments in various Non-traditional machining techniques*

Course Learning Outcomes (CLO):	*At the end of this course, learners will be able to:*	Learning 1: Level of Thinking (Bloom)	Learning 2: Expected Proficiency (%)	Learning 3: Expected Attainment (%)	PLO 1: Engineering Knowledge	PLO 2: Problem Analysis	PLO 3: Design & Development	PLO 4: Analysis, Design, Research	PLO 5: Modern Tool Usage	PLO 6: Society & Culture	PLO 7: Environment & Sustainability	PLO 8: Ethics	PLO 9: Individual & Team Work	PLO 10: Communication	PLO 11: Project Mgt. & Finance	PLO 12: Life Long Learning	PLO 13: PSO - 1	PLO 14: PSO - 2	PLO 15: PSO - 3
CLO-1 :	*Differentiate between Traditional and Non-traditional machining techniques.*	*1, 2*	*90*	*85*	*H*	-	-	-	-	-	*M*	-	-	-	-	-	-	-	*M*
CLO-2 :	*Acquire knowledge on basic components and working principles of different Non-traditional machining techniques.*	*1*	*90*	*85*	*H*	-	-	-	-	-	-	-	-	-	-	-	*H*	-	-
CLO-3 :	*Understand the major process parameters like operating voltage, current, time on, time off etc.*	*1*	*90*	*85*	*H*	-	-	-	*M*	-	-	-	-	-	-	-	*H*	-	-
CLO-4 :	*Evaluate the effect of various process parameters on machining characteristics like surface roughness, surface integrity, etc.*	*1, 2, 3*	*90*	*85*	*H*	-	-	-	*L*	-	-	-	-	-	-	-	*H*	-	-
CLO-5 :	*Learn the processes of machining hard to cut and high strength materials and alloys.*	*1, 2*	*90*	*85*	*H*	-	-	-	*L*	-	*M*	-	-	-	-	-	*H*	-	-
CLO-6 :	*Understand the recent developments and applications in Non-traditional machining techniques.*	*1, 3*	*90*	*85*	*H*	-	-	-	-	-	-	-	-	-	-	-	*H*	-	*M*

		Basics of Non-Traditional Machining and Mechanical Energy Techniques-I	Mechanical Energy Techniques-II	Chemical and Electro Chemical Techniques	Thermo Electrical Energy Techniques	Thermal Energy Techniques
Duration (hour)		9	9	9	9	9
S-1	SLO-1	*Introduction of non-traditional machining*	*Operating principles and equipment of water jet machining*	*Fundamentals, operating principle, advantages, limitations, applications of chemical machining process.*	*Operating principles and equipment of electrical discharge machining*	*Operating principle and equipment of electron beam machining*
	SLO-2	*Difference between traditional and non-traditional machining*	*Process parameters, applications, advantages and limitations of water jet machining*	*Classification and selection of Etchant and maskant*	*Subsystems of electrical discharge machining*	*Generation and control of electron beam*
S-2	SLO-1	*Need for non-traditional machining*	*Operating principles and equipment of abrasive water jet machining*	*Operating principles, equipment and subsystems of electrochemical machining*	*Power circuits and electrode feed mechanism in electrical discharge machining*	*Parameters influencing metal removal in electron beam machining*
	SLO-2	*Machining characteristics and classification of non-traditional machining*	*Mechanism of metal removal in abrasive water jet machining*	*Material removal rate and tool design in electrochemical machining*	*Process parameters, selection of tool electrode in electrical discharge machining*	*applications, advantages and limitations of electron beam machining*
S-3	SLO-1	*Consideration in process and material selection.*	*Parameters influencing metal removal rate*	*Tool Material, Tool Feed System, Design For Electrolyte Flow*	*Dielectric fluids and flushing methods in electrical discharge machining*	*Operating principle and equipment of plasma arc machining*
	SLO-2	*Applications of non-traditional machining*	*Applications, advantages and limitations of abrasive water jet machining*	*Process parameters in electrochemical machining*	*Characteristics of spark eroded surface*	*Gas mixture, Types of Torches of plasma arc machining*
S-4	SLO-1	*Operating principle, elements and equipment of Ultrasonic machining*	*Operating principle and equipment of abrasive flow machining*	*Problems for estimation of material removal rate in electrochemical machining*	*Recast layer formation*	*Parameters influencing metal removal in plasma arc welding*
	SLO-2	*Tool feed Mechanism*	*Mechanism of metal removal in abrasive flow machining*	*Advantages, limitations, applications and recent development of electrochemical machining*	*Surface finish and machining accuracy in electrical discharge machining*	*Applications, advantages and limitations of plasma arc machining*

S-5	SLO-1	*Cook's model for material removal*	*Process parameters in abrasive flow machining*	*Operating principle and equipment of electro chemical grinding*	*Tool Electrode design, Tool wear characteristics of spark eroded surfaces*	*Operating principle and equipment of laser beam machining*
	SLO-2	*Problems in estimation of Material removal rate (MRR) for Ultrasonic machining*	*Classification of abrasive flow machining, Applications, advantages and limitations of abrasive flow machining*	*Metal removal rate and process parameters in electro chemical grinding*	*Problems in estimation of material removal rate in electrical discharge machining*	*Process Characteristics and Thermal Features of laser beam machining*
S-6	SLO-1	*Process parameters of Ultrasonic machining*	*Operating Principle of magnetic abrasive machining*	*Problems for estimation of metal removal rate in electro chemical grinding*	*Operating principle of wire cut electrical discharge machining*	*Types of lasers used in laser beam machining*
	SLO-2	*Applications, Advantages and limitations of Ultrasonic machining*	*Elements and equipment of magnetic abrasive machining*	*Process Characteristics of electro chemical grinding*	*Equipment of wire cut electrical discharge machining*	*Parameters influencing metal removal, applications, advantages and limitations of laser beam machining*
S-7	SLO-1	*Operating Principle of Abrasive jet machining*	*Mechanism of metal removal in magnetic abrasive machining*	*Benefits, limitations and applications of electro chemical grinding*	*Process parameters of wire cut electrical discharge machining*	*Operating principle and equipment of Ion beam machining*
	SLO-2	*Elements and equipment of Abrasive jet machining*	*Process parameters of magnetic abrasive machining*	*Recent developments in electro chemical grinding process*	*Advantages, limitations and applications of wire cut electrical discharge machining*	*Process Characteristics of Ion beam machining*
S-8	SLO-1	*Mechanism of metal removal in Abrasive jet machining*	*Applications, advantages and limitations of magnetic abrasive machining*	*Electrochemical Drilling*	*Operating principles and equipment in electrical discharge grinding*	*Material removal rate, Accuracy and surface effects in Ion beam machining*
	SLO-2	*Process parameters of Abrasive jet machining*	*Process capabilities of magnetic abrasive machining*	*Electro Stream (Capillary) and Electrochemical jet drilling.*	*Process parameters, surface finish and machining accuracy in electrical discharge grinding*	*Parameters influencing metal removal rate*
S-9	SLO-1	*Process capabilities of Abrasive jet machining*	*Operating Principle of Ice jet machining*	*Fundamentals of electro chemical honing*	*Machine tool selection*	*Applications, advantages and limitations of Ion beam machining*
	SLO-2	*Applications, Advantages and limitations of Abrasive jet machining*	*Process description of Ice jet machining*	*Fundamentals of deburring process*	*Application and recent developments in electrical discharge grinding*	*Recent developments and trends in Thermal energy based non-traditional machining techniques*

Learning Resources	*P. C. Pandey and H.S. Shan, "Modern Machining Processes", McGraw Hill, 2017.* *Vijay K. Jain, "Advanced Machining Processes". Allied Publishers, 2007.* *P K Mishra, "Nonconventional Machining", Narosa Publishing House, 2007.* *G. F. Benedict, "Non-Traditional Manufacturing Processes", CRC Press, New York, 1987.* *Sahu R.K. and Somashekhar S.H, "Corona Discharge Micromachining for the Synthesis of Nanoparticles: Characterization and Applications", CRC Press, Taylor & Francis, New York, 2019.*	*Amithaba Bhattacharya, 'New Technology', Tata McGraw Hill, 2006.* *Hassan El-Hofy, 'Advanced Machining Processes', McGraw Hill, 2005.* *Wellar P C, 'Non-Traditional Machining Processes', SME Michigan, 1984.* *Carl Sommer, 'Non Traditional Machining Handbook', Advanced Pub, 2000.*

Learning Assessment

	Bloom's Level of Thinking	Continuous Learning Assessment (50% weightage)								Final Examination (50% weightage)	
		CLA – 1 (10%)		CLA – 2 (15%)		CLA – 3 (15%)		CLA – 4 (10%)#			
		Theory	Practice	Theory	Practice	Theory	Practice	Theory	Practice	Theory	Practice
Level 1	Remember Understand	40 %	-	30 %	-	30 %	-	30 %	-	30%	-
Level 2	Apply Analyze	40 %	-	40 %	-	40 %	-	40 %	-	40%	-
Level 3	Evaluate Create	20 %	-	30 %	-	30 %	-	30 %	-	30%	-
	Total	100 %		100 %		100 %		100 %		100 %	

CLA – 4 can be from any combination of these: Assignments, Seminars, Tech Talks, Mini-Projects, Case-Studies, Self-Study, MOOCs, Certifications, Conf. Paper etc.,

Course Designers

Experts from Industry	Experts from Higher Technical Institutions	Internal Experts
1. Mr.K.Balasubramanian, AGM, Lucas TVS Ltd., Puducherry	*1. Dr.V.Satheesh Kumar, Assistant Professor, Production Engg., NIT Trichy*	*1. Mr.V.Veeranaath, SRMIST*
2. Mr.Durga PrasadPadhy, Manager, Vendata Resources Ltd., Jharsuguda, Orissa		*2. Dr.Ranjeet Kumar Sahu, SRMIST*

Course Code	18MEE329T	Course Name	MODERN MANUFACTURING TECHNIQUES	Course Category	E	Professional Elective	L	T	P	C
							3	0	0	3

Pre-requisite Courses	NIL	Co-requisite Courses	NIL	Progressive Courses	NIL
Course Offering Department	Mechanical Engineering	Data Book / Codes/Standards	NIL		

Course Learning Rationale (CLR):	*The purpose of learning this course is to:*
CLR-1 :	*Be familiar with the modern casting methods*
CLR-2 :	*Know the modern methods of manufacturing from powders*
CLR-3 :	*Be familiar with the micro-electronic manufacturing*
CLR-4 :	*Acquire knowledge about polymers and composites manufacturing*
CLR-5 :	*Learn the methods of rapid prototyping and additive manufacturing*
CLR-6 :	*Be acquainted with manufacturing approaches of modern intricate products*

Course Learning Outcomes (CLO):	*At the end of this course, learners will be able to:*	Learning 1: Level of Thinking (Bloom)	2: Expected Proficiency (%)	3: Expected Attainment (%)	PLO 1: Engineering Knowledge	2: Problem Analysis	3: Design & Development	4: Analysis, Design, Research	5: Modern Tool Usage	6: Society & Culture	7: Environment & Sustainability	8: Ethics	9: Individual & Team Work	10: Communication	11: Project Mgt. & Finance	12: Life Long Learning	13: PSO - 1	14: PSO - 2	15: PSO - 3
CLO-1 :	*Acquire knowledge of modern and non-conventional casting methods for manufacturing complex intricate shapes of metals*	*1 & 2*	*90*	*85*	*H*				*L*		*M*						*H*		*H*
CLO-2 :	*Understand the manufacturing methods using powders of metals and ceramics*	*1 & 2*	*90*	*85*	*H*				*M*		*M*						*H*		*H*
CLO-3 :	*Get acquaintance with manufacturing methods of semiconductors and microelectronic devices*	*1, 2,3*	*90*	*85*	*H*				*H*		*L*						*H*		*M*
CLO-4 :	*Obtain knowledge of polymers and composites manufacturing methods*	*1 & 2*	*90*	*85*	*H*						*L*						*H*		*H*
CLO-5 :	*Understand the purpose and methods of rapid prototyping and additive manufacturing*	*1 & 2*	*90*	*85*	*H*				*H*								*H*		*M*
CLO-6 :	*Identify suitable methods for various product manufacturing*	*1, 2 ,3*	*90*	*85*	*H*				*H*		*L*						*H*		*M*

		Modern Casting Methods	Modern Forming Methods	Manufacturing Of Semiconductors And Electronic Deivices	Manufacturing Of Composite Materials	Rapid Proptotyping And Additive Manufacturing
Duration (hour)		9	9	9	9	9
S-1	SLO-1	*Introduction to conventional and modern casting methods*	*High speed metal forming- Explosive, Electromagnetic and electrohydraulic*	*Semiconductors and silicon-Introduction, Structure of silicon, Properties*	*Selection of composite matrices and reinforcements*	*Rapid prototyping - Introduction, Steps in RP Technology, STL Format, Support Structures*
S-2	SLO-1	*Expendable pattern casting - Pattern making process, Advantages, Applications*	*Semisolid metal forming Types (Thixocasting, Rheocasting, Thixomolding) Advantages, Applications*	*Crystal growing and wafer preparation*	*Overview of polymer matrix composites, Types of reinforcements, Preforms, Prepegs*	*Rapid prototyping- Advantages, Limitations, Applications*
S-3	SLO-1	*Plaster mold casting – Conventional and Antioch Process, Advantages, Applications*	*Peen forming of sheet metals - Process, Advantages, Applications*	*Film deposition -Evaporation, Sputtering, CVD*	*Open mould processes - Hand lay-up, Spray-up, Vacuum Bagging, Automated tape -laying machines*	*Introduction to Additive Manufacturing for product development – Advantages, Materials*
S-4	SLO-1	*Ceramic mold casting - Process, Advantages, Applications*	*Super plastic forming - Material requirements, Advantages, Disadvantages*	*Oxidation - Dry oxidation, Wet oxidation*	*Closed mould processes - Compression moulding, Transfer moulding, Injection moulding*	*Stereo lithography*
S-5	SLO-1	*Vacuum casting - Process, Advantages, Applications*	*Design consideration for Powder Metallurgy forming*	*Lithography - Photolithography process*	*Filament winding, Pultrusion, Pulforming, Cutting of FRP*	*Laminated object manufacturing*
S-6	SLO-1	*Squeeze casting - Process, Advantages, Applications*	*Production of metal powders Atomization, Reduction, Electrolytic Deposition, Carbonyls, Comminution, Mechanical Alloying*	*Etching - Wet chemical etching, Dry plasma etching, Cryogenic dry etching*	*Fabrication of metal matrix composites-Liquid state and Solid state*	*Selective laser sintering*
S-7	SLO-1	*Rapid solidification for amorphous alloys, Melt Spinning Process*	*Sintering, Finishing of sintered parts, Secondary and finishing operations*	*Diffusion, Drive-in Diffusion and Ion implantation*	*Deposition technique for MMC, Insitu composites*	*Fused deposition modeling*
S-8	SLO-1	*Casting techniques for single crystal components*	*Ceramic forming -casting, powder*	*Metallization - Requirement, Methods and testing*	*Conventional manufacturing of ceramic composites, Prepeg formation-slurry impregnation*	*Solid ground curing, 3D ink jet printing*

S-9	SLO-1	*Conventional casting of Turbine blades, Directional solidified blades, Single crystal blades*	*Forming and shaping glass-Flat Sheet, Rods and Tubes, Discrete Products, Glass Fiber*	*Bonding and packaging, MEMS, NEMS*	*Porous preform infiltration- Melt, Sol-gel, Polymer, Reactive liquid, Chemical vapour, Directed oxidation*	*Additive manufacturing-Applications*

Learning Resources	1. *Serope Kalpakjian, "Manufacturing Engineering and Technology", Fourth Edition, Addison-Wesley Publishing Co., Boston, 2014.* 2. *Mikell P. Groover, "Principles of Modern Manufacturing SI Version", Wiley India, 2018.* 3. *Parasuraman Swaminathan, "Semiconductor Materials, Devices and Fabrication", Wiley India, 2017.* 4. *Madou.M.J, "Fundamentals of micro fabrication: The Science of Miniaturization, Second Edition", CRC Press, USA, 2002.* 5. *C. S. Lim, K. F. Leong, C. K. Chua, "Rapid Prototyping: Principles and Applications" (3rd Edition), World Scientific Publishing Company, 2009.* 6. *P. D. Hilton, P.F. Jacobs, "Rapid Tooling: Technologies and Industrial Applications", ist Ed., Marcel Dekker, Inc., 2010.* 7. *Steinar Westhrin Killi, "Additive Manufacturing: Design, Methods, and Processes", Pan Stanford Pub., 2017.* 8. *T. DebRoy et al., Review Article – "Additive manufacturing of metallic components – Process, structure and properties", Progress in Materials Science, Volume 92 (2018), 112-224.*

Learning Assessment

	Bloom's Level of Thinking	Continuous Learning Assessment (50% weightage)								Final Examination (50% weightage)	
		CLA – 1 (10%)		CLA – 2 (15%)		CLA – 3 (15%)		CLA – 4 (10%)#			
		Theory	Practice	Theory	Practice	Theory	Practice	Theory	Practice	Theory	Practice
Level 1	Remember Understand	40 %	-	30 %	-	30 %	-	30 %	-	30%	-
Level 2	Apply Analyze	40 %	-	40 %	-	40 %	-	40 %	-	40%	-
Level 3	Evaluate Create	20 %	-	30 %	-	30 %	-	30 %	-	30%	-
	Total	100 %		100 %		100 %		100 %		100 %	

CLA – 4 can be from any combination of these: Assignments, Seminars, Tech Talks, Mini-Projects, Case-Studies, Self-Study, MOOCs, Certifications, Conf. Paper etc.,

Course Designers

Experts from Industry	Experts from Higher Technical Institutions	Internal Experts
Dr. Saurabh Kundu *Head Product Research* *Tata Steel Jamshedpur* *Email: saurabhkundu@tatasteel.com*	*Dr. Debdulal Das* *Associate Professor* *Dept of Metallurgy and Materials Engineering* *Indian Institute of Engineering Science and Technology, Shibpur* *Howrah, Email: debdulal_das@metal.iiests.ac.in*	*1. Dr.Shubhabrata Datta*
Dr. A. Velayutham, DRDO, Avadi, velayudham.a@cvrde.drdo.in	*2. Dr.N.Arunachalam, IIT Madras, chalam@iitm.ac.in*	*Dr. M. Iqbal, SRMIST*

Course Code	18MEE330T	Course Name	FLEXIBLE MANUFACTURING SYSTEMS	Course Category	E	Professional Elective	L	T	P	C
							3	0	0	3

Pre-requisite Courses	Nil	Co-requisite Courses	Nil	Progressive Courses	Nil
Course Offering Department	Mechanical Engineering	Data Book / Codes/Standards	Nil		

Course Learning Rationale (CLR):	*The purpose of learning this course is to:*
CLR-1 :	*Be familiar with the basic types of production systems*
CLR-2 :	*understand the group technology, methods and FMS*
CLR-3 :	*Be familiar with the fundamentals and need of FMS planning*
CLR-4 :	*Detailed study of flexible manufacturing cells and systems*
CLR-5 :	*Be familiar with the FMS software*
CLR-6 :	*Familiar with production systems, grouping of parts and FMS, FMC and different software's, hard ware components involving.*

Course Learning Outcomes (CLO):	*At the end of this course, learners will be able to:*	Learning			Program Learning Outcomes (PLO)														
		1	2	3	1	2	3	4	5	6	7	8	9	10	11	12	13	14	15
		Level of Thinking (Bloom)	Expected Proficiency (%)	Expected Attainment (%)	Engineering Knowledge	Problem Analysis	Design & Development	Analysis, Design, Research	Modern Tool Usage	Society & Culture	Environment & Sustainability	Ethics	Individual & Team Work	Communication	Project Mgt. & Finance	Life Long Learning	PSO - 1	PSO - 2	PSO - 3
CLO-1 :	*Understand and acquire knowledge on Basics types of production systems, inventory and scheduling*	*1*	*90*	*85*	*H*	*H*	-	-	-	-	-	-	-	-	-	-	*L*	-	*H*
CLO-2 :	*Understand the group technology, types of coding systems and FMS*	*1,2*	*90*	*85*	*H*	*H*	*H*	-	-	-	-	-	-	-	-	-	*M*	*L*	*H*
CLO-3 :	*Understand the basic fundamentals and analysis methods for FMS planning*	*1,2*	*90*	*85*	*H*	*M*	-	-	-	-	-	-	-	-	-	-	*M*	-	*M*
CLO-4 :	*Understand the Flexible manufacturing cells and Communication networks for different systems*	*1,2*	*90*	*85*	*H*	*M*	-	-	-	-	-	-	-	-	-	-	*M*	-	*M*
CLO-5 :	*Acquire knowledge on FMS software's*	*1,2*	*90*	*85*	*H*	*M*	-	-	-	-	-	-	-	-	-	-	*M*	-	*M*
CLO-6 :	*Understand about production systems, group technology coding and FMS, FMC systems*	*1,2*	*90*	*85*	*H*	*H*	*H*	-	-	-	-	-	-	-	-	-	*M*	*L*	*M*

		Production systems	Group technology and FMS	Flexible Planning	Flexible Manufacturing Cells	FMS Software
Duration (hour)		9	9	9	9	9
S-1	SLO-1	*Types of production systems job, batch and mass production system with examples*	*Introduction to GT, Formation of part families*	*Physical planning for FMS, Objective, guide line*	*Introduction of cell description and its classifications*	*Introduction to Different FMS software's and advantages*
S-2	SLO-1	*Different manufacturing functions, Manufacturing support*	*Part classification methods and different coding systems with examples*	*Need for flexibility and FMS in industries*	*Definition of unattended machining, Requirement and features.*	*General structure and Requirements for FMS software*
S-3	SLO-1	*Organization and information processing in manufacturing.*	*Production flow analysis methods, Machine cell design, Clustering algorithm.*	*User supplier responsibilities in planning, user – supplier role in site preparation.*	*Component handling and storage systems*	*Functional descriptions and operational overview*
S-4	SLO-1	*Different types of plant layouts and advantages of each layout.*	*Bond Energy algorithm method with example*	*Machine tool selection and layout of FMS.*	*Difference between Cellular system and FMS system*	*FMS installation*
S-5	SLO-1	*Plant location selection methods with examples*	*Scheduling and control in cellular manufacturing*	*Computer control system and different Data files, Reports and planning the FMS system.*	*FMC hardware configuration and controllers*	*Acceptance testing, Performance goals*
S-6	SLO-1	*Work in progress inventory models*	*System planning guide lines and sizing and human resources.*	*Human resources for FMS, Objective, staffing, supervisor role.*	*PLC and computer controllers, Different FMC Communication networks*	*FMS application in machining, sheet metal fabrication*
S-7	SLO-1	*Scheduling and its types and advantages*	*Industrial case study for total parts moving to machine cell and machine cell formation, Manufacturing cell*	*Quantitative Analysis methods for FMS, Simple problems for FMS System analysis.*	*A case study for modular control design method for a flexible manufacturing cell.*	*Prismatic component production*
S-8	SLO-1	*Simple problems in selection of plant location.*	*Introduction to FMS, components of FMS.*	*Benefits and limitations for FMS system*	*Lean manufacturing with example*	*FMS development towards factories of the future*
S-9	SLO-1	*Design the different layouts like automobile plant and supermarket and hospitals and airport…etc*	*FMS need and types FMS systems.*	*Simple example of FMS planning for Automobile plant.*	*Agile manufacturing and example case study*	*Example case study for FMS*

Learning Resources	1. *William W. Luggen, "Flexible manufacturing Cells and systems", Prentice hall of New Jersey 1991.* 2. *Mikell P. Groover, "Automation Production systems and Computer Integrated manufacturing", prentice hall of India, New Delhi, 2007.*	*3. Jha N.K, " Hand book of Flexible Manufacturing systems", Academic Press, 1991.* *4. David J. Parrish, "Flexible Manufacturing", Butterworth-Heinemann, Newton, MA, USA, 1990.*

Learning Assessment											
	Bloom's Level of Thinking	Continuous Learning Assessment (50% weightage)								Final Examination (50% weightage)	
		CLA – 1 (10%)		CLA – 2 (15%)		CLA – 3 (15%)		CLA – 4 (10%)#			
		Theory	Practice	Theory	Practice	Theory	Practice	Theory	Practice	Theory	Practice
Level 1	Remember Understand	40 %	-	30 %	-	30 %	-	30 %	-	30%	-
Level 2	Apply Analyze	40 %	-	40 %	-	40 %	-	40 %	-	40%	-
Level 3	Evaluate Create	20 %	-	30 %	-	30 %	-	30 %	-	30%	-
	Total	100 %		100 %		100 %		100 %		100 %	

CLA – 4 can be from any combination of these: Assignments, Seminars, Tech Talks, Mini-Projects, Case-Studies, Self-Study, MOOCs, Certifications, Conf. Paper etc.,

Course Designers		
Experts from Industry	Experts from Higher Technical Institutions	Internal Experts
1. Mr.Mariappan Kanagaraj (Manager - Part Quality Engineering (STA) at Renault Nissan Technology & Business Centre India Pvt Ltd, Chennai Area, India	*1. Dr. B. K .Ragunath, Associate Professor, Dept. of Manufacturing Engineering, Annamalai University*	*1. Mr. Abburi Lakshman Kumar, AP Mech, SRMIST, Kattankulathur*
2. Dr. A. Velayutham, DRDO, Avadi, velayudham.a@cvrde.drdo.in	*2. Dr.G. Elatharasan, Asst.Professor, Dept. of Mechanical Engg., Anna University, Pattukottai.*	*Dr. M. Iqbal, SRMIST*

Course Code	18MEE421T	Course Name	SUSTAINABLE GREEN MANUFACTURING	Course Category	E	Professional Elective	L	T	P	C
							3	0	0	3

Pre-requisite Courses	NIL	Co-requisite Courses	NIL	Progressive Courses	NIL
Course Offering Department	Mechanical Engineering	Data Book / Codes/Standards	NIL		

Course Learning Rationale (CLR):	*The purpose of learning this course is to:*
CLR-1 :	*Be familiar with objectives, concepts and role of Green Manufacturing*
CLR-2 :	*Be familiar with the tools of Green Manufacturing*
CLR-3 :	*Be familiar with the attribute's decision-making methods*
CLR-4 :	*Be familiar with creating Lean and Green organization*
CLR-5 :	*Be familiar with the Design resources saving into product and processes*
CLR-6 :	*Be familiar with the concepts, tools, attributes, design resources of green manufacturing*

		Learning			Program Learning Outcomes (PLO)														
		1	2	3	1	2	3	4	5	6	7	8	9	10	11	12	13	14	15
Course Learning Outcomes (CLO):	*At the end of this course, learners will be able to:*	Level of Thinking (Bloom)	Expected Proficiency (%)	Expected Attainment (%)	Engineering Knowledge	Problem Analysis	Design & Development	Analysis, Design, Research	Modern Tool Usage	Society & Culture	Environment & Sustainability	Ethics	Individual & Team Work	Communication	Project Mgt. & Finance	Life Long Learning	PSO - 1	PSO - 2	PSO - 3
CLO-1 :	*Understand Green Manufacturing and Sustainable engineering concepts*		*90*	*85*	*M*	*M*	*M*	*L*	*H*	*H*	*M*	*L*					*H*	*H*	*M*
CLO-2 :	*Develop Multi attributes decision making methods*		*90*	*85*	*M*	*M*	*M*	*L*	*H*	*H*	*M*	*L*					*H*	*H*	*M*
CLO-3 :	*Develop Green manufacturing management*		*90*	*85*	*M*	*M*	*M*	*L*	*H*	*H*	*M*	*L*					*H*	*H*	*M*
CLO-4 :	*Develop Applications in green manufacturing*		*90*	*85*	*M*	*M*	*M*	*L*	*H*	*H*	*M*	*L*					*H*	*H*	*M*
CLO-5 :	*Develop design resources saving into product and process*				*M*	*M*	*M*	*L*	*H*	*H*	*M*	*L*					*H*	*H*	*M*
CLO-6 :	*Understand about the green manufacturing concepts, management, applications and design development.*				*M*	*M*	*M*	*L*	*H*	*H*	*M*	*L*					*H*	*H*	*M*

Duration (hour)		8	9	9	9	10
S-1	SLO-1	*Definition of manufacturing, Impact of manufacturing in environmental ecology*	*Principles of green manufacturing and its efficiency*	*Introduction to Multi attributes decision making methods*	*Question wasteful practices*	*Design resources saving into product and processes*
S-2	SLO-1	*Role of manufacturing sector in national growth*	*Green manufacturing and sustainability*	*definition, structure for Multi attributes decision making methods*	*Gain lean and green endorsement, collaboration to achieve lean and green goals*	*Closed loop & Open Loop production system*
S-3	SLO-1	*Technological change and evolving risk*	*System model architecture and module*	*variants and analysis of different methods like Simple Additive Method (SAM)*	*Track progress for environment and profits*	*Green manufacturing through clean energy supply*
S-4	SLO-1	*concepts of "green" manufacturing need of green manufacturing*	*Design and planning, control or tools for green manufacturing (Qualitative Analysis)*	*Weighted Product Method (WPM)*	*Creation of sustainable growth*	*Various case studies of implementation of semiconductors manufacturing at industries*
S-5	SLO-1	*Green manufacturing strategies*	*Consumption Analysis, Life Cycle Analysis, Efficiency, Sustainability tools).*	*Analytic Hierarchy Process (AHP)*	*Enabling techniques for assuring green manufacturing*	*Green packaging and supply chain*
S-6	SLO-1	*Green manufacturing – motivation, barriers, regulation, policy*	*Standards for green manufacturing (ISO 14000 and OHSAS 18000)*	*Technique for Order of Preference by Similarity to Ideal Solution (TOPSIS), Grey Relation Analysis (GRA)*	*Drivers of green manufacturing, impact, advantages and disadvantages of drivers*	*Various case studies of implementation of Optimizing Logistics solution at industries*
S-7	SLO-1	*Casting defects and remedies.*	*Waste stream mapping and application*	*Elimination and Choice Expressing Reality (ELECTRE)*	*Green architecture and buildings, Sustainable manufacturing resources management*	*Environmental implication of Nano manufacturing*
S-8	SLO-1	*Advantages and limitations of green manufacturing*	*Identify and apply the concepts of product and process design with environmental forethought*	*VIKOR method*	*Carbon footprint analysis and management of manufacturing processes*	*Various case studies of implementation of lean manufacturing at industries*
S-9	SLO-1	*Significance of green manufacturing*	*Design for environment and for sustainability - Discuss the Product Life Cycle of manufactured goods.*	*Problems based on different MADMs. 1 C 3 3,4*	*Green Process Economics, Resource Recovery and Reuse*	*Various case studies of implementation of Optimizing process or product at industries*

Learning Resources	
Learning Resources	*1. Ronald G. Askin& Jeffrey B. Goldberg, "Design and Analysis of Lean Production Systems", John Wiley & Sons, 2003.* *2. Rao.P.N, "Manufacturing Technology, Vol I and II", Tata McGraw Hill Publishing Co., 3rd edition, Sixth Reprint 2010* *3. Charles Wankel "21st century management: a reference handbook" SAGE Publications, Inc., 2008.* *4. Christian N. Madu "Handbook of environmentally conscious manufacturing" London : Kluwer Academic Publishers, 2001.* *5. T.E. Graedel& B.R. Allenby "Industrial Ecology" Pearson Education, Inc. 2003.* *6. Joseph Sarkis "Greener manufacturing and operations: from design to delivery and back" Greenleaf Pub., 2001.* *7. Ranky, P.G.: "An Introduction to Alternative Energy Sources: An interactive multimedia 3D eBook publication by CIMware USA, Inc. and CIMware Ltd., UK, ISBN 1-872631- 97-5, 2008.* *8. Ranky, P.G.: "Digital Product Design: Design For Quality, Manufacturing, Assembly & Disassembly Principles, and an Inkjet Printer Disassembly Use Case", DVD video publication by CIMware USA, Inc. and CIMware Ltd., UK, 2008, UPC 632568002983*

Learning Assessment

	Bloom's Level of Thinking	Continuous Learning Assessment (50% weightage)								Final Examination (50% weightage)	
		CLA – 1 (10%)		CLA – 2 (15%)		CLA – 3 (15%)		CLA – 4 (10%)#			
		Theory	Practice	Theory	Practice	Theory	Practice	Theory	Practice	Theory	Practice
Level 1	Remember Understand	40 %	-	30 %	-	30 %	-	30 %	-	30%	-
Level 2	Apply Analyze	40 %	-	40 %	-	40 %	-	40 %	-	40%	-
Level 3	Evaluate Create	20 %	-	30 %	-	30 %	-	30 %	-	30%	-
	Total	100 %		100 %		100 %		100 %		100 %	

CLA – 4 can be from any combination of these: Assignments, Seminars, Tech Talks, Mini-Projects, Case-Studies, Self-Study, MOOCs, Certifications, Conf. Paper etc.,

Course Designers

Experts from Industry	Experts from Higher Technical Institutions	Internal Experts
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2. Dr. A. Velayutham, DRDO, Avadi, velayudham.a@cvrde.drdo.in	*2.Dr. D. Dinakaran, HITS Padur, dinakaran.d@hindustanuniv.ac.in*	*Dr.P. Nandakumar, SRMIST*

Course Code	18MEE422T	Course Name	ADDITIVE MANUFACTURING TECHNOLOGY	Course Category	E	Professional Elective	L	T	P	C
							3	0	0	3

Pre-requisite Courses	NIL	Co-requisite Courses	NIL	Progressive Courses	NIL
Course Offering Department	Mechanical Engineering	Data Book / Codes/Standards	NIL		

Course Learning Rationale (CLR):	*The purpose of learning this course is to:*
CLR-1 :	*Be familiar with the evolution of Additive manufacturing (Why it is disruptive in nature based on evolution) and the materials and design involved*
CLR-2 :	*Be familiar with the various process steps involved in Additive manufacturing (Generic process flow for AM systems)*
CLR-3 :	*Learn the various types of machines and systems involved in Additive manufacturing*
CLR-4 :	*Know the working of powder based Additive manufacturing processes and their applications and limitations*
CLR-5 :	*Know the working of solid and liquid based Additive manufacturing processes and their applications and limitations (Understanding the feedstock material in various AM process)*
CLR-6 :	*Be familiar with components of Additive manufacturing and its applications in industries (Understanding the requirement of process certification for various industrial applications) – Fabrication and repair applications*

Course Learning Outcomes (CLO):	*At the end of this course, learners will be able to:*	Learning 1: Level of Thinking (Bloom)	Learning 2: Expected Proficiency (%)	Learning 3: Expected Attainment (%)	PLO 1: Engineering Knowledge	PLO 2: Problem Analysis	PLO 3: Design & Development	PLO 4: Analysis, Design, Research	PLO 5: Modern Tool Usage	PLO 6: Society & Culture	PLO 7: Environment & Sustainability	PLO 8: Ethics	PLO 9: Individual & Team Work	PLO 10: Communication	PLO 11: Project Mgt. & Finance	PLO 12: Life Long Learning	PLO 13: PSO - 1	PLO 14: PSO - 2	PLO 15: PSO - 3
CLO-1 :	*Understand the basic concepts of Additive manufacturing (Why they are classed as disruptive technology(ies)*	*1&2*	*90*	*85*	*H*														
CLO-2 :	*The knowledge acquired on the process chain of Additive manufacturing and the various steps involved (Opportunities of implementation in India, global relevance of AM in supply chain – The concepts of Remanufacturing)*	*1&2*	*90*	*85*	*H*		*M*		*H*							*M*	*H*	*H*	
CLO-3 :	*Recognize the various machines and systems involved in Additive manufacturing and understand their role (in industrial application – fabrication or repair of component)*	*1*	*90*	*85*	*H*	*M*	*M*	*H*	*H*							*M*	*H*	*H*	
CLO-4 :	*Understand the major solid and liquid based Additive manufacturing processes such as stereolithography and fused deposition modeling and recognize their application and potential*	*1&2*	*90*	*85*	*H*	*M*	*M*	*H*	*H*							*M*	*H*	*H*	
CLO-5 :	*Understand the major powder based Additive manufacturing processes such as 3D printing (Directed Energy deposition, powder bed fusion)and electron beam melting, Binder jetting and recognize their application and potential in fabrication and repair for various industrial application*	*1&2*	*90*	*85*	*H*	*M*	*M*	*H*	*H*							*M*	*H*	*H*	
CLO-6 :	*Recognize the importance of Additive manufacturing and its various processes and systems – Industry specific (such as Aerospace, power generation, heavy machinery, Automotive)*	*1&2*	*90*	*85*	*H*														

		Introduction To Additive Manufacturing	Process Chain Of Additive Manufacturing	Machines And Systems Of Additive Manufacturing	Solid And Liquid Based Additive Manufacturing	Powder Based Additive Manufacturing
Duration (hour)		9	9	9	9	9
S-1	SLO-1	*Evolution of Additive manufacturing, Need, Comparison with CNC machining (Concepts of Hybrid manufacturing & applications)*	*Conceptualisation, Synergistic interaction of processes (AM + CNC/Adaptive)*	*Introduction to various machines and systems of Additive manufacturing (based on feedstock material, based on energy used, application)*	*Classification (scale of printing)*	*Classification (scale of printing)*
S-2	SLO-1	*Basic principles of additive manufacturing (Complex interaction of process, design and materials)*	*CAD model preparation, CAM operations (Tool path generation)*	*Construction of CNC machines, Process chamber (Subtractive process conversion to AM process)*	*Guidelines for process selection*	*Powder fusion mechanisms: solid-state sintering, Chemically induced sintering*
S-3	SLO-1	*Classification of Additive manufacturing processes*	*Part orientation and support generation*	*Energy Delivery: Lasers and electron beam, plasma arc, kinetic energy (cold spray in AM)*	*Fused deposition modeling - Processes and principle*	*Selective laser sintering: process, principles*
S-4	SLO-1	*Materials for Additive manufacturing (selection of feedstock materials)*	*Conversion to Stereolithographic file format*	*Material delivery: Powder feeding and wire feeding systems (difference in powder and wire feedstock – adantages and limitations for both), handling of feedstock material*	*Advantages, applications*	*Advantages, applications*

S-5	SLO-1	*Designing for Additive manufacturing (Design optimization)*	*Transfer to Additive manufacturing machine and file manipulation*	*Rapid tooling equipment: direct and indirect methods*	*Laminated object manufacturing*	*3D printing: process, principles*
S-6	SLO-1	*Role of Additive manufacturing in product development (Complex geometry requirements, strength to weight requirements)*	*Machine setup and build, Health & Safety practice (best practice), Feedstock material handling*	*Post processing equipment: support material removal , preparation for use as a pattern*	*Stereolithography apparatus: processes and principle*	*Advantages, applications*
S-7	SLO-1	*Advantages, Disadvantages, Applications and Opportunities of Additive manufacturing (Opportunities in Indian industries, global prospective)*	*Removal and clean up, Health & Safety practice (best practice),*	*Temperature, humidity, oxygen level controllers (process monitoring, affect on mechanical and microstructural properties with these variables)*	*Advantages, applications*	*Laser engineered net shaping (LENS process, unique advantages on hybrid scale), process control advantages, limitations,*
S-8	SLO-1	*Emerging trends and business models (Concepts of Remanufacturing)*	*Post processing (insitu or external transformative post processing such as heat treatments), machining*	*Scanning: Raster scan, patterned vector scanning*	*Challenges in solid and liquid AM processes*	*Electron beam melting*
S-9	SLO-1	*Related technologies: Reverse engineering, Computer aided engineering, AM process simulation concepts, preditive modelling*	*Property enhancement by thermal and non-thermal methods (In relation to type of material)*	*Post processing: surface texture, accuracy and aesthetic improvement*	*Case study (with relevance to technology certification)*	*Case study (with relevance to technology certification)*

Learning Resources	1. *Ian Gibson, David W Rosen, Brent Stucker., "Additive Manufacturing Technologies: Rapid Prototyping to Direct Digital Manufacturing", Springer, 2015.* 2. *Chua C.K., Leong K.F., and Lim C.S., "Rapid prototyping: Principles and applications", Third Edition, World Scientific Publishers, 2010.* 3. *Gebhardt A., "Rapid prototyping", Hanser Gardener Publications, 2003.* 4. *Liou L.W. and Liou F.W., "Rapid Prototyping and Engineering applications: A tool box for prototype development", CRC Press, 2007.* 5. *Kamrani A.K. and Nasr E.A., "Rapid Prototyping: Theory and practice", Springer, 2006.* 6. *Hilton P.D. and Jacobs P.F., "Rapid Tooling: Technologies and Industrial Applications", CRC press, 2000.* 7. *Pham D.T, Dimov S.S, "Rapid Manufacturing: The Technologies and Applications of Rapid Prototyping and Rapid Tooling", Springer 2001.* 8. *Gu D, "Laser Additive Manufacturing of High-Performance Materials", Springer, 2014.* 9. *Rafiq Noorani, "Rapid prototyping: Principles and Applications in Manufacturing" John Wiley & Sons, 2006.*

Learning Assessment

	Bloom's Level of Thinking	Continuous Learning Assessment (50% weightage)								Final Examination (50% weightage)	
		CLA – 1 (10%)		CLA – 2 (15%)		CLA – 3 (15%)		CLA – 4 (10%)#			
		Theory	Practice	Theory	Practice	Theory	Practice	Theory	Practice	Theory	Practice
Level 1	Remember Understand	40 %	-	30 %	-	30 %	-	30 %	-	30%	-
Level 2	Apply Analyze	40 %	-	40 %	-	40 %	-	40 %	-	40%	-
Level 3	Evaluate Create	20 %	-	30 %	-	30 %	-	30 %	-	30%	-
	Total	100 %		100 %		100 %		100 %		100 %	

CLA – 4 can be from any combination of these: Assignments, Seminars, Tech Talks, Mini-Projects, Case-Studies, Self-Study, MOOCs, Certifications, Conf. Paper etc.,

Course Designers

Experts from Industry	Experts from Higher Technical Institutions	Internal Experts
Mr.Purushothaman, Tesscorn Nano Science Inc.	*1. Dr. P. Hariharan, Anna University, hari@annauniv.edu, hariharan2311@gmail.com*	*Dr. P. Mohan Babu, SRMIST*
Dr. A. Velayutham, DRDO, Avadi, velayudham.a@cvrde.drdo.in	*2. Dr.N.Arunachalam, IIT Madras, chalam@iitm.ac.in*	*Dr. M. Iqbal, SRMIST*

Course Code	18MEE423T	Course Name	PRECISION ENGINEERING	Course Category	E	Professional Elective	L	T	P	C
							3	0	0	3

Pre-requisite Courses	NIL	Co-requisite Courses	NIL	Progressive Courses	NIL
Course Offering Department	Mechanical Engineering	Data Book / Codes/Standards	NIL		

Course Learning Rationale (CLR):	*The purpose of learning this course is to:*
CLR-1 :	*Understand the concept of accuracy and precision in various parametric testing*
CLR-2 :	*Realize the striving need for precision and applications*
CLR-3 :	*Know the causes for dimensional and geometrical characteristics errors prior and during machining*
CLR-4 :	*Impart knowledge about basics of precision and ultra precision machining methods*
CLR-5 :	*Be familiar with different precision measuring systems at micro/nano level*
CLR-6 :	*Be familiar with the various lithography techniques*

Course Learning Outcomes (CLO):	*At the end of this course, learners will be able to:*	Learning 1: Level of Thinking (Bloom)	Learning 2: Expected Proficiency (%)	Learning 3: Expected Attainment (%)	PLO 1: Engineering Knowledge	PLO 2: Problem Analysis	PLO 3: Design & Development	PLO 4: Analysis, Design, Research	PLO 5: Modern Tool Usage	PLO 6: Society & Culture	PLO 7: Environment & Sustainability	PLO 8: Ethics	PLO 9: Individual & Team Work	PLO 10: Communication	PLO 11: Project Mgt. & Finance	PLO 12: Life Long Learning	PLO 13: PSO - 1	PLO 14: PSO - 2	PLO 15: PSO - 3
CLO-1 :	*Acquire knowledge about the basics of accuracy and alignment tests*	1&3	80	85	H				M		M					H	M		H
CLO-2 :	*Identify the dimensional and geometrical errors prior and during machining*	1&2	70	85	H	L			M								M		M
CLO-3 :	*Deepen the knowledge of static stiffness and thermal effects*	1, 2&3	75	85	H	L		M	M								H	M	
CLO-4 :	*Understand the principles of precision machining and importance of digitization in micro-machining*	1,2&3	85	85	H	H	L	M	M		M		L			H	H		H
CLO-5 :	*Understand the principles of nano measuring systems*	1&2	80	85	M			M	H		L		M			M			M
CLO-6 :	*Understand the principles of various lithographic techniques and currently emerging microscopic techniques*	1&2	80	85	M	H	L	M	M		M		L			H	H		H

Duration (hour)		9	9	9	9	9
S-1	SLO-1	*General concept of accuracy, repeatability and precision; Spindle rotation accuracy*	*Static stiffness*	*Introduction to precision Engineering and need for having high precision*	*Introduction to nanotechnology and need for measurement in nanotechnology*	*Nano Lithography*
S-2	SLO-1	*Test methods for displacement accuracy*	*Nature of deformation in a machine tool*	*Precision machining and finishing operations*	*Measuring Systems for Nano-manufacturing*	*Photolithography*
S-3	SLO-1	*Dimensional wear of cutting tools*	*Overall stiffness of a lathe*	*Ultra-precision Processes*	*In - process measurement of position of processing point*	*Electron beam lithography*
S-4	SLO-1	*Accuracy of NC systems, Clamping errors, Setting errors*	*Compliance of work piece*	*Tool Materials for Precision Machining: Carbides, Ceramic, Diamond, Cubic Boron Nitride*	*Post process and online measurement of dimensional features*	*Ion Beam lithography*
S-5	SLO-1	*Location of rectangular prism, cylinder*	*Errors due to the variation of the cutting force and total compliance*	*Ultra-Precision Machine Elements*	*Mechanical measuring systems*	*Optical lithography*
S-6	SLO-1	*Basic type of tests, Measuring instruments used for testing machine tools*	*Case study: Errors caused by cutting force deformation in turning and milling*	*Machining of micro-sized components*	*Optical measuring systems*	*LIGA process*
S-7	SLO-1	*Alignment, Straightness, Flatness tests*	*Study of thermal effects on machine tool accuracy*	*Positioning mechanisms and drives – precision gears, servo control systems, electromagnetic and piezo actuators*	*Electron beam measuring systems*	*Nanocoatings*
S-8	SLO-1	*Parallelism, Squareness tests*	*Methods of decreasing thermal effects*	*Micro- electro-Mechanical Systems: Characteristics and Principles, Materials, and Fabrication processes*	*X-ray imaging systems*	*Micro-metrology*
S-9	SLO-1	*Circularity, Cylindricity tests*	*Influence of vibration and noise on accuracy*	*Emergence of digital precision machining*	*Pattern recognition and inspection systems*	*Microscopy techniques for materials characterization: Electron microbe analysis and atom probe tomography*

Learning Resources	1. *Murthy.R.L, "Precision Engineering in Manufacturing", New Age International, New Delhi, 2005.* 2. *V.C.Venktesh, Precision Engineering, Tata Mc.Graw Hill, New Delhi 2007* 3. *Kalpakjian S., Manufacturing Engineering and Technology. 3rd Ed. Addision-Wesley Publishing Co.,New York, 2001.* 4. *Norio Taniguchi, "Nanotechnology", Oxford university press, Cambridge, 1996.* 5. *Lee Tong Hong, "Precision Motion control, Design and Implementation", Springer Verlag, U.K., 2001.* 6. *Liangchi Zhang, "Precision Machining of Advanced Materials", Trans Tech Publications Ltd., Switzerland, 2001.* 7. *HiromuNakazawa, "Principles of precision engineering", Oxford University Press, 1994.* 8. *Sahu R.K. and Somashekhar S.H, "Corona Discharge Micromachining for the Synthesis of Nanoparticles: Characterization and Applications", CRC Press, Taylor & Francis, New York, 2019.*

* Combination of surprise, quiz and assignment tests.

Learning Assessment											
	Bloom's Level of Thinking	Continuous Learning Assessment (50% weightage)								Final Examination (50% weightage)	
		CLA – 1 (10%)		CLA – 2 (15%)		CLA – 3 (15%)		CLA – 4 (10%)#			
		Theory	Practice	Theory	Practice	Theory	Practice	Theory	Practice	Theory	Practice
Level 1	Remember Understand	40 %	-	30 %	-	30 %	-	30 %	-	30%	-
Level 2	Apply Analyze	40 %	-	40 %	-	40 %	-	40 %	-	40%	-
Level 3	Evaluate Create	20 %	-	30 %	-	30 %	-	30 %	-	30%	-
	Total	100 %		100 %		100 %		100 %		100 %	

CLA – 4 can be from any combination of these: Assignments, Seminars, Tech Talks, Mini-Projects, Case-Studies, Self-Study, MOOCs, Certifications, Conf. Paper etc.,

Course Designers		
Experts from Industry	Experts from Higher Technical Institutions	Internal Experts
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Dr. A. Velayutham, DRDO, Avadi, velayudham.a@cvrde.drdo.in	*2. Dr.N.Arunachalam, IIT Madras, chalam@iitm.ac.in*	*Dr. M. Iqbal, SRMIST*

Course Code	18MEE424T	Course Name	TECHNOLOGY OF SURFACE COATING	Course Category	E	Professional elective	L	T	P	C
							3	0	0	3

Pre-requisite Courses	NIL	Co-requisite Courses	NIL	Progressive Courses	NIL
Course Offering Department	Mechanical Engineering	Data Book / Codes/Standards	NIL		

Course Learning Rationale (CLR):	*The purpose of learning this course is to:*
CLR-1 :	*Understand the fundamentals of surface engineering*
CLR-2 :	*Understand the practical application and importance of coatings*
CLR-3 :	*Understand the different methods of coatings in micro and nano level*
CLR-4 :	*Understand the measurement techniques of different properties of coating*
CLR-5 :	*Understand the maintenance procedures and trouble shooting*
CLR-6 :	*Understand the special surface coating techniques*

		Learning			Program Learning Outcomes (PLO)														
		1	2	3	1	2	3	4	5	6	7	8	9	10	11	12	13	14	15
Course Learning Outcomes (CLO):	*At the end of this course, learners will be able to:*	Level of Thinking (Bloom)	Expected Proficiency (%)	Expected Attainment (%)	Engineering Knowledge	Problem Analysis	Design & Development	Analysis, Design, Research	Modern Tool Usage	Society & Culture	Environment & Sustainability	Ethics	Individual & Team Work	Communication	Project Mgt. & Finance	Life Long Learning	PSO - 1	PSO - 2	PSO - 3
CLO-1 :	*Be familiar with the concepts of surface engineering of various types of coatings.*	*1&2*	*90*	*75*	*H*												*H*	*L*	*M*
CLO-2 :	*Be familiar with the concepts of surface science of various types of coatings*	*1 & 2*	*90*	*75*	*H*												*H*	*L*	*M*
CLO-3 :	*Be familiar with the concepts of surface characterization methods for various types of coatings*	*1 & 2*	*90*	*75*	*H*		*M*	*H*									*L*	*H*	*M*
CLO-4 :	*Be familiar on the principles and working of special coating methods*	*1 & 2*	*90*	*75*	*H*	*H*	*M*		*M*		*L*						*M*	*L*	*H*
CLO-5 :	*Be familiar on the application of suitable methods of coatings on the surface*	*3*	*90*	*75*	*H*	*H*	*H*	*M*	*H*	*M*	*M*						*H*	*H*	*H*
CLO-6 :	*solve various unwanted problems raised on material surface because of degradation by using suitable methods and measurement*	*2 & 3*	*90*	*75*	*H*	*H*	*H*	*M*	*H*	*M*	*M*						*M*	*H*	*H*

		Fundamental Of Surface Engineering	Special Surface Coating And Surface Modification Techniques I	Special Surface Coating And Surface Modification Techniques II	Surface Characterization Techniques Of Coatings	Applications Of Surface Coatings
Duration (hour)		9	9	9	9	9
S-1	SLO-1	*Introduction: Engineering components,*	*Introduction to Electro Chemical Deposition - Electro Plating*	*Surface Coating by Wetting, Mechanism of Wetting*	*Measurement of coatings thickness*	*Cold Spraying and Hard Facing*
S-2	SLO-1	*Surface dependent properties and failures,*	*Anodizing and Electro-Less Plating*	*Coating on Ceramics by Wetting,*	*porosity & adhesion of surface coatings*	*Case studies based on coatings of important engineering components II*
S-3	SLO-1	*Importance and scope of surface engineering*	*Thermal Spray Coating-Combustion Spray and Plasma Spray Process*	*Coating of Monolayer Abrasive grain by Wetting*	*Measurement of residual stress & stability*	*Case studies based on surface modification of important engineering components I*
S-4	SLO-1	*Surface and surface energy: Structure and types of interfaces, surface energy and related equations.*	*Sputter deposition of thin films & coatings – DC & RF*	*DLC and diamond coatings,*	*Spectrum of secondary electrons, Scanning Electron Microscopy*	*Case studies based on surface modification of important engineering components II*
S-5	SLO-1	*Surface engineering: classification, definition, scope and general principles*	*Sputter deposition of thin films & coatings – Magnetron & Ion Beam*	*Antifriction and anti-scratch coatings*	*Electron energy analyzers*	*Functional and nano-structured coatings*
S-6	SLO-1	*Surface engineering by material removal: Cleaning, pickling, etching, grinding, polishing*	*Hybrid / Modified PVD coating processes*	*Sol Gel Coating,*	*Auger Electron spectroscopy, Transmission Electron Microscopy*	*Functional and nano-structured coatings applications in photovoltaic*
S-7	SLO-1	*Buffing / puffing (techniques employed, its principle). Role and estimate of surface roughness.*	*CVD Coating of TiC, Nitride, Chromium, Aluminum Oxide and Diamond*	*Laser Assisted Surface Engineering*	*Surface microscopy & topography by scanning probe microscopy*	*Functional and nano-structured coatings applications in bio- and chemical sensors*
S-8	SLO-1	*Surface engineering by material addition (principle and its application with examples).*	*Plasma and ion beam assisted surface modification*	*Micro Arc Oxidation,*	*Electron Energy Loss Spectroscopy*	*Surface engineering of polymers*
S-9	SLO-1	*Surface modification of steel, non-ferrous and ferrous components: (principle and scope of application).*	*Surface modification by Ion implantation and Ion beam mixing*	*Electro Spark Coating*	*Photoelectron Spectroscopy*	*Surface engineering of composites*

Learning Resources	*1. K.G. Budinski, Surface Engineering for Wear Resistances, Prentice Hall, Englewood Cliffs, 1988.* *2. M. Ohring, The Materials Science of Thin Films, Academic Press Inc, 2005* *3. D. Satas, Arthur A. Tracton, "Coatings technology handbook", Marcel Dekker, 2000* *4. K. Oura, V. G. Lifshits, A. A. Saranin, A. V. Zotov and M. Katayama, "Surface Science – An Introduction" Springer, 2009.* *5. B G Miller, "Surface coatings for protection against wear", Wood head Publishing, 1st Edition, 2006* *6. Riviere.J.C and Myhra.S, "Handbook of Surface and Interface analysis", CRC Press, 2009.* *7. Hari Singh Nalwa, "Nanostructured Materials and Nanotechnology", Academic Press, 2002.*

Learning Assessment

	Bloom's Level of Thinking	Continuous Learning Assessment (50% weightage)								Final Examination (50% weightage)	
		CLA – 1 (10%)		CLA – 2 (15%)		CLA – 3 (15%)		CLA – 4 (10%)#			
		Theory	Practice	Theory	Practice	Theory	Practice	Theory	Practice	Theory	Practice
Level 1	Remember Understand	40 %	-	30 %	-	30 %	-	30 %	-	30%	-
Level 2	Apply Analyze	40 %	-	40 %	-	40 %	-	40 %	-	40%	-
Level 3	Evaluate Create	20 %	-	30 %	-	30 %	-	30 %	-	30%	-
	Total	100 %		100 %		100 %		100 %		100 %	

CLA – 4 can be from any combination of these: Assignments, Seminars, Tech Talks, Mini-Projects, Case-Studies, Self-Study, MOOCs, Certifications, Conf. Paper etc.,

Course Designers

Experts from Industry	Experts from Higher Technical Institutions	Internal Experts
1. Dr. O P Khatri, CSIR-Indian Institute of Petroleum, Dehradun – 248005 (India)- 400701 opkhatri@iip.res.in	*1. Dr. P Ramkumar, IIT Madras, ramkumar@iitm.ac.in*	*Dr. Jitendra Kumar Katiyar, SRMIST jitendrakumar.v@ktr.srmuniv.ac.in*
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Course Code	18MEE425T	Course Name	SUPPLY CHAIN MANAGEMENT	Course Category	E	Professional Elective	L	T	P	C
							3	0	0	3

Pre-requisite Courses	NIL	Co-requisite Courses	NIL	Progressive Courses	NIL
Course Offering Department	Mechanical Engineering	Data Book / Codes/Standards	NIL		

Course Learning Rationale (CLR):	*The purpose of learning this course is to:*
CLR-1 :	*Understand the role of logistics*
CLR-2 :	*Understand the phases of supply chain*
CLR-3 :	*Understand the evolution of supply chain models*
CLR-4 :	*Understand the supply chain activities*
CLR-5 :	*Understand the SCM organization and information system*
CLR-6 :	*Understand the role, phases, evolution, activities and SCM information system*

Course Learning Outcomes (CLO):	*At the end of this course, learners will be able to:*	Learning 1: Level of Thinking (Bloom)	Learning 2: Expected Proficiency (%)	Learning 3: Expected Attainment (%)	PLO 1: Engineering Knowledge	PLO 2: Problem Analysis	PLO 3: Design & Development	PLO 4: Analysis, Design, Research	PLO 5: Modern Tool Usage	PLO 6: Society & Culture	PLO 7: Environment & Sustainability	PLO 8: Ethics	PLO 9: Individual & Team Work	PLO 10: Communication	PLO 11: Project Mgt & Finance	PLO 12: Life Long Learning	PLO 13: PSO - 1	PLO 14: PSO - 2	PLO 15: PSO - 3
CLO-1 :	*Familiar in Logistics and its role of operations.*	1 2&3	90	85	H		L			M	M		L						
CLO-2 :	*Familiar in Supply chain and its different phases.*	1 2&3	90	85	H		L			M	L		L						
CLO-3 :	*Familiar in evolution of supply chain models and solution for engineering problem*	1 2&3	90	85	H		L			M	L		L						
CLO-4 :	*Familiar with the activities of supply chain*	1 2&3	90	85	H		L			M	L		L						
CLO-5 :	*Familiar in Understanding different SCM organization and different ERP systems*	1 2&3	90	85	H		L			M			M						
CLO-6 :	*Familiar in logistics operations, SCM phases, SCM models, SCM activities, SCM organization and different ERP systems*	1 2&3	90	85	H		L			M			M						

		Introduction to Logistics	Phases of Supply Chain	Evolution of Supply Chain Models	Supply Chain Activities	Scm Organisation and Information System
Duration (hour)		09	09	09	09	09
S-1	SLO-1	*Introduction of Logistics and its concepts*	*The new paradigm shift*	*Strategy of supply chain*	*Introduction of Structuring the supply chain*	*The management task*
S-2	SLO-1	*Logistics definitions*	*The modular company*	*structure of supply chain*	*Supply chain challenge – five tasks for management*	*Types of Logistics organization*
S-3	SLO-1	*Different Logistics approaches*	*Introduction to strategic core, network structures, management networks and vertical integration*	*Factors of supply chain*	*Supply Chain as activity systems*	*The logistics in information systems*
S-4	SLO-1	*Factors influencing logistics*	*The network relations in supply chain*	*Manufacturing strategy stages*	*New products of supply chain*	*Topology of Supply chain application*
S-5	SLO-1	*Basic tasks of supply chain*	*Supplier relationship, partnerships and alliances, cooperation and integration, Governance, boundary management, global networks*	*Supply chain progress*	*Foundation for supply chain change*	*Product Data Management*
S-6	SLO-1	*Defection of supply chain*	*Supply processes in supply chain*	*Introduction of Model for competing through supply chain management*	*Functional roles in supply chain change*	*Warehouse management system MRP- I,*
S-7	SLO-1	*Approaches of supply chain*	*Process flow, product design, product issues, product structure, logistics issue*	*PLC grid in supply chain management*	*Frame work Design for supply chain*	*Warehouse management system MRP- 2*
S-8	SLO-1	*Influencing supply chain*	*Procurement processes in supply chain*	*Redesigning of supply chain*	*Institutionalizing supply chain changes*	*ERP case study*
S-9	SLO-1	*A new corporate model.*	*Distribution management in supply chain*	*linking supply chain with customer*	*Collaborative product commerce*	*ERP software's*

Learning Resources	*1 Shari, P. B. and Lassen, T. S., Managing the global supply chain, Viva books, New Delhi, 2000.* *2. Ayers, J. B., Hand book of supply chain management, The St. Lencie press, 2000. 1.* *3. Nicolas, J. N., Competitive manufacturing management – continuous improvement, Lean production, customer focused quality, McGrawHill, New York, 1998.* *4. Steudel, H. J. and Desruelle, P., Manufacturing in the nineteen – How to become a mean, lean and world class competitor, Van No strand Reinhold, New York, 1992.*

Learning Assessment

	Bloom's Level of Thinking	Continuous Learning Assessment (50% weightage)								Final Examination (50% weightage)	
		CLA – 1 (10%)		CLA – 2 (15%)		CLA – 3 (15%)		CLA – 4 (10%)#			
		Theory	Practice	Theory	Practice	Theory	Practice	Theory	Practice	Theory	Practice
Level 1	Remember Understand	40 %	-	30 %	-	30 %	-	30 %	-	30%	-
Level 2	Apply Analyze	40 %	-	40 %	-	40 %	-	40 %	-	40%	-
Level 3	Evaluate Create	20 %	-	30 %	-	30 %	-	30 %	-	30%	-
	Total	100 %		100 %		100 %		100 %		100 %	

CLA – 4 can be from any combination of these: Assignments, Seminars, Tech Talks, Mini-Projects, Case-Studies, Self-Study, MOOCs, Certifications, Conf. Paper etc.,

Course Designers

Experts from Industry	Experts from Higher Technical Institutions	Internal Experts
1. Dr. R. Kalimuthu, ISRO, Mahendragiri, r_kalimuthu@vssc.gov.in, rkpearls@yahoo.com	*1. Dr.M. K. Marichelvam, Mepco Schlenk Engineering College, Sivakasi.*	*1. Mr.M. Sachidhanandham Asst. Professor, ME* *SRM Institute of Science and Technology, Kattankulathur,*
2. Dr. A. Velayutham, DRDO, Avadi, velayudham.a@cvrde.drdo.in	*2.Mr.A.Prabukarthi A, PSG College of Technology Coimbatore-641004*	*Dr. M. Iqbal, SRMIST*

Course Code	18MEE426T	Course Name	COMPOSITE MATERIALS AND MECHANICS	Course Category	E	Professional Elective	L	T	P	C
							3	0	0	3

Pre-requisite Courses	Nil	Co-requisite Courses	Nil	Progressive Courses	Nil
Course Offering Department	Mechanical Engineering	Data Book / Codes/Standards	Nil		

Course Learning Rationale (CLR):	*The purpose of learning this course is to:*
CLR-1 :	*Understand the overview, constituents, classifications, and advanced applications of composites*
CLR-2 :	*Understand the mechanics and performance of composite materials*
CLR-3 :	*Understand the manufacturing techniques and inspection of various composite materials*
CLR-4 :	*Learn to test and understand the failure, and analysis methods of laminated composites and their constituents and analyze the characteristics of laminated composites*
CLR-5 :	*Learn design aspects and acquiring knowledge on material selection for advanced engineering composite materials.*
CLR-6 :	*Understand the applications, performance, inspection of composites*

Course Learning Outcomes (CLO):	*At the end of this course, learners will be able to:*	Learning 1: Level of Thinking (Bloom)	2: Expected Proficiency (%)	3: Expected Attainment (%)	PLO 1: Engineering Knowledge	2: Problem Analysis	3: Design & Development	4: Analysis, Design, Research	5: Modern Tool Usage	6: Society & Culture	7: Environment & Sustainability	8: Ethics	9: Individual & Team Work	10: Communication	11: Project Mgt. & Finance	12: Life Long Learning	13: PSO - 1	14: PSO - 2	15: PSO - 3
CLO-1 :	*Familiar with the Overview, constituents, classifications, and advanced applications of composites and composites mechanics*	*1& 2*	*90*	*85*	*H*				*M*										
CLO-2 :	*Familiar the mechanics and performance of composite materials*	*1& 2*	*90*	*85*	*H*	*H*													
CLO-3 :	*Familiar with the manufacturing techniques and inspection of various composite materials*	*1& 2*	*90*	*85*	*H*		*M*	*L*											
CLO-4 :	*Familiar with the testing and understand the failure, and analysis methods of laminated composites and their constituents and analyze the characteristics of laminated composites*	*1& 2*	*90*	*85*		*M*	*H*		*M*										
CLO-5 :	*Familiar with the Design and select the material for advanced engineering composite materials.*	*1& 2*	*90*	*85*	*H*		*H*	*M*	*M*										
CLO-6 :	*Familiar with overview, performance, applications and inspection of composites*	*1&2*	*90*	*85*	*H*		*H*	*M*	*L*										

		Overview of Composites	Mechanics and Performance	Manufacturing	Testing and Analysis	Design and Material selection
Duration (hour)		9	9	9	9	9
S-1	SLO-1 & 2	*Introduction to composites - Definitions Classification of composite materials*	*Introduction to solid mechanics - lamina and laminates*	*Overview of composite manufacturing processes*	*Fiber test, Neat resin matrix test Tensile, compressive test In-plane shear, Interlaminar shear tests Flexural, Interlaminar fracture, Fiber/Matrix interface tests*	*Failure predictions in a Unidirectional Lamina*
S-2	SLO-1 & 2	*Polymer matrix Ceramic matrix,*	*Mechanics terminology Interlaminar stresses*	*Overview of glass fibre production*	*Analysis of an orthographic lamina*	*Failure predictions for Unnotched Laminates*
S-3	SLO-1 & 2	*Metal matrix; Special composites - Functionally graded materials*	*Unidirectional and angle lamina and laminates*	*Carbon fiber production*	*Analysis of an orthographic laminates*	*Laminated Design Consideration*
S-4	SLO-1 & 2	*Characteristics of composite materials Mechanical behavior of composite materials*	*Engineering constants of an angle lamina and laminates*	*Spray-up, Hand lay-up*	*Hooke's law, stiffness and compliance matrices*	*Bonded joints; Bolted joints; Bonded-Bolted joints*
S-5	SLO-1 & 2	*Structural Materials Constituent materials for composite materials*	*Static Mechanical Properties Hooke's law for different types of materials*	*Filament winding Fiber placement*	*Strengths of orthographic lamina*	*Design requirements and design failure criteria*
S-6	SLO-1 & 2	*Matrix materials – types and properties Reinforced materials– types and properties*	*Effective modulus in stress-strain*	*Closed-mould processes, Bag Moulding*	*Stress analysis of laminated composite beams*	*Design load definitions Design analysis philosophy for composite structures*

S-7	SLO-1 & 2	*Fibers for advanced composites* *Current and potential advantages of fiber-reinforced composite materials*	*Symmetry in stress-strain*	*Compression moulding, Pultrusion, and Other manufacturing processes*	*Stress analysis of laminated composite Plates*	*Laminate optimization Design examples*
S-8	SLO-1 & 2	*Applications of composite materials* *- Military aircraft, Civil aircraft*	*Fatigue and Impact properties and Environmental effects*	*Quality Inspection method*	*Stress analysis of laminated composite Shells*	*Materials selection criteria* *Different material section factors*
S-9	SLO-1 & 2	*- Automotive applications, Commercial applications,*	*Fracture Behavior and Damage Tolerance*	*Composite defects, detection and possible solution*	*Free vibration*	*- Fiber selection factor* *- Matrix selection factor - Importance of constituents*

Learning Resources	1. *P.K. Mallick, FIBRE REINFORCED COMPOSITES: MATERIALS, MANUFACTURING AND DESIGN, Marcel Dekker, 1993.* 2. *J.C. Halpin, PRIMER ON COMPOSITE MATERIALS, ANALYSIS, Techomic Publishing Co., 1984.* 3. *B.D. Agarwal, and L.J. Broutman, ANALYSIS AND PERFORMANCE OF FIBRE COMPOSITES, John Wiley and Sons, New York, 1990.* 4. *P.K. Malick and S. Newman, (eds), COMPOSITE MATERIALS TECHNOLOGY: PROCESSES AND PROPERTIES, Hansen Publisher, Munich, 1990.* 5. *R.P.L. Nijssen, COMPOSITE MATERIALS AN INTRODUCTION, A VKCN publication, 1st Edition, 2015.* 6. *Robert M. Jones, MECHANICS OF COMPOSITE MATERIALS, 2nd Edition, Taylor & Francis, 1999.* 7. *Ronald F. Gibson, PRINCIPLE OF COMPOSITES MATERIAL MECHANICS, McGraw Hill, 1994.* 8. *Autar K. Kaw, MECHANICS OF COMPOSITE MATERIALS, 2nd Edition, Taylor & Francis, 2006.* 9. *Valery V. Vasiliev and Evgeny V. Morozov, ADVANCED MECHANICS OF COMPOSITE MATERIALS AND STRUCTURAL ELEMENTS, 3rd Edition, Elsevier, 2013.* 10. *Madhujit Mukhopadhyay, Mechanics of Composite Materials and Structures, University Press, 2018.* 11. *Reddy J. N., Mechanics of Laminated Composites Plates and Shells, CRC Press, 2016.* 12. *Bhagwan D. Agarwal, Analysis and Performance of Fiber, Wiley India, 2015.* 13. *Balasubramaniam, Composite Materials, John Wiley & Sons, Indian Ed., 2013.* 14. *K.K. Chawla, Composite Materials, Springer, 2012.*

Learning Assessment

	Bloom's Level of Thinking	Continuous Learning Assessment (50% weightage)								Final Examination (50% weightage)	
		CLA – 1 (10%)		CLA – 2 (15%)		CLA – 3 (15%)		CLA – 4 (10%)#			
		Theory	Practice	Theory	Practice	Theory	Practice	Theory	Practice	Theory	Practice
Level 1	Remember Understand	40 %	-	30 %	-	30 %	-	30 %	-	30%	-
Level 2	Apply Analyze	40 %	-	40 %	-	40 %	-	40 %	-	40%	-
Level 3	Evaluate Create	20 %	-	30 %	-	30 %	-	30 %	-	30%	-
	Total	100 %		100 %		100 %		100 %		100 %	

CLA – 4 can be from any combination of these: Assignments, Seminars, Tech Talks, Mini-Projects, Case-Studies, Self-Study, MOOCs, Certifications, Conf. Paper etc.,

Course Designers

Experts from Industry	Experts from Higher Technical Institutions	Internal Experts
1. Mr. Asit Ghanti *Assistant General Manager* *Vedanta Electrosteel Steel Ltd.* *Tel: +91-8651037058* *Email: asit.ghanti@vedanta.co.in*	*1 Dr. Mamilla Ravi Sankar* *Assistant Professor, ME* *IIT Tirupati* *Tel: +91-877 2503410* *Email: evmrs@iittp.ac.in*	*1. Dr. Shubhabrata Datta* *Research Professor, ME* *SRM Institute of Science and Technology, Kattankulathur,* *H/P: +91-9477485253* *Email: shubhabrata.p@ktr.srmuniv.ac.in*
Dr. A. Velayutham, DRDO, Avadi, velayudham.a@cvrde.drdo.in	*2. Dr.N.Arunachalam, IIT Madras, chalam@iitm.ac.in*	*2 Dr. Sumit PRAMANIK* *Research Associate Professor, ME* *SRM Institute of Science and Technology, Kattankulathur,* *H/P: +91-8777740422* *Email: sumitpramanik.s@ktr.srmuniv.ac.in*

Course Code	18MEE427T	Course Name	GLOBAL OPTIMIZATION ALGORITHMS	Course Category	E	Professional Elective	L	T	P	C
							3	0	0	3

Pre-requisite Courses	NIL	Co-requisite Courses	NIL	Progressive Courses	NIL
Course Offering Department	Mechanical Engineering	Data Book / Codes/Standards	NIL		

Course Learning Rationale (CLR):	*The purpose of learning this course is to:*
CLR-1 :	*Be familiar with evolutionary algorithm*
CLR-2 :	*Be familiar with particle genetic algorithm*
CLR-3 :	*Be familiar with modern optimization techniques*
CLR-4 :	*Be familiar with search algorithms*
CLR-5 :	*Be able to apply the knowledge of optimization in mechanical engineering applications*
CLR-6 :	*Be familiar with evolutionary algorithm, genetic algorithm, modern optimization techniques, search algorithms and optimization applications*

Course Learning Outcomes (CLO):	*At the end of this course, learners will be able to:*	Learning 1: Level of Thinking (Bloom)	2: Expected Proficiency (%)	3: Expected Attainment (%)	PLO 1: Engineering Knowledge	2: Problem Analysis	3: Design & Development	4: Analysis, Design, Research	5: Modern Tool Usage	6: Society & Culture	7: Environment & Sustainability	8: Ethics	9: Individual & Team Work	10: Communication	11: Project Mgt. & Finance	12: Life Long Learning	13: PSO - 1	14: PSO - 2	15: PSO - 3
CLO-1 :	*Recall the concepts of optimality criteria for various types of optimization problems.*	*1*	*90*	*85*	*H*				*M*				*H*	*H*	*M*		*H*	*H*	*M*
CLO-2 :	*Understand the problems*	*2*	*90*	*85*	*H*	*H*		*H*	*M*	*M*			*M*	*H*	*H*		*H*	*H*	*M*
CLO-3 :	*Apply the methods of optimization to solve real life problems*	*3*	*90*	*85*	*H*	*H*	*H*	*H*	*H*	*M*		*M*	*M*	*M*	*M*		*H*	*H*	*M*
CLO-4 :	*Analyze the methodology followed and test the results*	*4*	*90*	*85*	*H*	*H*	*H*		*H*		*M*				*M*		*H*	*H*	*M*
CLO-5 :	*Investigate the results to obtain the optimized solution*	*5*	*90*	*85*	*H*	*H*			*H*	*M*							*H*	*H*	*M*
CLO-6 :	*Investigate with evolutionary algorithm, genetic algorithm, modern optimization techniques, search algorithms and optimization applications*	*1-5*	*90*	*85*	*H*	*H*	*H*	*H*	*H*	*M*		*M*	*M*	*M*	*M*		*H*	*H*	*M*

		Global optimization technique	Modern optimization techniques Part I	Modern optimization techniques Part Ii	Search Methods	Applications of optimization techniques
Duration (hour)		9	9	9	9	9
S-1	*SLO-1*	*Introduction to Optimization Algorithms*	*Introduction to Particle Swam Optimization (PSO)*	*Introduction to Simulated Annealing algorithm (SAA)*	*Linear search and binary search*	*Desirable and undesirable effects, functional requirements such as geometry and materials.*
S-2	*SLO-1*	*The Structure of Optimization - Formulae and Search Space/Operator Design*	*Theoretical derivatives in particle swarm optimization, Variants of PSO*	*Asymtotic convergence and typical behavior of SAA,Multi objective SA*	*Jump search,interpolation search*	*Stochastic optimization*
S-3	*SLO-1*	*Evolutionary algorithms, ranking selection, VEGA, Convergence prevention*	*Performance Enhancing techniques in PSO, Applications of PSO*	*External optimization, Tabu Search,Memetic and Hybrid algorithms*	*Exponential search, Fibonacci search*	*Integrating simulation in optimization models*
S-4	*SLO-1*	*Optimization problems in engineering, Inverse problems; Scheduling and Routing*	*Introduction to Ant colony optimization(ACO), Framework of ACO*	*Downhill simplex , Applications of SAA*	*Golden selection, Random, pattern and gradient search methods*	*Multi-Disciplinary Optimization in enhancing the features of an automobile.*
S-5	*SLO-1*	*Data Mining, Intelligent System designing, Introduction to Genetic Algorithm, Operators of GA"s, Differences and similarities between genetic algorithms and traditional techniques*	*Hill Climbing, Multi-Objective Hill Climbing*	*Introduction to Differential Evolution (DE)*	*State Space Search, Uninformed Search*	*Optimization for modular design.*
S-6	*SLO-1*	*Introduction to utilization of computer programs in GA, Schema Algorithm, Advanced operators and techniques in genetic search*	*Problems in Hill Climbing, Hill Climbing with Random Restarts*	*Structure of Differential algorithm (DA)*	*Breadth-First Search, Depth-First Search*	*Optimization of design parameters to design a mechanical component.*
S-7	*SLO-1*	*Genetic algorithm and machine learning, Introduction to multi objective*	*GRASP, Raindrop Method, Random Optimization*	*Computing environments in DE*	*Depth-limited Search, Iterative Deepening Depth*	*Optimization of process parameters in machining operations.*

		optimization, Types of multi objective problems and principles				
S-8	SLO-1	*Pareto optimality, Non-Elitist multi objective algorithms, Elitist multi objective algorithms*	*Monte Carlo methods*	*Applications of DA*	*Informed Search - Greedy Search- A* search - Adaptive Walks, Tree search,*	*Optimization in minimizing cost and enhancing strength mechanical elements*
S-9	SLO-1	*Constrained multi objective algorithm, Usage of multi objective optimization in various optimization techniques*	*Multi disciplinary optimization methods and their applications in engineering.*	*Optimization with parameter uncertainities – Robust Optimisation, formulation, algorithms, applications*	*Interpolation methods: quadratic and cubic, direct root method.*	*Optimization problems on scheduling.*

Learning Resources	1. *Kalyanmoy Deb, "Optimization for Engineering design-Algorithms and Examples", Prentice Hall, India, 2012.* 2. *Kalyanmoy Deb, "Multi objective optimization using Evolutionary algorithms", John Wiley, 2001.* 3. *Joshua Knowles, David Corne, Kalyanmoy Deb "Multiobjective Problem Solving from Nature: From Concepts to Applications",Springer- 2008.* 4. *Thomas Weise, "Global Optimization Algorithms – Theory and Application", Thomas Weise, 2009.* 5. *S.S Rao, "Optimization – Theory and Applications", Wiley Eastern, New Delhi, 2009* 6. *Parsopoulos K and Vrahatis M.N, " Particle Swarm Optimization and Intelligence:Advances and Applications", IGI Global, 2010.*

Learning Assessment

	Bloom's Level of Thinking	Continuous Learning Assessment (50% weightage)								Final Examination (50% weightage)	
		CLA – 1 (10%)		CLA – 2 (15%)		CLA – 3 (15%)		CLA – 4 (10%)#			
		Theory	Practice	Theory	Practice	Theory	Practice	Theory	Practice	Theory	Practice
Level 1	Remember Understand	40 %	-	30 %	-	30 %	-	30 %	-	30%	-
Level 2	Apply Analyze	40 %	-	40 %	-	40 %	-	40 %	-	40%	-
Level 3	Evaluate Create	20 %	-	30 %	-	30 %	-	30 %	-	30%	-
	Total	100 %		100 %		100 %		100 %		100 %	

CLA – 4 can be from any combination of these: Assignments, Seminars, Tech Talks, Mini-Projects, Case-Studies, Self-Study, MOOCs, Certifications, Conf. Paper etc.,

Course Designers		
Experts from Industry	Experts from Higher Technical Institutions	Internal Experts
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Dr. A. Velayutham, DRDO, Avadi, velayudham.a@cvrde.drdo.in	*2. Dr.N.Arunachalam, IIT Madras, chalam@iitm.ac.in*	*Dr. Shubhabrata Datta,SRMIST*

Course Code	18MEE428T	Course Name	SIMULATION OF MECHANICAL SYSTEMS	Course Category	E	Professional Elective	L	T	P	C
							3	0	0	3

Pre-requisite Courses	NIL	Co-requisite Courses	NIL	Progressive Courses	NIL
Course Offering Department	Mechanical Engineering	Data Book / Codes/Standards	NIL		

Course Learning Rationale (CLR):	*The purpose of learning this course is to:*
CLR-1 :	*Be familiar with the function of physical system*
CLR-2 :	*Be familiar with the models use in need for simulation*
CLR-3 :	*understand about different methods of simulation*
CLR-4 :	*Be familiar with translational simulation*
CLR-5 :	*Be familiar with rotational mechanical systems*
CLR-6 :	*Be familiar with simulation of hydraulic and manufacturing system*

Course Learning Outcomes (CLO):	*At the end of this course, learners will be able to:*	Learning 1: Level of Thinking (Bloom)	2: Expected Proficiency (%)	3: Expected Attainment (%)	PLO 1: Engineering Knowledge	2: Problem Analysis	3: Design & Development	4: Analysis, Design, Research	5: Modern Tool Usage	6: Society & Culture	7: Environment & Sustainability	8: Ethics	9: Individual & Team Work	10: Communication	11: Project Mgt. & Finance	12: Life Long Learning	13: PSO - 1	14: PSO - 2	15: PSO - 3
CLO-1 :	*Recognize and analyze the use of different methods of simulation*	*1&2*	*90*	*85*	*H*	*M*	*M*	*M*	*L*					*L*		*L*	*H*		*L*
CLO-2 :	*Acquire knowledge on basic components and working of various mechanical systems*	*1*	*90*	*85*	*H*	*M*	*H*	*M*	*L*		*L*						*H*		*L*
CLO-3 :	*Recognize the application of Random variables and their properties, estimation of means, variance and correlation*	*1*	*90*	*85*	*H*	*H*	*M*	*M*	*M*								*M*		
CLO-4 :	*Understand the Static and dynamic modeling*	*1&2*	*90*	*85*	*H*	*M*	*M*	*M*									*H*		
CLO-5 :	*Recognize the Numerical computation techniques based upon the application*	*1&2*	*90*	*85*	*H*	*M*	*M*	*H*	*H*								*H*		
CLO-6 :	*Simulation of rotational systems and translational system as well as the hydraulic system*	*1*	*90*	*85*	*H*	*M*	*L*	*L*	*M*					*L*			*H*		*M*

		Introduction	Types and principles ofmodeling	Methods of simulation	simulation of translational and Rotational systems	Simulation of hydraulic systems and manufacturing system
Duration (hour)		09	09	09	09	09
S-1	SLO-1	*Need for modeling and simulation in mechanical systems*	*Static modeling with examples*	*Monte Carlo simulation*	*Building of simulation models in mechanical systems*	*Simulation of hydraulic systems*
S-2	SLO-1	*Basics of modeling of physical systems*	*dynamic modeling with examples*	*Experimental nature of simulation*	*Simulation of translational systems*	*hydraulic systems with real time examples*
S-3	SLO-1	*methods of modeling*	*Stochastic models with examples*	*Numerical computation techniques*	*Case studies – Translatory motion for Serial Manipulator*	*Simulation of material handling systems in manufacturing*
S-4	SLO-1	*Review of basic probability and statistics*	*Principles of modeling*	*Analog system models*	*Simulation of rotational systems*	*Case studies –Automated guided vehicle (AGV) in Goods Transportation* *Simulation in flexible manufacturing*
S-5	SLO-1	*Random variables and their properties, estimation of means, variance and correlation*	*Study and evaluation of model*	*hybrid system models*	*real time examples*	*Case studies- vice casting product*
S-6	SLO-1					
S-7	SLO-1	*Concept of system and environment, continues and discrete systems*	*Continues system models*	*Continues system models*	*Transform Function Analysis. Developing a Linear Model*	*Simulation of waiting line system*
S-8	SLO-1	*Linear systems*	*Introduction to simulation, basic simulation, advantages of simulation*	*Role of computers in simulation*	*Case studies – Rotary Joint Link for SCARA ROBOT*	*waiting line system in manufacturing with examples*
S-9	SLO-1	*nonlinear systems*	*Role of simulation in model evaluation with examples*	*introduction to simulation software packages*	*Techniques for variance reduction*	

Learning Resources	1. *Dym C.L, "Principles of Mathematical Modeling", Elsevier, 2nd Edition 2004.* 2. *Geoffrey Gordon, "System Simulation" Phi Learning, 2nd Edition 2002* 3. *M. Close and Dean K. Frederick, "Modeling and Analysis of Dynamic Systems", Houghton Mifflin, 3rd Edition, 2002* 4. *Guy L, Richard M. Feldman, "Manufacturing Systems Modeling and Analysis", Springer, 2011.* 5. *Performance Modeling of Automated Manufacturing Systems (Prentice Hall Information and System Sciences Series) 1st Edition Edition, 1992* 6. *J. Schwarzenbach and K.F. Gill, "System Modeling and Control".Halsted Press, New York, 1992* 7. *Robert E. Shannon, "System Simulation: The Art and Science", Prentice Hall, 1975* 8. *Automation, Production Systems, and Computer-Integrated Manufacturing 4 Edition (English, Paperback, Mikell P. Groover), 2016*

Learning Assessment

	Bloom's Level of Thinking	Continuous Learning Assessment (50% weightage)								Final Examination (50% weightage)	
		CLA – 1 (10%)		CLA – 2 (15%)		CLA – 3 (15%)		CLA – 4 (10%)#			
		Theory	Practice	Theory	Practice	Theory	Practice	Theory	Practice	Theory	Practice
Level 1	Remember Understand	40 %	-	30 %	-	30 %	-	30 %	-	30%	-
Level 2	Apply Analyze	40 %	-	40 %	-	40 %	-	40 %	-	40%	-
Level 3	Evaluate Create	20 %	-	30 %	-	30 %	-	30 %	-	30%	-
	Total	100 %		100 %		100 %		100 %		100 %	

CLA – 4 can be from any combination of these: Assignments, Seminars, Tech Talks, Mini-Projects, Case-Studies, Self-Study, MOOCs, Certifications, Conf. Paper etc.,
SLO – Session Learning Outcome

Course Designers

Experts from Industry	Experts from Higher Technical Institutions	Internal Experts
1. Mr. S.Bhargav, GM,Rane Brake, Trichy	*1. Dr. V.Srinivasan,Annamalai University, srinivraghavan@yahoo.com*	*1. Dr. M. Prakash, SRMIST*
2. Dr. Muthumanikkam, Jt. Director, CVRDE, DRDO,Avadi,Chennai.	*2.Dr.Ashok Kumar, Govn. Col.of. Eng, Bargur, Krishnagiri, Tamil Nadu Akrt02au@gmail.com*	*2. Dr.A.Arul Jeya Kumar, SRMIST*

Course Code	18MEE429T	Course Name	INDUSTRY 4.0	Course Category	E	Professional Elective	L	T	P	C
							3	0	0	3

Pre-requisite Courses	Nil	Co-requisite Courses	Nil	Progressive Courses	Nil
Course Offering Department	Mechanical Engineering	Data Book / Codes/Standards	Nil		

Course Learning Rationale (CLR):	*The purpose of learning this course is to:*
CLR-1 :	*Understand the Architectural Overview of Internet of Things*
CLR-2 :	*Be familiar with the concepts of big data analytics*
CLR-3 :	*Learn the basics of cloud computing*
CLR-4 :	*Be familiar with method and new frameworks of information security management.*
CLR-5 :	*understand the fundamentals concepts of digital manufacturing*
CLR-6 :	*Understand the concepts of Internet of things, big data analysis, cloud computing, cyber security and digital manufacturing*

		Learning			Program Learning Outcomes (PLO)														
		1	2	3	1	2	3	4	5	6	7	8	9	10	11	12	13	14	15
Course Learning Outcomes (CLO):	*At the end of this course, learners will be able to:*	Level of Thinking (Bloom)	Expected Proficiency (%)	Expected Attainment (%)	Engineering Knowledge	Problem Analysis	Design & Development	Analysis, Design, Research	Modern Tool Usage	Society & Culture	Environment & Sustainability	Ethics	Individual & Team Work	Communication	Project Mgt. & Finance	Life Long Learning	PSO - 1	PSO - 2	PSO - 3
CLO-1 :	*Recognize and analyze the use of different methods of simulation*	*1&2*	*90*	*85*	*H*	*M*	*M*	*M*	*L*					*L*		*L*	*H*		*L*
CLO-2 :	*Acquire knowledge on basic components and working of various mechanical systems*	*1*	*90*	*85*	*H*	*M*	*H*	*M*	*L*		*L*						*H*		*L*
CLO-3 :	*Recognize the application of Random variables and their properties, estimation of means, variance and correlation*	*1*	*90*	*85*	*H*	*H*	*M*	*M*	*M*								*M*		
CLO-4 :	*Understand the Static and dynamic modeling*	*1&2*	*90*	*85*	*H*	*M*	*M*	*M*									*H*		
CLO-5 :	*Recognize the Numerical computation techniques based upon the application*	*1&2*	*90*	*85*	*H*	*M*	*M*	*H*	*H*								*H*		
CLO-6 :	*Simulation of rotational systems and translational system as well as the hydraulic system*	*1*	*90*	*85*	*H*	*M*	*L*	*L*	*M*					*L*			*H*		*M*

Duration (hour)	9	9	9	9	9
S-1	*IoT-An Architectural Overview*	*Big Data Platforms for the Internet of Things*	*Introduction to the Cloud Computing*	*Myths Of Information Security Mana*	*Introduction To Digital Manufacturing*
S-2	*Building an architecture*	*Network protocol*	*History of cloud computing*	*The big picture*	*Features and development of digital manufacturing*
S-3	*Main design principles and needed capabilities*	*Data dissemination –current state of art*	*Cloud service options*	*Learning from experience*	*Theory system of digital manufacturing science*
S-4	*An IoT architecture outline, standards considerations*	*Improving Data and Service Interoperability with Structure*	*Cloud Deployment models*	*Weaknesses in Information Security*	*Operation Mode*
S-5	*M2M and IoT Technology Fundamentals*	*Compliance, Conformance*	*Business concerns in the cloud,Cloud Orchestration*	*The extent of crime in cyberspace*	*Architecture of Digital Manufacturing System*
S-6	*Devices and gateways, Local and wide area networking*	*Context Awareness*	*Exploring virtualization, Load balancing*	*The cyberspace crimoid syndrome*	*Additive Manufacturing - overview, Techniques.*
S-7	*Data management, Business processes in IoT*	*interoperability problem in the IoT context*	*Hypervisors, Machine imaging,*	*Policies and technologies*	
S-8	*Everything as a Service (XaaS)*	*Big Data Management Systems for the Exploitation of Pervasive Environment*	*Cloud marketplace overview*	*A new framework for information security.*	*Rapid manufacturing-Future development-Virtual prototyping*
S-9	*M2M and IoT Analytics, Knowledge Management.*	*Big Data challenges and requirements coming from different Smart City applications.*	*Comparison of Cloud providers.*		

Learning Resources	1. *Vijay Madisetti and ArshdeepBahga, "Internet of Things (A Hands-on-Approach)", 1st Edition, VPT, 2014.* 2. *Bernd Scholz-Reiter, Florian Michahelles, "Architecting the Internet of Things", ISBN 978-3-642-19156-5 e-ISBN 978-3-642-19157-2, Springer* 3. *Stackowiak, R., Licht, A., Mantha, V., Nagode, L.," Big Data and The Internet of Things Enterprise Information Architecture for A New Age", Apress, 2015* 4. *Cloud Computing: Principles and Paradigms by RajkumarBuyya, James Brobergand Andrzej M. Goscinski, Wiley, 2011.* 5. *Zude Zhou, Shane (Shengquan) Xie and Dejun Chen, Fundamentals of Digital Manufacturing Science, Springer-Verlag London Limited,2012* 6. *Chua.C.K, "Rapid Prototyping", John Wiley, New York, 1997.*

Learning Assessment											
	Bloom's Level of Thinking	Continuous Learning Assessment (50% weightage)								Final Examination (50% weightage)	
		CLA – 1 (10%)		CLA – 2 (15%)		CLA – 3 (15%)		CLA – 4 (10%)#			
		Theory	Practice	Theory	Practice	Theory	Practice	Theory	Practice	Theory	Practice
Level 1	Remember Understand	40 %	-	30 %	-	30 %	-	30 %	-	30%	-
Level 2	Apply Analyze	40 %	-	40 %	-	40 %	-	40 %	-	40%	-
Level 3	Evaluate Create	20 %	-	30 %	-	30 %	-	30 %	-	30%	-
	Total	100 %		100 %		100 %		100 %		100 %	

CLA – 4 can be from any combination of these: Assignments, Seminars, Tech Talks, Mini-Projects, Case-Studies, Self-Study, MOOCs, Certifications, Conf. Paper etc.,
SLO – Session Learning Outcome

Course Designers		
Experts from Industry	Experts from Higher Technical Institutions	Internal Experts
1. Dr. R. Kalimuthu, ISRO, Mahendragiri, r_kalimuthu@vssc.gov.in, rkpearls@yahoo.com	*1. Dr. P. Hariharan, Anna University, hari@annauniv.edu, hariharan2311@gmail.com*	*Dr.U.Mohammed Iqbal*
2. Dr. A. Velayutham, DRDO, Avadi, velayudham.a@cvrde.drdo.in *3. Mr.P.Karthikeyan, Head Operations Improvement, Nokia Solutions, Oragadam Kartikeyan.p@nokia.com*	*2. Dr.N.Arunachalam, IIT Madras, chalam@iitm.ac.in*	*J.Santhakumar*

Course Code	18MEE430T	Course Name	TQM AND RELIABILITY ENGINEERING	Course Category	E	Professional Elective	L	T	P	C
							3	0	0	3

Pre-requisite Courses	NIL	Co-requisite Courses	NIL	Progressive Courses	NIL
Course Offering Department	Mechanical Engineering	Data Book / Codes/Standards	NIL		

Course Learning Rationale (CLR):	*The purpose of learning this course is to:*
CLR-1 :	*Understand the importance of TQM and its concepts, tools and techniques and apply in the real-world environment*
CLR-2 :	*Analyze the role of human involvement to improve the quality of product and service*
CLR-3 :	*Understand, apply and evaluate the tools and techniques used for product and service quality*
CLR-4 :	*Understand the basic concepts of reliability, apply and evaluate reliability for different systems*
CLR-5 :	*Understand and apply the concept of maintainability of a system to evaluate time for different cases*
CLR-6 :	*Understand the importance of quality and reliability in every process in the current scenario*

Course Learning Outcomes (CLO):	*At the end of this course, learners will be able to:*	Learning 1: Level of Thinking (Bloom)	2: Expected Proficiency (%)	3: Expected Attainment (%)	PLO 1: Engineering Knowledge	2: Problem Analysis	3: Design & Development	4: Analysis, Design, Research	5: Modern Tool Usage	6: Society & Culture	7: Environment & Sustainability	8: Ethics	9: Individual & Team Work	10: Communication	11: Project Mgt. & Finance	12: Life Long Learning	13: PSO - 1	14: PSO - 2	15: PSO - 3
CLO-1 :	*Recognize the importance of quality in every activity of an organization and in personal life*	*1,2*	*80*	*75*	*M*	*M*	*M*	-	*M*	-	-	*M*	*H*	*M*	-	-	-	-	*M*
CLO-2 :	*Apply the different tools and techniques to solve day to day issues and will seek an opportunity to practice*	*1,2,3*	*80*	*75*	*M*	*H*	-	-	*H*	-	-	-	*H*	*M*	-	*M*	-	-	*M*
CLO-3 :	*Think from the customer perspective and will plan for customer retention through total quality management*	*1,2,3*	*80*	*75*	*M*	*H*	*M*	-	*H*	*M*	-	*M*	*H*	*H*	-	-	-	-	*M*
CLO-4 :	*Develop and test a system for its reliability*	*1,2*	*80*	*75*	*M*	*M*	*M*	-	*M*	-	-	-	-	-	-	-	-	-	*M*
CLO-5 :	*Estimate MTTF, MTTR, MMT and MDT and plan for a maintenance strategy*	*1,2,3*	*80*	*75*	*M*	*H*	*M*	-	*H*	-	-	-	-	-	-	-	-	-	*M*
CLO-6 :	*Recognize the importance of quality in every activity of an organization and in personal life*	*1,2*	*80*	*75*	*M*	*M*	*M*	-	*M*	-	-	*M*	*H*	*M*	-	-	-	-	*M*

		Evolution, theories and implementation	Principles and 7 QC tools	Management Tools	Reliability	Maintainability
Duration (hour)		9	9	9	9	9
S-1	SLO-1	*Evolution of Total Quality Management*	*Customer Satisfaction – Types of customers, customer supplier chain*	*Affinity diagram – Relations diagram*	*Probabilistic nature of failures*	*Introduction Availability and Maintainability*
S-2	SLO-1	*Definition of quality, Dimensions of Quality*	*Customer perception of quality customer feed back*	*Tree diagram – Matrix diagram – Matrix data analysis diagram*	*Mean failure rate – Meantime between failures*	*Types of maintenance strategy*
S-3	SLO-1	*Deming's theory*	*Customer complaints – Customer retention – Service quality*	*Process decision program chart, Arrow diagram*	*Hazard rate – Hazard models*	*Mean time– to repair (MTTR)*
S-4	SLO-1	*Juran and Crosby theories*	*Employee involvement and motivation – Maslow's hierarchy of needs*	*5S Principles*	*Weibull model*	*Factors contributing to Mean Down Time (MDT)*
S-5	SLO-1	*Taguchi and Ishikawa theories*	*Herzberg theory – Empowerment and team work*	*Quality Function Deployment (QFD)*	*System reliability improvement*	*Fault diagnosis, and routine testing for unrevealed faults*
S-6	SLO-1	*Quality costs, Product quality Vs Service quality*	*Seven QC tools – Check sheets*	*Failure mode and effects analysis (FMEA)*	*Redundancy*	*Factors contributing to Mean Maintenance Time – (MMT) on condition maintenance*
S-7	SLO-1	*Goal setting*	*Histograms, control charts*	*Root cause analysis, poka-yoke*	*Series – Parallel and Mixed configurations*	*Total Productive Maintenance (TPM)*
S-8	SLO-1	*Strategic Quality planning*	*Pareto diagram, Cause and effect diagram*	*Introduction to Six Sigma*	*Problems in Series – Parallel and Mixed configurations*	*Periodic condition monitoring, Continuous condition monitoring*
S-9	SLO-1	*TQM implementation*	*Stratification, Scatter diagrams*	*DMAIC*	*Problems in Series – Parallel and Mixed configurations*	*Economics of maintenance*

Learning Resources	
	1. M. P. Poonia, S.C. Sharma, "Total Quality Management", Khanna Publishing, 2019. 2. R Kiran, "Total Quality Management: Key Concepts and Case Studies", Elsevier Inc., 2017. 3. Dale H Besterfield, "Total Quality Management", Fourth Edition, Pearson Education Asia, 2015. 4. John Oakland, Peter Morris "TQM – A pictorial guide for managers", Routledge, 2011. 5. Roderick A Munro, Govindarajan Ramu and Daniel J Zrymiak, "The Certified Six Sigma Green Belt Handbook", Second Edition, American Society for Quality, USA, 2015. 6. L S Srinath, "Reliability Engineering", Fourth Edition, Affiliated East West Press, 2008. 7. E Balagurusamy, "Reliability Engineering", Tata McGraw Hill Education, 2010.

Learning Assessment

	Bloom's Level of Thinking	Continuous Learning Assessment (50% weightage)								Final Examination (50% weightage)	
		CLA – 1 (10%)		CLA – 2 (15%)		CLA – 3 (15%)		CLA – 4 (10%)#			
		Theory	Practice	Theory	Practice	Theory	Practice	Theory	Practice	Theory	Practice
Level 1	Remember Understand	40 %	-	30 %	-	30 %	-	30 %	-	30%	-
Level 2	Apply Analyze	40 %	-	40 %	-	40 %	-	40 %	-	40%	-
Level 3	Evaluate Create	20 %	-	30 %	-	30 %	-	30 %	-	30%	-
	Total	100 %		100 %		100 %		100 %		100 %	

CLA – 4 can be from any combination of these: Assignments, Seminars, Tech Talks, Mini-Projects, Case-Studies, Self-Study, MOOCs, Certifications, Conf. Paper etc.,

Course Designers

Experts from Industry	Experts from Higher Technical Institutions	Internal Experts
Mr. R. Nanda Kumar *Vice Chairman* *National Institution for Quality and Reliability (NIQR)*	*1. Dr. P. Hariharan, Anna University, hari@annauniv.edu, hariharan2311@gmail.com*	*Mr. E. Vijayaragavan, SRM IST*
Mr. N. Palani *Head – Quality Assurance* *Rane TRW Steering Systems Limited*	*2. Dr.N.Arunachalam, IIT Madras, chalam@iitm.ac.in*	

Course Code	18MEE431T	Course Name	DESIGN OF JIGS, FIXTURE AND PRESS TOOLS	Course Category	E	Professional Elective	L	T	P	C
							3	0	0	3

Pre-requisite Courses	NIL	Co-requisite Courses	NIL	Progressive Courses	NIL
Course Offering Department	Mechanical Engineering	Data Book / Codes/Standards	DESIGN DATA BOOK		

Course Learning Rationale (CLR):	*The purpose of learning this course is to:*
CLR-1 :	*Explore the various locating and clamping method*
CLR-2 :	*Understand the functions and design principles of Jigs*
CLR-3 :	*Understand the functions and design principles of Fixtures*
CLR-4 :	*Understand the functions and design principles of press work*
CLR-5 :	*Understand the functions and design principles of bending, forming and drawing*
CLR-6 :	*Be Familiar with design of jigs, Fixtures and Press Tools*

Course Learning Outcomes (CLO):	*At the end of this course, learners will be able to:*	Learning 1 Level of Thinking (Bloom)	2 Expected Proficiency (%)	3 Expected Attainment (%)	PLO 1 Engineering Knowledge	2 Problem Analysis	3 Design & Development	4 Analysis, Design, Research	5 Modern Tool Usage	6 Society & Culture	7 Environment & Sustainability	8 Ethics	9 Individual & Team Work	10 Communication	11 Project Mgt. & Finance	12 Life Long Learning	13 PSO - 1	14 PSO - 2	15 PSO - 3
CLO-1 :	*Able to design the locator and the clamp for the mechanical component*	1&2	80	85	H	M	H	-	-	-	-	-	-	-	-	-	M	-	-
CLO-2 :	*Acquire knowledge on different type of jigs and its application*	1	80	85	H	M	H	-	-	-	-	-	-	-	-	-	H	-	-
CLO-3 :	*Acquire knowledge on different type of fixture and its application*	1	80	85	H	M	H	-	-	-	-	-	-	-	-	-	H	-	-
CLO-4 :	*Understand the major design principle of press work and element of cutting die*	1&2	80	85	H	L	M		-	-	-	-	-	-	-	-	-	-	-
CLO-5 :	*Understand the functions and design principles of bending, forming and drawing*	1&2	80	85	H	-	M		-	-	-	-	-	-	-	-	-	-	-
CLO-6 :	*Understand the functions and design principles of locator and clamping of jigs and fixtures, use of press tools in bending, forming and drawing operations*	1&2	80	85	H	H	M	-	-	-	-	-	-	-	-	-	-	-	-

		Locating and Clamping Principles	Design of Jigs	Design of Fixtures	Press Working Terminologies and Element of Cutting Dies	Bending, Forming and Drawing Dies
Duration (hour)		9	9	9	9	9
S-1	SLO-1	*Objective of tool design, Function, features and advantages of jigs and fixture.*	*Types of jigs – Template and Plate Jigs*	*Introduction to fixture, type of fixtures*	*Press working terminology, types of presses*	*Types of Bending dies, press capacity*
S-2	SLO-1	*Locating Principle, Locating methods and devices,*	*Channel, Pot, Turnover, Box and Post Jig*	*Design Principles of milling fixture*	*Press accessories and press working operation.*	*Spring back, knockout, direct and indirect, pressure pads, ejectors*
S-3	SLO-1	*Pin and Button locator, Rest pads and plates, Diamond pin locator*	*Indexing Jigs*	*Lathe fixture*	*Shearing action, clearances, press work materials.*	*Variables affecting metal flow in drawing operation*
S-4	SLO-1	*Clamping Principles, types of clamps, mechanical actuation clamps*	*Drill Bushes and Jig Buttons*	*Design Principles of boring fixture, and Broaching Fixture*	*Center of pressure, design of various elements of dies*	*Draw die insert, draw beads, ironing*
S-5	SLO-1	*Pneumatic actuation clamping*	*method of construction of drill jigs*	*Design Principles of Grinding Fixture*	*Accessories of blanking dies – punch, punch holder, die set, stripper, pilots*	*Design and development of bending and forming*
S-6	SLO-1	*Hydraulic actuation clamping*	*General consideration in the design of Drill jigs*	*Assembly, Inspection and welding fixtures*		*Drawing reverse re-drawing and combination die*
S-7	SLO-1	*Vacuum and magnetic clamping*	*Drill jigs and modern manufacturing*	*Modular fixturing system,*	*Selection of standard parts*	*Blank development for axisymmetric, rectangular and elliptic parts, single and double action dies*
S-8	SLO-1	*Standard parts in jigs and fixtures*	*Design and development of jigs and for given component 1*	*Design and development of fixtures and for given component 1*	*Design and preparation of four standard views of simple blanking and piercing die*	*Bulging, swaging, Embossing, coining, curling*
S-9	SLO-1	*Limits, fits, Tolerances and types of tolerances*			*Shaving, notching, compound and progressive dies*	*Hole flanging, shaving, and sizing, assembly, fine blanking dies*

Learning Resources	1. *Donaldson, Lecain and Goold "Tool Design " , 3rd edition Tata McGraw hill ,2007* 2. *Joshi, P.H. "Jigs and Fixtures" second edition, Tata McGraw hill publishing co., ltd., New delhi,2004* 3. *K.Venkataraman, "Design of Jigs Fixtures and Press tool", Tata McGraw hill New delhi,2005* 4. *Kempster, "jigs and fixtures design" Hoddes and Stoughton – third edition 1974* 5. *Joshi, P.H "Press tool – Design and Construction", S.Chand &company, 2010.* 6. *Hoffman "Jigs and Fixtures Design" – Thomson Delmar learning, Singapore, 2004.* 7. *ASTME fundamentals of tool design prentice hall of India.* 8. *P.S.G tech…, "design data book", kalaikathir Achchagam, 2012.*

Learning Assessment											
	Bloom's Level of Thinking	Continuous Learning Assessment (50% weightage)								Final Examination (50% weightage)	
		CLA – 1 (10%)		CLA – 2 (15%)		CLA – 3 (15%)		CLA – 4 (10%)#			
		Theory	Practice	Theory	Practice	Theory	Practice	Theory	Practice	Theory	Practice
Level 1	Remember Understand	40 %	-	30 %	-	30 %	-	30 %	-	30%	-
Level 2	Apply Analyze	40 %	-	40 %	-	40 %	-	40 %	-	40%	-
Level 3	Evaluate Create	20 %	-	30 %	-	30 %	-	30 %	-	30%	-
	Total	100 %		100 %		100 %		100 %		100 %	

CLA – 4 can be from any combination of these: Assignments, Seminars, Tech Talks, Mini-Projects, Case-Studies, Self-Study, MOOCs, Certifications, Conf. Paper etc.,

Course Designers		
Experts from Industry	Experts from Higher Technical Institutions	Internal Experts
1. Dr. R. Kalimuthu, ISRO, Mahendragiri, r_kalimuthu@vssc.gov.in, rkpearls@yahoo.com	*1. Dr. P. Hariharan, Anna University, hari@annauniv.edu, hariharan2311@gmail.com*	*1. Kolli Balasivarama Reddy Asst. Professor, ME SRM Institute of Science and Technology, Kattankulathur,*
2. Dr. A. Velayutham, DRDO, Avadi, velayudham.a@cvrde.drdo.in	*2.Dr.N.Arunachalam, IIT Madras, chalam@iitm.ac.in*	

Course Code	18MEE341T	Course Name	REFRIGERATION AND AIR CONDITIONING SYSTEMS	Course Category	E	Professional Elective	L	T	P	C
							3	0	0	3

Pre-requisite Courses	18MEC107T	Co-requisite Courses	NIL	Progressive Courses	NIL
Course Offering Department	Mechanical Engineering	Data Book / Codes/Standards	Refrigerant and Psychrometric Properties Tables &Charts/M.L.Mathur &F.S.Mehta		

Course Learning Rationale (CLR):	The purpose of learning this course is to:
CLR-1 :	*Be familiar with vapour compression system*
CLR-2 :	*Be familiar with the refrigeration cycles and methods for improving Performance*
CLR-3 :	*Understand the working of components of refrigeration systems.*
CLR-4 :	*Be familiar with design of air conditioning systems*
CLR-5 :	*Be familiar with air conditioning systems for various applications.*
CLR-6 :	*Be familiar with refrigeration and air conditioning system s*

Course Learning Outcomes (CLO):	At the end of this course, learners will be able to:	Learning 1: Level of Thinking (Bloom)	2: Expected Proficiency (%)	3: Expected Attainment (%)	PLO 1: Engineering Knowledge	2: Problem Analysis	3: Design & Development	4: Analysis, Design, Research	5: Modern Tool Usage	6: Society & Culture	7: Environment & Sustainability	8: Ethics	9: Individual & Team Work	10: Communication	11: Project Mgt. & Finance	12: Life Long Learning	13: PSO - 1	14: PSO - 2	15: PSO - 3
CLO-1 :	*Recognize and analyze the vapour compression systems*	1&2	90	80	H	H		M			H							H	
CLO-2 :	*Acquire knowledge on refrigeration cycles and methods for improving Performance*	1,2,3	90	80	H	M		M			L							H	
CLO-3 :	*Understand the working of refrigeration systems.*	1,2	90	80	H						H							H	
CLO-4 :	*Analyze and design ofair conditioning systems.*	1,2,3	90	80	H	H	H	M			M							H	
CLO-5 :	*Appreciate the need and applications of air conditioning systems.*	1&2	90	80	H					L								H	
CLO-6 :	*Understand and analyze the refrigeration and air conditioning system s*	1&2	90	80	H	M		M			H							H	

		Vapour Compression Refrigeration Systems	Absorption Refrigeration Systems	Refrigeration Equipment's & Contro	Design of Air Conditioning Systems	Applications of Refrigeration And Air Conditioning Systems
Duration (hour)		9	9	9	9	9
S-1	SLO1	*Review of thermodynamic principles of refrigeration*	*Ideal vapour absorption refrigeration system*	*Construction features of reciprocating compressors, Rotary and screw compressors*	*Different heat sources-sensible heat load, Latent heat load*	*Preservation of different products*
S-2	SLO1	*Simple vapour compression refrigeration system*	*Absorbent refrigerant combination - Properties of refrigerant absorbent pair*	*Type of Condenser, heat transfer in condensers*	*Heating and Cooling Load - Occupants load, equipment load, fresh air load, infiltration air load*	*Construction and working of Ice factory*
S-3	SLO1	*Problem on COP of VCR system*	*Vapour absorption refrigeration system based on Water-lithium bromide.*	*Types of cooling towers- Construction features of Natural, Mechanical draft.*	*Design of air conditioning system-cooling load and air quantities*	*The heating and cooling requirements for different dairy products and processes in Dairy plant*
S-4	SLO1	*Methods to improve the COP of VCR system*	*Problems based on Water - lithium bromide systems*	*Type of Evaporators-working of dry expansion and flooded evaporator.*	*Bypass factor(BPF) of heating and cooling coil, Effective sensible heat factor(ESHF)*	*Application of non-conventional refrigeration method in vortex and pulse tube refrigeration. system*
S-5	SLO1	*Multiple evaporator and compressor system*	*Vapour absorption refrigeration system based on Aqua Ammonia*	*Working of automatic (or) constant pressure expansion valve and thermostatic expansion valve*	*Room sensible heat factor(RSHF).Grand sensible heat factor*	*Application of non-conventional refrigeration method in Solar Refrigeration system*
S-6	SLO1	*Cascade system*	*Problems based on Aqua -Ammonia Systems*	*Properties of refrigerants*	*Factors affecting Human comfort*	*Application of air conditioning in hotels and restaurants*
S-7	SLO1	*COP comparison with sub cooling and super heating*	*Single effect absorption refrigeration system*	*Selection of refrigerants-alternate refrigerants*	*Problems on –RSHF, and GSHF*	*Application of air conditioning in theatres*
S-8	SLO1	*Problems based on sub cooling*	*Comparison of vapour compression refrigeration system versus vapour absorption refrigeration system*	*thermostatic control-operating and safety controls*	*Problems on design of air conditioning system*	*Application of air conditioning in auditorium and hospitals*
S-9	SLO1	*Problems based on super heating*	*Advantage and disadvantage of vapour absorption system*	*Refrigerant charging procedure, methods for measuring a Refrigerant Charge*	*Cooling coils and dehumidifier, air washers*	*Cryogenics-low temperature applications*

Learning Resources	3. Arora, S. C. and Domkundwar, S., A course in Refrigeration and Air conditioning, DhanpatRai (P) Ltd., New Delhi, 2012 4. Ananthanarayanan.P.N, "Basic Refrigeration and Air Conditioning" ,Tata McGraw Hill ,3rd Edition,New Delhi,2006 5. Manohar Prasad, Refrigeration and A 6. Air conditioning, New Age International (P) Ltd, New Delhi, 2010 7. Roy J. Dossat, Principles of Refrigeration, Pearson Education Asia, 4th edition, 2001 8. Arora, C. P., Refrigeration and Air Conditioning, Tata McGraw Hill, New Delhi, 2006 9. Andrew D. Althouse,Modern Refrigeration and Air Conditioning,Goodheart-Willcox Company, Incorporated, 2016 10. G F Hundy Refrigeration, Air conditioning and heat pumps, McGraw-Hill Book company(UK) Ltd, fifth edition 2016 11. S.N.Sapali,Refrigeration and Air conditioning ,published by asoke K.Ghosh,PHI Learning Private Limited, Second edition 2014 12. Ml Mathur Fs Mehta, Refrigerant & Psychrometric Properties Tables & Charts,Published by Jain Brothers,2010

Learning Assessment											
	Bloom's Level of Thinking	Continuous Learning Assessment (50% weightage)								Final Examination (50% weightage)	
		CLA – 1 (10%)		CLA – 2 (15%)		CLA – 3 (15%)		CLA – 4 (10%)#			
		Theory	Practice	Theory	Practice	Theory	Practice	Theory	Practice	Theory	Practice
Level 1	Remember Understand	40 %	-	30 %	-	30 %	-	30 %	-	30%	-
Level 2	Apply Analyze	40 %	-	40 %	-	40 %	-	40 %	-	40%	-
Level 3	Evaluate Create	20 %	-	30 %	-	30 %	-	30 %	-	30%	-
	Total	100 %		100 %		100 %		100 %		100 %	

CLA – 4 can be from any combination of these: Assignments, Seminars, Tech Talks, Mini-Projects, Case-Studies, Self-Study, MOOCs, Certifications, Conf. Paper etc.,
SLO – Session Learning Outcome

Course Designers		
Experts from Industry	Experts from Higher Technical Institutions	Internal Experts
1. Dr. R. Kalimuthu, ISRO, Mahendragiri, r_kalimuthu@vssc.gov.in, rkpearls@yahoo.com	*Dr P.Balachander Assistant Professor Thermal Sciences Block Refrigeration & Air Conditioning Department of Mechanical Engineering, College of Engineering, Guindy campus, Anna University, Chennai-600025 Email:p_balachander@annauniv.edu*	*Mr.J.Thavamani Assistant Professor, Department of Mechanical Engineering SRM IST Email: thavamani.j@ktr.srmuniv.ac.in*
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Course Code	18MEE342T	Course Name	INTERNAL COMBUSTION ENGINES	Course Category	E	Professional Elective	L	T	P	C
							3	0	0	3

Pre-requisite Courses	18MEC101T,18MEC102T	Co-requisite Courses	NIL	Progressive Courses	NIL
Course Offering Department	Mechanical Engineering	Data Book / Codes/Standards	NIL		

Course Learning Rationale (CLR):	The purpose of learning this course is to:
CLR-1 :	*familiarizewith the I.C.enginebasics, analyze the ideal cycles and performance characteristics*
CLR-2 :	*Study about carburetors, fuel injection systems, ignition, lubrication and cooling systems.*
CLR-3 :	*Understand the combustion in S.I. engines, combustion chambers and knocking phenomena*
CLR-4 :	*Understand the combustion in C.I. engine, diesel combustion chambers and abnormal combustion;*
CLR-5 :	*Study about the emissions from the I.C. engines, alternative fuels and new combustion concepts*
CLR-6 :	*Understand the design principles of I.C. engines*

Course Learning Outcomes (CLO):	At the end of this course, learners will be able to:	Learning 1	2	3	Program Learning Outcomes (PLO) 1	2	3	4	5	6	7	8	9	10	11	12	13	14	15
		Level of Thinking (Bloom)	Expected Proficiency (%)	Expected Attainment (%)	Engineering Knowledge	Problem Analysis	Design & Development	Analysis, Design, Research	Modern Tool Usage	Society & Culture	Environment & Sustainability	Ethics	Individual & Team Work	Communication	Project Mgt. & Finance	Life Long Learning	PSO - 1	PSO - 2	PSO - 3
CLO-1 :	*Performance calculations of I.C. engines, Interpret the ideal and fuel-air cycles; performance maps*	1,2&3	90	80	H	H	H	H	L	L	M						M	H	M
CLO-2 :	*Evaluate the functioning of various auxiliary systems*	1&2	90	80	H	H	H	M	M	L	M						M	H	M
CLO-3 :	*Analyze SI engine combustion, knocking and the design principles of combustion chamber.*	1&2	90	80	H	H	M	H	M	L	M						M	H	M
CLO-4 :	*Analyze CI engine combustion, design principles of combustion chamber and abnormal combustion*	1&2	90	80	H	H	M	H	M	L	M						M	H	M
CLO-5 :	*Recognize the need for reducing the emission from I.C. engines, and alternate fuels*	1&2	90	80	H	M	M	H	H	M	H						M	H	M
CLO-6 :	*Evaluate the performance, combustion and emissions of I.C. engines from thermodynamic principles*	1,2&3	90	80	H	H	M	M	M	M	H						M	H	M

		Performance of I.C. Engines	Engine Auxiliary systems	Combustion in S.I. Engines	Combustion in C.I. Engines	Emissions and Alternative fuels
Duration (hour)		9	9	9	9	9
S-1	SLO-1	*Engine operating cycle, terminology and components, four stroke and two stroke engines and their comparison*	*Carburation, mixture requirements at different loads and speeds, simple carburetor*	*Combustion in spark ignition engines, Stages of combustion in SI engine, flame front propagation*	*Combustion in Compression Ignition engines, Stages of combustion in CI engines,*	*Air pollution due to IC engines, Emissions standards, hydrocarbon and CO emissions,*
S-2	SLO-1	*Operation of SI and CI engines, their p-v diagrams and comparison, classifications and applications IC engines,*	*Problems on simple carburetor*	*Analysis of cylinder pressure data*	*Analysis of cylinder pressure data and heat-release analysis*	*Oxides of nitrogen and soot, aldehydes, sulphur, lead and phosphorus emissions*
S-3	SLO-1	*Volumetric efficiency, and its variation with respect to engine speed, supercharging and turbocharging of engines*	*Functional requirements and classification of an injection systems, injection pump*	*Factors influencing the flame speed,*	*Factors affecting the delay period*	*Exhaust gas recirculation and catalytic converter*
S-4	SLO-1	*First law applied to engine, thermal, mechanical efficiencies, pumping work, mean effective pressure*	*Nozzle types, EFI systems: MPFI, PFI, GDI*	*Rate of pressure riseAbnormal combustion, knocking in SI engines,*	*Basics of fuel sprays: Fuel flow rate through injector nozzle, Overall spray structure*	*Basics of selective catalyst reduction, diesel particulate filter*
S-5	SLO-1	*Engine parameter measurements.*	*Functional requirements of ignition systems, Battery ignition system*	*Effect of engine variables on engine knock*	*Atomization and spray penetration*	*Flame ionization detector, non-dispersive infrared detector*
S-6	SLO-1	*Problems on engine performance.*	*magneto ignition system, Ignition timing and engine parameters*	*Combustion chambers for SI engines*	*Phenomenon of knock in CI engines, comparison of knock in CI and SI engine*	*Chemiluminescence analyzer, smoke types, Bosch smoke meter*
S-7	SLO-1	*Concept of heat balance and problems*	*Functional requirements of lubrication system, properties of lubricants, mist lubrication system*	*Smooth engine operation, High power output and thermal efficiency*	*Combustion chambers for CI engine: Direct injection engines*	*Fuels for IC engines: Liquid fuels: Alcohol, methanol, ethanol, vegetable oil*
S-8	SLO-1	*Review of ideal cycles and fuel-air cycles significance*	*Wet and dry sump lubrication system*	*Concept of hybrid electric drive trains*	*Gasoline Direct Injection (GDI) Engines: Direct injection Vs port injection, classification of GDI eninges*	*Bio diesel advantages and disadvantages; Gaseous fuels: CNG, LPG, Hydrogen*
S-9	SLO-1	*Engine performance characteristics*	*Liquid and air cooling systems, properties of the coolant and antifreeze solutions*	*Architectures of hybrid electric drive trains*	*Spray, wall and air guided combustion systems for GDI engines*	*Advanced concepts: Stratified charge and HCCI engines*

Learning Resources	1. *Ganesan. V, "Internal Combustion Engines", Tata McGraw-Hill, New Delhi, 2015* 2. *Heywood, J.B., "Internal Combustion Engine Fundamentals", McGraw-Hill International, New York, 2017* 3. *Ramalingam, K.K., "Internal Combustion Engines-Theory and Practice", SciTech Publications India Pvt Ltd, Chennai 2016.* 4. *Thipse, S.S., "Internal Combustion Engines", Jaico Publication House, 2010.* 5. *Sharma, M.L., and Mathur R.P., "A Course in Internal Combustion Engines" DhanpantRai& Sons, New Delhi, 2014.* 6. *Fuquan Zhao, David L.Harrington and Ming-Chia D. Lai, "Automotive Gasoline Direct-Injection Systems", SAE International Publisher, 2002* 7. *Mehrdad Ehsani, Yimin Gao, Stefano Longo and Kambiz Ebrahimi "Modern Electric, Hybrid Electric and Fuel Cell Vehhicles", CRC Press, 2018*

Learning Assessment

	Bloom's Level of Thinking	Continuous Learning Assessment (50% weightage)								Final Examination (50% weightage)	
		CLA – 1 (10%)		CLA – 2 (15%)		CLA – 3 (15%)		CLA – 4 (10%)#			
		Theory	Practice	Theory	Practice	Theory	Practice	Theory	Practice	Theory	Practice
Level 1	Remember Understand	40 %	-	30 %	-	30 %	-	30 %	-	30%	-
Level 2	Apply Analyze	40 %	-	40 %	-	40 %	-	40 %	-	40%	-
Level 3	Evaluate Create	20 %	-	30 %	-	30 %	-	30 %	-	30%	-
	Total	100 %		100 %		100 %		100 %		100 %	

CLA – 4 can be from any combination of these: Assignments, Seminars, Tech Talks, Mini-Projects, Case-Studies, Self-Study, MOOCs, Certifications, Conf. Paper etc.,
SLO – Session Learning Outcome

Course Designers

Experts from Industry	Experts from Higher Technical Institutions	Internal Experts
K. SaratChander Prasad, Sr. Lead Engineer, Mahindra & Mahindra Pvt Ltd	*Dr. ShamitBakshi, Professor, Indian Institute of Technology Madras*	*Dr. D. Siva Krishna Reddy, Assistant Professor, SRM IST*
Ramesh K.J., Kistler, Product Manager, Instruments India Pvt Ltd	*Dr. Maha Lakshmi, Professor, Anna University*	*Dr. G. Balaji, Associate Professor, SRM IST*

Course Code	18MEE343T	Course Name	ELEMENTS OF SPACE TECHNOLOGY	Course Category	E	Professional Elective	L	T	P	C
							3	0	0	3

Pre-requisite Courses	NIL	Co-requisite Courses	NIL	Progressive Courses	NIL
Course Offering Department	Mechanical Engineering	Data Book / Codes/Standards	NIL		

Course Learning Rationale (CLR):	*The purpose of learning this course is to:*
CLR-1 :	*Develop a basic knowledge on earth's atmosphere.*
CLR-2 :	*Learn the different orbit bodies. & Understand the aspects of satellite injection.*
CLR-3 :	*Know the interplanetary and missile trajectories and materials for Spacecraft.*

Course Learning Outcomes (CLO):	*At the end of this course, learners will be able to:*	Learning 1: Level of Thinking (Bloom)	Learning 2: Expected Proficiency (%)	Learning 3: Expected Attainment (%)	PLO 1: Engineering Knowledge	PLO 2: Problem Analysis	PLO 3: Design & Development	PLO 4: Analysis, Design, Research	PLO 5: Modern Tool Usage	PLO 6: Society & Culture	PLO 7: Environment & Sustainability	PLO 8: Ethics	PLO 9: Individual & Team Work	PLO 10: Communication	PLO 11: Project Mgt. & Finance	PLO 12: Life Long Learning	PLO 13: PSO - 1	PLO 14: PSO - 2	PLO 15: PSO - 3
CLO-1 :	*Develop a basic knowledge on earth's atmosphere.*	*1&2*	*100*	*95*	*H*														
CLO-2 :	*Learn the different orbit bodies. & Understand the aspects of satellite injection.*	*1*	*100*	*95*	*H*	*H*		*H*											
CLO-3 :	*Know the interplanetary and missile trajectories and materials for Spacecraft.*	*1*	*100*	*95*	*H*			*H*											

Duration (hour)		9	9	9	9	9
S-1	SLO-1	*The solar system*	*The Many body problem – Lagrange, Jacobi identity*	*General aspects of satellite injections The*	*Two-dimensional interplanetary trajectories*	*Introduction to Hypersonic Aerodynamics, thin shock layers, Entropy layer, Viscous interaction, High temperature flow, Low density flow.*
S-2	SLO-1	*Reference frames and coordinate systems*	*The circular restricted three body problem*	*Launch Phase, The Orbit Injection Phase*	*Fast interplanetary trajectories*	*High temperature gas dynamics- Importance of high temperature flows.*
S-3	SLO-1	*Motion in Acceleration Reference Frames*	*Libration points*	*Satellite orbit transfer - Various cases*	*Three dimensional interplanetary trajectories Launch of interplanetary spacecraft*	*Atmospheric entry of blunt nosed body.*
S-4	SLO-1	*The celestial sphere*	*Relative Motion in the N-body problem*	*Orbit deviations due to injection errors*	*Trajectory Characteristics*	*Spacecraft acoustics and shock loads*
S-5	SLO-1	*The ecliptic, Motion of vernal equinox*	*The two body problem*	*Special and general perturbations - Cowell's Method ,*	*Trajectory about the target plant.6*	*Thermal environment and Thermal Balance*
S-6	SLO-1	*Precession and Equatorial Coordinates*	*Satellite orbits ,Relations between position and time*	*Encke's method*	*The boost phase, The ballistic phase*	*Thermal analysis and Thermal design*
S-7	SLO-1	*Sidereal time, Solar time, Standard time*	*Orbital elements.*	*Cowell's Method ,*	*Trajectory geometry - Optimal flights*	*Thermal active & passive control and thermal control coatings.*
S-8	SLO-1	*The earth's atmosphere.*	*Parameters used to describe the orientation in space*	*Method of variations of orbital elements*	*Time of flight, Reentry phase*	*Requirements and material selection*
S-9	SLO-1	*Troposphere, Stratosphere, Mesosphere, Thermosphere,& Exosphere*	*Examples of orbits*	*General perturbations approach.*	*The position of the impact point , Influence coefficients*	*Spacecraft materials and composite materials.*

Learning Resources	1. *Sutton. G.P, "Rocket Propulsion Elements", 7th Edition, John Wiley & Sons, NewYork, 2011* 2. *Cornelisse.J.W, "Rocket Propulsion and Space Dynamics", W.H. Freeman & Co., New York, 2005* 3. *Rudolph X. Meyer., "Elements of Space Technology", Academic press, London, 2003.* 4. *Parker.E.R, "Materials for Missiles and Spacecraft", McGraw Hill Book Co., NewYork, 2000.* 5. *Ramamurthi. K, "Rocket Propulsion", MacmillanPublishers India Ltd. 2010.*

Learning Assessment

	Bloom's Level of Thinking	Continuous Learning Assessment (50% weightage)								Final Examination (50% weightage)	
		CLA – 1 (10%)		CLA – 2 (15%)		CLA – 3 (15%)		CLA – 4 (10%)#			
		Theory	Practice	Theory	Practice	Theory	Practice	Theory	Practice	Theory	Practice
Level 1	Remember Understand	40 %	-	30 %	-	30 %	-	30 %	-	30%	-
Level 2	Apply Analyze	40 %	-	40 %	-	40 %	-	40 %	-	40%	-
Level 3	Evaluate Create	20 %	-	30 %	-	30 %	-	30 %	-	30%	-
	Total	100 %		100 %		100 %		100 %		100 %	

CLA – 4 can be from any combination of these: Assignments, Seminars, Tech Talks, Mini-Projects, Case-Studies, Self-Study, MOOCs, Certifications, Conf. Paper etc.,
SLO – Session Learning Outcome

Course Designers		
Experts from Industry	Experts from Higher Technical Institutions	Internal Experts
1. Dr. R. Kalimuthu, ISRO, Mahendragiri, r_kalimuthu@vssc.gov.in, rkpearls@yahoo.com	*Dr.Raju Abraham, Scientist –F, National Institute of Ocean Technology Chennai – 600 100*	*Mr. P.Udayakumar Assistant Professor (O.G) Department of Mechanical Engineering SRM IST*
2. Dr. A. Velayutham, DRDO, Avadi, velayudham.a@cvrde.drdo.in	*Dr. R.Velraj, Professor, Institute for Energy Studies, Anna University, Chennai, India - 600025*	*Dr. M. Cheralathan, SRMIST*

Course Code	18MEE344T	Course Name	ENERGY ENGINEERING AND MANAGEMENT	Course Category	E	Professional Elective	L	T	P	C
							3	0	0	3

Pre-requisite Courses	NIL	Co-requisite Courses	NIL	Progressive Courses	NIL
Course Offering Department	Mechanical Engineering	Data Book / Codes/Standards	NIL		

Course Learning Rationale (CLR):	*The purpose of learning this course is to:*
CLR-1 :	*Understand Environmental aspects of energy utilization.*
CLR-2 :	*Understand Energy conservation concepts.*
CLR-3 :	*Understand concepts of energy savings in various thermal systems.*
CLR-4 :	*Energy management techniques*
CLR-5:	*Energy economics concepts*
CLR-6:	*Know about the importance of energy management systems and its utilization.*

Course Learning Outcomes (CLO):	*At the end of this course, learners will be able to:*	Learning 1 Level of Thinking (Bloom)	2 Expected Proficiency (%)	3 Expected Attainment (%)	PLO 1 Engineering Knowledge	2 Problem Analysis	3 Design & Development	4 Analysis, Design, Research	5 Modern Tool Usage	6 Society & Culture	7 Environment & Sustainability	8 Ethics	9 Individual & Team Work	10 Communication	11 Project Mgt. & Finance	12 Life Long Learning	13 PSO - 1	14 PSO - 2	15 PSO - 3
CLO-1 :	*Recognize the importance of energy usage as per the requirements*	*1&2*	*90*	*80*	*H*	*L*	*L*	*L*	*L*	*M*	*H*	*M*			*L*				
CLO-2 :	*Acquire knowledge on the energy conservations and acts*	*1&2*	*90*	*80*	*H*	*L*	*L*	*L*	*L*	*M*	*H*	*M*	*M*		*L*				
CLO-3 :	*Knowledge of the working of various heat exchangers and various energy storage systems.*	*1&2*	*90*	*80*	*H*	*L*	*L*	*L*	*L*	*L*	*H*	*L*			*L*				
CLO-4 :	*Recognize the cost involved for energy systems*	*1,2&3*	*90*	*80*	*H*	*L*	*L*	*L*	*L*	*L*	*M*	*M*	*H*	*M*	*H*				
CLO-5:	*Implementation of energy management systems in industries*	*1,2&3*	*90*	*80*	*H*	*L*	*L*	*L*	*L*	*L*	*M*	*M*	*H*	*M*	*H*				
CLO-6:	*Get the knowledge about the various energy sources and its management systems*	*1,2&3*	*90*	*80*	*H*	*L*	*L*	*L*	*L*	*L*	*H*	*M*	*H*	*H*	*L*				

		Energy And Environment	Energy Conservation	Energy Savings In Thermal Systems	Energy Management	Energy Economics
Duration (hour)		09	09	09	09	09
S-1	SLO-1	*Introduction to Energy and Environment*	*Introduction to energy conservation*	*Fuels and its consumption*	*Energy management principles.*	*Introduction to engineering economics*
S-2	SLO-1	*Represent World energy consumption*	*Energy conservation schemes*	*Energy savings in Boiler.*	*Energy resource management.*	*Costing techniques in energy engineering*
S-3	SLO-1	*Effect of Greenhouse gases*	*Industrial energy conservation methods*	*Firing methodology in boilers*	*Energy management levels.*	*Cost factors*
	SLO-2	*Global warming*				*Break even analysis*
S-4	SLO-1	*Renewable energy sources*	*Energy surveying for industries.*	*Waste heat recovery systems*	*Energy management information systems.*	*Cost optimization for energy engineering techniques*
	SLO-2		*Energy auditing for industries.*			*Optimal target investment schedule*
S-5	SLO-1	*Environment aspects utilization*	*Energy index and cost*	*Energy saving system in HVAC*	*Energy instrumentation.*	*Financial appraisal and profitability*
S-6	SLO-1	*Energy prices*	*Energy conservation in engineering and process industry*	*Energy savings in Refrigeration systems*	*Energy measurement in energy management*	*Investment decisions*
S-7	SLO-1	*World energy reserves*	*Simple case study of energy auditing in process industries*	*Energy Storage systems*	*Energy management Techniques.*	*Method of investment appraisal*
	SLO-2					*Discounted cash flow*
S-8	SLO-1	*World energy polices*	*Energy conservation in Buildings*	*Energy saving methodologies by using Insulated pipe work systems*	*Computerized energy management*	*Summary investment appraisal techniques*
	SLO-2					*Optimization with one variable*
S-9	SLO-1	*The energy future and the role of renewable energy*	*Concept of Green building*	*Heat exchangers*	*Importance of energy management*	*Optimization with multiple variable.*

Learning Resources	1. *Murphy.W.R and McKay G, "Energy Management", Butterworths, London, 2007.* 2. *Reay.D.A, "Industrial Energy Conservation", Pergamon Press, 2003.* 3. *Steve Doty, Wayne C. Turner, "Energy Management Handbook", Fairmont Press, 7th edition, 2009.* 4. *Barney L. Capehart, Wayne C. Turner, William J. Kennedy, "Guide to Energy Management", The Faimont Press, 6th edition, 2008.* 5. *Callaghan.P.W.O, "Design and Management for Energy Conservation", Pergamon Press, Oxford, 2003.* 6. *Hamies, "Energy Auditing and Conservation; Methods", Measurements, Management and Case study", Hemisphere, 2003.* 7. *Trivedi.P.R and Jolka.K.R, "Energy Management", Common Wealth Publication, 2002.*

Learning Assessment

	Bloom's Level of Thinking	Continuous Learning Assessment (50% weightage)								Final Examination (50% weightage)	
		CLA – 1 (10%)		CLA – 2 (15%)		CLA – 3 (15%)		CLA – 4 (10%)#			
		Theory	Practice	Theory	Practice	Theory	Practice	Theory	Practice	Theory	Practice
Level 1	Remember Understand	40 %	-	30 %	-	30 %	-	30 %	-	30%	-
Level 2	Apply Analyze	40 %	-	40 %	-	40 %	-	40 %	-	40%	-
Level 3	Evaluate Create	20 %	-	30 %	-	30 %	-	30 %	-	30%	-
	Total	100 %		100 %		100 %		100 %		100 %	

CLA – 4 can be from any combination of these: Assignments, Seminars, Tech Talks, Mini-Projects, Case-Studies, Self-Study, MOOCs, Certifications, Conf. Paper etc.,

Course Designers

Experts from Industry	Experts from Higher Technical Institutions	Internal Experts
1. Dr.R.Kalimuthu, ISRO, Mahendragiri, r_kalimuthu@vssc.gov.in	*Dr.M.VENKATA RAMANAN Professor Institute for Energy Studies venkat@annauniv.edu*	*S.PANNEERSELVAM Department of Mechanical Engineering SRM IST Email: panneerselvam.s@ktr.srmuniv.ac.in*
2. Dr. A. Velayutham, DRDO, Avadi, velayudham.a@cvrde.drdo.in	*Dr.S.KUMAR MRT TNEB CHENNAI.*	*Dr. M. Cheralathan, SRMIST*

Course Code	18MEE345T	Course Name	TURBOMACHINES	Course Category	E	Professional elective	L	T	P	C
							3	0	0	3

Pre-requisite Courses	18MEC102T	Co-requisite Courses	NIL	Progressive Courses	NIL
Course Offering Department	Mechanical Engineering	Data Book / Codes/Standards	NIL		

Course Learning Rationale (CLR):	*The purpose of learning this course is to:*
CLR-1 :	*Understand the basic flow concepts in turbo machines*
CLR-2 :	*Understand the performance of centrifugal flow machines.*
CLR-3 :	*Understand the performance of axial flow machines*
CLR-4 :	*Familiarize the performance of axial flow turbines*
CLR-5 :	*Know the Working and performance of hydraulic turbines.*
CLR-6 :	*Understand the performance and design of turbomachines.*

		Learning			Program Learning Outcomes (PLO)														
		1	2	3	1	2	3	4	5	6	7	8	9	10	11	12	13	14	15
Course Learning Outcomes (CLO):	*At the end of this course, learners will be able to:*	Level of Thinking (Bloom)	Expected Proficiency (%)	Expected Attainment (%)	Engineering Knowledge	Problem Analysis	Design & Development	Analysis, Design, Research	Modern Tool Usage	Society & Culture	Environment & Sustainability	Ethics	Individual & Team Work	Communication	Project Mgt. & Finance	Life Long Learning	PSO - 1	PSO - 2	PSO - 3
CLO-1 :	*Acquire the knowledge on basic flow concepts in turbomachines.*	*1& 2*	*90*	*85*	*H*	*M*	-	-	-	-	-	-	-	-	-	-	-	-	-
CLO-2 :	*Appreciate the working and performance of centrifugal flow machines.*	*1& 2*	*90*	*85*	*H*	*H*	-	*M*	-	-	-	-	-	-	-	-	-	-	-
CLO-3 :	*Analyze the working and performance of axial flow machines.*	*1&2*	*90*	*85*	*H*	*H*	-	*M*	-	-	-	-	-	-	-	-	-	-	-
CLO-4 :	*Recognize the working and performance of axial flow turbines*	*1&2*	*90*	*85*	*H*	*H*	-	*M*	-	-	-	-	-	-	-	-	-	-	-
CLO-5 :	*Analyze the working and performance of hydraulic turbines.*	*1&2*	*90*	*85*	*H*	*H*	-	*M*	-	-	-	-	-	-	-	-	-	-	-
CLO-6 :	*Acquire the knowledge on performance and design of turbomachines.*	*1&2*	*90*	*85*	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-

		Basic flow concepts in turbomachines	Centrifugal flow machines	Axial flow machines	Axial flow turbines	Hydraulic turbines
Duration (hour)		9	9	9	9	9
S-1	SLO-1	*Definition, classification and stages of turbo machines*	*Fans - different impeller sizes, shapes, blade angles, speed and construction*	*Aero-Thermodynamics of flow through an Axial flow Compressor stage.Blade profile, lift and drag coefficients*	*Introduction:Turbinestage:Turbine blade 2-D (cascade)analysis Work done.*	*Pelton turbine- impulse wheel, single jet and multiple jet units*
S-2	SLO-1	*Estimation of specific work for incompressible and compressible flow machines*	*Blade shape, blade number,designcalculations*	*Compressors - brief introduction to two-dimensional cascade and its application to design*	*Degree of reaction;Losses and Efficiency.*	*Velocity triangles at inlet and exit of buckets*
S-3	SLO-1	*Internal and external losses, various efficiencies*	*Performance in series and parallel*	*Flow deflection and stagnation pressure loss across blade rows*	*Flowpassage:Subsonic,transonic and supersonic turbines,Multi-staging of Turbine.*	*Performance calculations considering losses in the nozzle and buckets*
S-4	SLO-1	*Representation of specific work on T-s and h-s diagrams*	*Compressor - slip, inducers, designs without inducer but with inlet guide vanes (IGV)*			*Francis turbine - reaction, impeller shapes for different shape Numbers/heads*
S-5	SLO-1	*Velocity triangles - centrifugal and axial flow machine impellers*	*problems with inducer and IGV's - blade angles,temperature rise and static pressure rise across the impeller*	*Expression for pressure rise coefficient in terms of flow angles and loss coefficient*	*Exit flow conditions:Turbine cooling*	*Calculations on impeller dimensions, blade angles and performance using velocity triangles, draft tubes*
S-6	SLO-1	*Euler's energy equation across the impeller as applicable to all machines,*			*Turbine blade design*	*Kaplan / Propeller Turbine - reaction, impeller (adjustable and fixed) blades and guide blades*
S-7	SLO-1	*Slip and its estimation*	*Vaned and vaneless diffuser and volute casing.Surging; Chocking; Rotating stall*	*Design of impeller blades for free vortex and forced vortex*	*Turbine profiles, Testing of turbine - test rigs - standard instrumentation- operational characteristics*	
S-8	SLO-1	*Degree of reaction*	*Pump - system head, priming of pumps, net positive suction head, minimum starting speed and cavitations.Testing of pumps - test rigs – standard instrumentation- operational characteristics*	*Design and performance calculations. Stall and surgephenomenon. Noise problem in Axial Compressorsand Fans.*	*Airfoil data and Profile construction.*	*Calculation of performance using velocity triangles / blade angles at different radii for free vortex flow, its suitability for low heads*
S-9	SLO-1	*Blade angles and their effects, calculations considering slip.*				

Learning Resources	1. .Gopalakrishnan.G, PrithviRaj.D, *"Treatise on Turbomachines", 1st Edition, Chennai, SciTechPublications, 2006.* 2. *.Seppo A. Korpela., "Priniciple of Turbomachinery", John Wiley and Sons Ltd, 2012.* 3. *.Yahya.S.M, "Turbines, Fans and Compressors", 3rd Edition, Tata McGraw Hill Publications, 2010.* 4. *.Dixon.S.L, "Fluid mechanics and Thermodynamics of Turbomachinery", 5th edition, ElsevierButterworth Heinemann, 2005.* 5. *.Venkanna. B.K, "Fundamentals of Turbomachinery", 4th Edition, New Delhi, PHI Learning Pvt. Ltd,2011.*

Learning Assessment											
	Bloom's Level of Thinking	Continuous Learning Assessment (50% weightage)								Final Examination (50% weightage)	
		CLA – 1 (10%)		CLA – 2 (15%)		CLA – 3 (15%)		CLA – 4 (10%)#			
		Theory	Practice	Theory	Practice	Theory	Practice	Theory	Practice	Theory	Practice
Level 1	Remember Understand	40 %	-	30 %	-	30 %	-	30 %	-	30%	-
Level 2	Apply Analyze	40 %	-	40 %	-	40 %	-	40 %	-	40%	-
Level 3	Evaluate Create	20 %	-	30 %	-	30 %	-	30 %	-	30%	-
	Total	100 %		100 %		100 %		100 %		100 %	

CLA – 4 can be from any combination of these: Assignments, Seminars, Tech Talks, Mini-Projects, Case-Studies, Self-Study, MOOCs, Certifications, Conf. Paper etc.,

Course Designers		
Experts from Industry	Experts from Higher Technical Institutions	Internal Experts
1. Dr.R.Kalimuthu, ISRO, Mahendragiri, r_kalimuthu@vssc.gov.in	*Dr.RavindranS,Professor,Hindustan University Padur,Chennai E-mail: drravimepco@gmail.com*	*Mr. N. Vijay Krishna Assistant Professor (O.G) Department of Mechanical Engineering SRM IST Email: vijaykrishna.n@ktr.srmuniv.ac.in*
2. Dr.A.Velayutham, DRDO, Avadi, velayudham.a@cvrde.drdo.in	*Vanjeswaran MN, Engineer. Tata Steels Ltd, Jamshedpur Email:mechvanje@gmail.com*	*Mr. P. Sudhakar Assistant Professor(S.G) Department of Mechanical Engineering SRM IST Email: sudhakar.p@ktr.srmuniv.ac.in*

Course Code	18MEE346T	Course Name	THERMAL POWER SYSTEM	Course Category	E	Professional Elective	L	T	P	C
							3	0	0	3

Pre-requisite Courses	NIL	Co-requisite Courses	NIL	Progressive Courses	NIL
Course Offering Department	Mechanical Engineering	Data Book / Codes/Standards	NIL		

Course Learning Rationale (CLR):	*The purpose of learning this course is to:*
CLR-1 :	*Know the functions of various auxiliary combustion equipment's.*
CLR-2 :	*Understand the various Thermal power systems.*
CLR-3 :	*Analyze the performance of boiler and condenser. Familiarize with operation of cooling towers.*
CLR-4 :	*Familiarize with operation of Nuclear, Diesel and Gas turbine power plants.*
CLR-5 :	*Know the power plant economics.*

Course Learning Outcomes (CLO):	*At the end of this course, learners will be able to:*	Learning 1: Level of Thinking (Bloom)	2: Expected Proficiency (%)	3: Expected Attainment (%)	PLO 1: Engineering Knowledge	2: Problem Analysis	3: Design & Development	4: Analysis, Design, Research	5: Modern Tool Usage	6: Society & Culture	7: Environment & Sustainability	8: Ethics	9: Individual & Team Work	10: Communication	11: Project Mgt. & Finance	12: Life Long Learning	13: PSO - 1	14: PSO - 2	15: PSO - 3
CLO-1 :	*Familiarize with the combustion equipment of Thermal power plants.*	12	90	80	H														
CLO-2 :	*Familiarize with the Boilers, accessories and mountings in thermal power system.*	12	90	80	H	H		M											
CLO-3 :	*Familiarize with the working principle of cooling tower and condensers*	12	90	80	H	H													
CLO-4 :	*Familiarize with the working principle of Nuclear power plant and Diesel power plant.*	12	90	80	H						M								
CLO-5 :	*Familiarize with economics in power plant*	12	90	80	H										L				

		Fuel Combustion	Thermal Power	Performance Of Thermal Power System	Nuclear, Diesel And Gas Turbine Power Plants	Power Plant Economics
Duration (hour)		09	09	09	09	09
S-1	SLO-1	*equipmentIntroduction to power plant-Layout of Thermal power plant*	*systemsclassification of steam generators.*	*Selectionof Boilers*	*Fuels for Nuclear power plants*	*Power load factor*
	SLO-2	*Combustion equipment's and its types.*			*Moderator for Nuclear power plants*	*Utilization factor*
S-2	SLO-1	*Solid fuel firing method*	*Working principle of high pressure boilers*	*Boiler capacity rating*	*Control rods for Nuclear power plants*	*Power plant cost economics*
	SLO-2				*Coolants for Nuclear power plant.*	
S-3	SLO-1	*Classification and working of stokers*	*Working principle of high pressure boilers*	*Boiler testing and performance*	*Types of Nuclear reactor*	*Tariff rates for electricity*
	SLO-2			*Boiler Energy Balance*		
S-4	SLO-1	*Fuel and ash handling system*	*Working principle of supercritical boilers*	*Condenser design factors*	*Boiling water reactor*	*Demand changes for electricity*
	SLO-2				*Pressurized water reactor.*	*Load distribution*
S-5	SLO-1	*Working principle of draft system its type*	*Working of fluidized bed boilers.*	*Air removal rate and performance of condenser*	*Radiation hazards*	*Effect of Variable load on plant design*
	SLO-2				*Radioactive waste disposal.*	*Energy conservation in power plant*
S-6	SLO-1	*Heat recovery equipmments: Economiser, preheaters and reheaters*	*Boiler mountings*	*Cooling towers range and*	*Classification of Diesel power plant*	*Energy audit in power plant*
	SLO-2					
S-7	SLO-1	*Types of superheaters*	*Boiler accessories*	*Cooling towers approach*	*Components of Diesel power plant*	*Maintenance aspects of power plant*
	SLO-2	*Types of desuperheaters.*	*Feed water Treatment*		*Selection of Engine type.*	
S-8	SLO-1	*Emission control methods-Flue gas cleaning*	*Working of Condensers*	*Cooling towers load and performance*	*Closed cycle Gas Turbine plant*	*Maintenance aspects of power plant*
	SLO-2		*Types of Condensers. Factors affecting condenser. Theory and Design of Condenser*		*Open cycle gas turbine plant.*	
S-9	SLO-1	*Particulate and gaseous emission control methods.*	*Working of cooling towers.*	*Selections of condenser and cooling towers.*	*Combined power cycles.*	*Natural and global energy scenario.*
	SLO-2		*Types of cooling towers.Factors affecting cooling Tower*			

Learning Resources	1.	*El Wakil MM "Power plant Technology" McGraw Hill Inc 2010.*
	2.	*Nag P K " Power plant Engineering" Tata McGraw-Hill, New Delhi, 4th Edition, 2014*
	3.	*Ramalingam K K "Power plant engineering", Scitech publications Pvt Ltd, 2015*
	4.	*Arora S C and Domkundwar S "Power plant Engineering",DhanapatRai& sons, New Delhi, 2015*
	5.	*Rai G D " Non-Conventional Energy sources, "Khanna publishers, 5thEdition, New Delhi, 2014*

Learning Assessment												
	Bloom's Level of Thinking		Continuous Learning Assessment (50% weightage)								Final Examination (50% weightage)	
			CLA – 1 (10%)		CLA – 2 (15%)		CLA – 3 (15%)		CLA – 4 (10%)#			
			Theory	Practice	Theory	Practice	Theory	Practice	Theory	Practice	Theory	Practice
Level 1	Remember	Understand	40 %	-	30 %	-	30 %	-	30 %	-	30%	-
Level 2	Apply	Analyze	40 %	-	40 %	-	40 %	-	40 %	-	40%	-
Level 3	Evaluate	Create	20 %	-	30 %	-	30 %	-	30 %	-	30%	-
	Total		100 %		100 %		100 %		100 %		100 %	

CLA – 4 can be from any combination of these: Assignments, Seminars, Tech Talks, Mini-Projects, Case-Studies, Self-Study, MOOCs, Certifications, Conf. Paper etc.,

Course Designers		
Experts from Industry	Experts from Higher Technical Institutions	Internal Experts
1. Dr.R.Kalimuthu, ISRO, Mahendragirir_kalimuthu@vssc.gov.in	*Dr. K Karuppasamy Assistant Professor Department of Mechanical Engineering Anna University Regional Campus Tirunelveli - 627 007*	*Mr. S.Malarmannan Assistant Professor, Department of Mechanical Engineering SRM IST Email: malarmannan.s@ktr.srmuniv.ac.in*
2. Dr.A.Velayutham, DRDO, Avadi, velayudham.a@cvrde.drdo.in	*D.Ramesh Kumar, Shin Thermo Dynamic Engineering Private Limited Chennai-600 002 Phone:9445534340 Email: ramesh@shinthermo.co.in*	*Dr. M. Cheralathan Professor, Department of Mechanical Engineering SRM IST Email: cheralathan.m@ktr.srmuniv.ac.in*

Course Code	18MEE347T	Course Name	SOLAR ENERGY SYSTEMS	Course Category	E	Professional Elective	L	T	P	C
							3	0	0	3

Pre-requisite Courses	18MEC101T-Thermodynamics	Co-requisite Courses	NIL	Progressive Courses	NIL
Course Offering Department	Mechanical Engineering	Data Book / Codes/Standards	NIL		

Course Learning Rationale (CLR):	The purpose of learning this course is to:
CLR-1 :	*be familiar with basics of solar radiation*
CLR-2 :	*understand the working of solar collectors*
CLR-3 :	*be familiar with the solar thermal energy systems and their applications*
CLR-4 :	*understand the solar thermal energy storage and solar cooling systems*
CLR-5 :	*be familiar with the solar photovoltaic energy conversion systems*
CLR-6 :	*be familiar with the solar energy conversion systems*

Course Learning Outcomes (CLO):	At the end of this course, learners will be able to:	Learning 1: Level of Thinking (Bloom)	2: Expected Proficiency (%)	3: Expected Attainment (%)	PLO 1: Engineering Knowledge	2: Problem Analysis	3: Design & Development	4: Analysis, Design, Research	5: Modern Tool Usage	6: Society & Culture	7: Environment & Sustainability	8: Ethics	9: Individual & Team Work	10: Communication	11: Project Mgt. & Finance	12: Life Long Learning	13: PSO - 1	14: PSO - 2	15: PSO - 3
CLO-1 :	*understand the fundamentals of solar radiation*	1,2	90	80	H			M			M							H	
CLO-2 :	*understand the basic principles of solar collector systems*	1,2	90	80	H		H											H	
CLO-3 :	*analyze and design solar thermal energy systems*	1,2,3	90	80	H	M	H			L	H							H	
CLO-4 :	*acquire knowledge on solar thermal energy storage and solar cooling systems*	1,2	90	80	H	H		M			H							H	
CLO-5 :	*acquire knowledge and analyze solar photovoltaic energy conversion systems*	1,2,3	90	80	H			M		M	H							H	
CLO-6 :	*acquire knowledge on solar energy conversion systems*	1,2,3	90	80	H			H		L	M							H	

		Solar Radiation	Solar Thermal Collectors	Design of Solar Thermal Systems	Solar Thermal Energy Storage and Solar Cooling	Solar Photovoltaic Energy Conversion
Duration (hour)		9	9	9	9	9
S-1	SLO-1	*The sun and the earth, electromagnetic spectrum*	*Cassification of solar collectors and solar flat plate collectors*	*Design of solar flat plate collector systems*	*Need for solar thermal energy storage*	*Photovoltaic effect , advantages and disadvantages of solarphotovoltaic technology and classification,*
S-2	SLO-1	*Laws of thermal radiation*	*Solar evacuated tube collectors*		*Sensibleand latent heat storage, its advantages and disadvantages*	*Semiconductors, p-n junction, photo generation of charge carriers*
S-3	SLO-1	*Solar radiation:beam and diffuse radiations, terrestrial radiation*	*Advantages and disadvantages of concentrators over flat plate collectors*	*Problems on solar flat plate collector systems*	*Stratified thermal energy storage*	*I-V characteristics of solar cell*
S-4	SLO-1	*Sun and earth geometry*	*Solar concentrators and receiver geometries, concentrationratio*	*Design of solar active systems using f-chart method*	*PCM based solar thermal energy storage*	*Losses in solar cells and solar module*
S-5	SLO-1	*Solar angles*	*Compound parabolic concentrators, fresnel lens collectors*	*Design of solar cooker*	*Selection of latent heat storage materials*	*Maximum power point tracking in solar photovoltaic system*
S-6	SLO-1	*Sunrise, sunset and day length*	*Solar parabolic concentrators: trough systems*	*Solar air heater and solar dryer*	*Solar cooling systems and its advantages*	*Photovoltaic modules in series and parallel*
S-7	SLO-1	*Solar radiation on tilted surfaces*	*Solar parabolic concentrators: dish systems*	*Solar desalination: types, and operation*	*Vapour compression refrigeration systems and its solar operation*	*Concentrated photovoltaic cells*
S-8	SLO-1	*Measurement of solar radiation: pyranometer*	*Solar central receiver system*	*Solar pond: types, principles and applications*	*Vapour absorption cooling systems*	*Temperature dependencies and multi junction solar cells*
S-9	SLO-1	*Measurementof solar radiation: pyrheliometer, sunshinerecorder*	*Solar collector orientation and sun tracking systems*	*Solar thermal power plants and solar furnace*	*Solar thermoelectric cooling systems*	*Grid connected and standalone photovoltaic system*

Learning Resources	1. Duffie.J.A, &Beckman.W.A, "Solar Engineering of Thermal Processes", 3ro Edition, John Wiley & Sons, Inc.,2006 2. Sukhatme.K, Suhas P. Sukhatme, "Solar energy: Principles of thermal collection and storage", Tata McGraw 3. Hill publishing Co. Ltd, 8th Edition, 2011. 4. Green MA. Solar cells: operating principles, technology, and system applications. Englewood Cliffs, NJ, Prentice-Hall, Inc., 2009. 5. Garg. H.P, Prakash.J, "Solar energy fundamentals and applications", Tata McGraw Hill publishing Co. Ltd, 6. 2006. 7. Yogi Goswami.D, Frank Kreith, Jan F.Kreider, "Principle of solar engineering", Taylor and Francis, 2nd Edition,2000. 8. Chetan Singh Solanki, "Solar Photovoltaic technology and systems: A manual for Technicians, Trainers and a. Engineers", PHI Learning private limited, 2013. 9. G. N. Tiwari and M. K. Ghosal, "Renewable Energy Applications", Narosa Publications, 2004.

Learning Assessment											
	Bloom's Level of Thinking	Continuous Learning Assessment (50% weightage)								Final Examination (50% weightage)	
		CLA – 1 (10%)		CLA – 2 (15%)		CLA – 3 (15%)		CLA – 4 (10%)#			
		Theory	Practice	Theory	Practice	Theory	Practice	Theory	Practice	Theory	Practice
Level 1	Remember Understand	40 %	-	30 %	-	30 %	-	30 %	-	30%	-
Level 2	Apply Analyze	40 %	-	40 %	-	40 %	-	40 %	-	40%	-
Level 3	Evaluate Create	20 %	-	30 %	-	30 %	-	30 %	-	30%	-
	Total	100 %		100 %		100 %		100 %		100 %	

CLA – 4 can be from any combination of these: Assignments, Seminars, Tech Talks, Mini-Projects, Case-Studies, Self-Study, MOOCs, Certifications, Conf. Paper etc.,

Course Designers		
Experts from Industry	Experts from Higher Technical Institutions	Internal Experts
1. Dr.R.Kalimuthu, ISRO, Mahendragiri, r_kalimuthu@vssc.gov.in	Dr. G Kumaresan Associate ProfessorInstitute for Energy StudiesCollege of Engineering Guindy Anna UniversityE-Mail : gkumaresan@annauniv.edu	Dr. S. Manikandan Research Assistant Professor,Department of Mechanical Engineering SRM IST Email: maniandan.su@ktr.srmuniv.ac.in
2. Dr.A.Velayutham, DRDO, Avadi, velayudham.a@cvrde.drdo.in	Mr. SAI SANTHOSH SOMASUNDARAM Senior Designer – Solar Easi Engineering Chennai, Tamil Nadu, India E-Mail : saisanthoshsomasundaram@gmail.com	Mr. Joji Johnson Assistant Professor, Department of Mechanical Engineering SRM IST Email: joji.j@ktr.srmuniv.ac.in

Course Code	18MEE348T	Course Name	GAS TURBINE TECHNOLOGY	Course Category	E	Professional Elective	L	T	P	C
							3	0	0	3

Pre-requisite Courses	NIL	Co-requisite Courses	NIL	Progressive Courses	NIL
Course Offering Department	Mechanical Engineering	Data Book / Codes/Standards		Approved Gas Tables are permitted	

Course Learning Rationale (CLR):	*The purpose of learning this course is to:*
CLR-1 :	*Familiarize the functions of components of gas turbine.*
CLR-2 :	*Analyze the power cycles for optimum thermal performance.*
CLR-3 :	*Understand axial flow compressor characteristics.*
CLR-4 :	*Understand combustion systems and axial flow turbine operation*
CLR-5 :	*Familiar with the performance predictions.*
CLR-6:	Familiar with gas turbine technologies and their performances

Course Learning Outcomes (CLO):	*At the end of this course, learners will be able to:*	Learning 1: Level of Thinking (Bloom)	Learning 2: Expected Proficiency (%)	Learning 3: Expected Attainment (%)	PLO 1: Engineering Knowledge	PLO 2: Problem Analysis	PLO 3: Design & Development	PLO 4: Analysis, Design, Research	PLO 5: Modern Tool Usage	PLO 6: Society & Culture	PLO 7: Environment & Sustainability	PLO 8: Ethics	PLO 9: Individual & Team Work	PLO 10: Communication	PLO 11: Project Mgt. & Finance	PLO 12: Life Long Learning	PLO 13: PSO - 1	PLO 14: PSO - 2	PLO 15: PSO - 3
CLO-1 :	*Appreciate the functions of components of gas turbine.*	1& 2	90	80	H	-	-	-	-	-	-	-	-	-	-	-	-	-	-
CLO-2 :	*Appreciate the analysis knowledge of the power cycles for optimum thermal performance.*	1,2,3	90	80	H	H	H	-	-	-	-	-	-	-	-	-	-	-	-
CLO-3 :	*Appreciate the understanding of the axial flow compressor characteristics.*	1,2, 3	90	80	H	H	H	-	-	-	-	-	-	-	-	-	-	-	-
CLO-4 :	*Appreciate the understanding of the combustion systems and axial flow turbine operation*	1,2,3	90	80	H	H	H	-	-	-	-	-	-	-	-	-	-	-	-
CLO-5 :	*Appreciate the familiarity with the performance predictions of gas turbines.*	1,2,3	90	80	H	H	H	L	L	-	-	-	-	-	-	-	-	-	-
CLO-6 :	*Appreciate the familiarity with gas turbine technologies and their performances*	1,2,3	90	80	H	H	H	L	L	-	-	-	-	-	-	-	-	-	-

Duration (hour)		9	9	9	9	9
S-1	SLO-1	*Definition, classification of gas turbines*	*Ideal cycle operation and thermal performance*	*Centrifugal compressor, Principle of operation, work done. Pressure rise and the diffuser*	*Operation requirements*	*Prediction performance of gas turbines component characteristics*
S-2	SLO-1	*Open cycle single shaft and twin shaft multi speed arrangement, Closed cycle, aircraft propulsion*	*Methods of determining component losses*	*Compressibility effects, Non dimensional quantities*	*type of combustion – Factors affecting combustion process, Combustion chamber performance*	*Off design operation and its relative performance*
S-3	SLO-1	*Gas turbine components and their description*	*Design point performance calculations, Comparative performance of actual and practical cycles.*	*Computerized design procedure. Axial flow compressor basic operation*	*Different types of combustion chambers and their relative merits and demerits*	*Equilibrium running of gas generator*
S-4	SLO-1	*Representation of specific work on T-s and h-s diagrams*	*Analysis of polytropic efficiency (Infinitesimal stage efficiency) of a gas turbine and Velocity triangles*		*Turbine construction – Performance, Impeller blade fixing*	*Off design operation of free turbine – Methods of displacing of the equilibrium running line*
S-5	SLO-1	*Comparison of steam and gas turbines*	*Closed cycle gas turbine and Combined cycle and Cogeneration schemes, Integrated gasification combined cycle.*	*Elementary theory, Factors effecting stage pressure ratio, Blockage in compressor annulus*	*Cooling of turbine blades – Blade vibration*	*Incorporation of variable pressure losses*
S-6	SLO-1	*Applications of gas turbine in various fields.Industrial applications of gas turbines.*			*Protective coating – Gas turbine turbo chargers - Power expanders*	*Matching procedure for two spool engines – Principle of control systems.*
S-7	SLO-1	*Gas Turbine in Co- Generation - Heat recovery and steam generation scheme.*	*Reheat, intercooling and Regenerator cycles for improved thermal performance.*	*Degree of reaction, Blade fixing details, Sealing materials, Material selection for compressor blades, Stage performance*		
S-8	SLO-1	*Gas turbine fuels and their properties*	*Optimum pressure ratio for maximum thermal efficiency, work ratio, air rate, effect of operating variables on thermal efficiency, work ratio, and air rate*	*Design and off design performance characteristics.*	*Vortex theory – Estimation of stage performance.*	*Factors influence the gas turbine performance and the improvement methods.*
S-9	SLO-1	*Environmental issues related to the operation and maintenance, Future of gas turbine engines and the new possibilities*				

Learning Resources	1. *Ganesan.V, "Gas Turbines", Tata McGraw Hill, 3rd Edition, 2010.* 2. *Mattingly.J.D, "Elements of Propulsion: Gas turbines and Rockets", McGraw Hill, 2012* 3. *Yahya S.M, "Turbines, Fans and Compressors", 3rd Edition, Tata McGraw Hill Publications, 2010.* 4. *Irwin E. Treager, 'Gas Turbine Engine Technology ', Mc Graw Hill Education,3rd edition, 2013.* 5. *Saravanamuttoo. H.I.H, Rogers.G.F.C, Henry Cohen, "Gas Turbine Theory",Pearson Prentice Hall, 6th Edition, 2009.* 6. *Gopalakrishnan.G, Prithvi Raj D, "Treatise on Turbomachines", 1st Edition, Chennai, SciTech Publications, 2006.* 7. *Horlock.J.H, "Advanced Gas Turbine Cycles", Elsevier Science Ltd, 2003.* 8. *Venkanna.B.K, "Fundamentals of Turbomachinery", 4th Edition, New Delhi, PHI Learning Pvt. Ltd, 2011.* 9. *Yahya.S.M, "Gas Tables for compressible flow calculations", New Age International (P) Ltd, NewDelhi, 6th Edition, 2011*

Learning Assessment											
	Bloom's Level of Thinking	Continuous Learning Assessment (50% weightage)								Final Examination (50% weightage)	
		CLA – 1 (10%)		CLA – 2 (15%)		CLA – 3 (15%)		CLA – 4 (10%)#			
		Theory	Practice	Theory	Practice	Theory	Practice	Theory	Practice	Theory	Practice
Level 1	Remember Understand	40 %	-	30 %	-	30 %	-	30 %	-	30%	-
Level 2	Apply Analyze	40 %	-	40 %	-	40 %	-	40 %	-	40%	-
Level 3	Evaluate Create	20 %	-	30 %	-	30 %	-	30 %	-	30%	-
	Total	100 %		100 %		100 %		100 %		100 %	

CLA – 4 can be from any combination of these: Assignments, Seminars, Tech Talks, Mini-Projects, Case-Studies, Self-Study, MOOCs, Certifications, Conf. Paper etc.,

Course Designers		
Experts from Industry	Experts from Higher Technical Institutions	Internal Experts
1. Dr.R.Kalimuthu, ISRO, Mahendragiri, r_kalimuthu@vssc.gov.in	*Dr.K. Karunamurthy, Associate Professor, School of Mechanical and Building Sciences, VIT, Chennai. Email: karunamurthy.k@vit.ac.in*	*Dr. R. Senthil Associate Professor Department of Mechanical Engineering SRM IST. Kattankulathur Campus. Email: senthil.r@ktr.srmuniv.ac.in*
2. Dr.A.Velayutham, DRDO, Avadi, velayudham.a@cvrde.drdo.in	*Mr.M.Periyasamy Chief Manager, NLC Limited, Neyveli.Tamil Nadu Email: mpsamy34912@gmail.com*	*Dr. M. Cheralathan Professor, Department of Mechanical Engineering SRM IST Email: cheralathan.m@ktr.srmuniv.ac.in*

Course Code	18MEE349T	Course Name	SOLAR ENERGY UTILIZATION	Course Category	E	Professional Elective	L	T	P	C
							3	0	0	3

Pre-requisite Courses	NIL	Co-requisite Courses	NIL	Progressive Courses	NIL
Course Offering Department	Mechanical Engineering	Data Book / Codes/Standards	NIL		

Course Learning Rationale (CLR):	*The purpose of learning this course is to:*
CLR-1 :	*Be familiar with basics of solar radiation data and its measurement*
CLR-2 :	*Be familiar with construction and operation of solar thermal energy systems*
CLR-3 :	*Understand the operation of solar thermal power plants*
CLR-4 :	*Be familiar with basics and design of solar photovoltaic systems*
CLR-5 :	*Be exposed to the concept solar architecture in buildings and green buildings*
CLR-6 :	*Be familiar with solar energy concepts and various applications of solar energy like thermal systems, photovoltaic systems and building architecture*

Course Learning Outcomes (CLO):	*At the end of this course, learners will be able to:*	Learning 1: Level of Thinking (Bloom)	Learning 2: Expected Proficiency (%)	Learning 3: Expected Attainment (%)	PLO 1: Engineering Knowledge	PLO 2: Problem Analysis	PLO 3: Design & Development	PLO 4: Analysis, Design, Research	PLO 5: Modern Tool Usage	PLO 6: Society & Culture	PLO 7: Environment & Sustainability	PLO 8: Ethics	PLO 9: Individual & Team Work	PLO 10: Communication	PLO 11: Project Mgt. & Finance	PLO 12: Life Long Learning	PLO 13: PSO - 1	PLO 14: PSO - 2	PLO 15: PSO - 3
CLO-1 :	*Understand solar radiation, solar angles and recognize and analyze the working of solar radiation measuring instruments*	*1&2*	*85*	*75*	*H*	*M*					*H*							*H*	
CLO-2 :	*Understand the components and working of low temperature solar thermal systems*	*1*	*85*	*75*	*M*					*M*	*H*						*M*	*H*	
CLO-3 :	*Acquire knowledge on basic components and working of concentrated solar thermal systems for power generation*	*1*	*85*	*75*	*M*					*M*	*H*						*M*	*H*	
CLO-4 :	*Comprehend the solar cell working and manufacturing and can design a solar system for buildings*	*1&2*	*85*	*75*	*M*	*M*				*M*	*H*						*M*	*H*	
CLO-5 :	*Recognize the various solar architecture in buildings and gain a basic knowledge in green buildings*	*1*	*85*	*75*	*M*					*L*	*H*						*M*	*H*	
CLO-6 :	*Understand solar radiation and its seasonal variations along with understanding of the practical application of solar energy powered systems in the three main domains of thermal, photovoltaic and building architecture*	*1*	*85*	*75*	*M*						*H*						*M*	*H*	

		Solar Radiation and its measurement	Low Temperature Systems	High Temperature systems	Photovoltaics	Solar Systems for Buildings
Duration (hour)		18	18	18	18	18
S-1	SLO-1	*The Sun and the Earth, Electromagnetic spectrum*	*Solar flat plate collectors*	*Solar concentrators and receiver geometries, Concentration ratio*	*Photovoltaic effect, Classification, Advantages and disadvantages of Solar photovoltaic technology*	*Need for passive architecture, Thermal comfort*
S-2	SLO-1	*Laws of radiation*	*Basic design of solar flat plate collectors, example problems*	*Advantages and disadvantages of concentrated collectors over non-concentrated collectors*	*Semiconductors, p-n junction, Photo generation of charge carriers*	*Sun's motion, Orientation and design of buildings*
	SLO-2	*Solar radiation: beam and diffuse radiations, Terrestrial radiation*				
S-3	SLO-1	*Depletion of Solar radiation in atmosphere*	*Solar evacuated tube collectors*	*Rankine power cycle*	*Photovoltaic cell manufacture: Czochralski, Zone refining and ribbon growth*	*Thermal capacity, Sensible and latent heat storage in buildings, Insulation*
S-4	SLO-1	*Solar angles, example problems*	*Domestic hot water systems: Integral collector storage, Thermosiphon system, Drain back system, Drain down system, Anti-freeze system*	*Compound parabolic concentrators, Fresnel lens collectors*	*I-V characteristics of solar cell*	*Solar Passive architecture : Heating of Buildings*
S-5	SLO-1		*Solar Cooker : Box type and Dish type*	*Solar parabolic concentrators: trough system*	*Losses in solar cell*	*Solar Passive architecture : Cooling of Buildings*
S-6	SLO-1	*Sunrise, sunset and day length, example problems*	*Solar Cooking application problems*	*Solar parabolic concentrators: dish system*	*Solar Module manufacturing*	*Air conditioning : Solar vapour compression refrigeration system*
S-7	SLO-1	*Solar radiation on tilted surfaces*	*Solar air heater, Solar dryer and its types*	*Central receiver plant / Power tower*	*Photovoltaic system for power generation : Standalone system and grid connected system*	*Air conditioning : Solar vapour absorption refrigeration system*
S-8	SLO-1	*Measurement of solar radiation: Pyranometer*	*Solar desalination, solar still design, example problems*	*Solar furnaces: types, principle and application*	*Photovoltaic system design for a building: DC system and AC system, example problems*	*Green buildings, Zero energy buildings, Rating systems*
S-9	SLO-1	Measurement of solar radiation: Pyrheliometer, Sunshine Recorder	Solar Pond: types, principle and application	Orientation and sun tracking systems		

Learning Resources	1. *Duffie.J.A, &Beckman.W.A, "Solar Engineering of Thermal Processes", 4th Edition, John Wiley & Sons, Inc., 2013.* 2. *Sukhatme.K, Suhas P. Sukhatme, "Solar energy: Principles of thermal collection and storage", Tata McGraw Hill publishing Co. Ltd, 8th Edition, 2011.* 3. *Chetan Singh Solanki,"Solar Photovoltaic: Fundamentals, Technologies and Applications", PHI Learning private limited, 2015.* 4. *Jan F. Kreider, "The solar heating design process: active and passive systems, McGraw-Hill, 2007.* 5. *G.D. Rai, "Solar Energy Utilisation", Khanna Publishers, 5th Edition, 2014.* 6. *Yogi Goswami.D, Frank Kreith, Jan F.Kreider, "Principle of solar engineering", Taylor and Francis, 2nd Edition, 2000. Andy Walker, "Solar Energy", John Wiley & Sons, 2013.* 7. *Garg. H.P, Prakash.J, "Solar energy fundamentals and applications", Tata McGraw Hill publishing Co. Ltd, 2006.* 8. *Tiwari.G.N, "Solar energy: Fundamentals, Design, Modeling and Applications", Alpha Science International, Limited, 2013.* 9. *David A Bainbridge, Ken Haggard, "Passive solar architecture: Heating, Cooling, Ventilation and more use of natural flows", Chelsea Green Publishing, 2011.*

Learning Assessment

	Bloom's Level of Thinking	Continuous Learning Assessment (50% weightage)								Final Examination (50% weightage)	
		CLA – 1 (10%)		CLA – 2 (15%)		CLA – 3 (15%)		CLA – 4 (10%)#			
		Theory	Practice	Theory	Practice	Theory	Practice	Theory	Practice	Theory	Practice
Level 1	Remember Understand	40 %	-	30 %	-	30 %	-	30 %	-	30%	-
Level 2	Apply Analyze	40 %	-	40 %	-	40 %	-	40 %	-	40%	-
Level 3	Evaluate Create	20 %	-	30 %	-	30 %	-	30 %	-	30%	-
	Total	100 %		100 %		100 %		100 %		100 %	

CLA – 4 can be from any combination of these: Assignments, Seminars, Tech Talks, Mini-Projects, Case-Studies, Self-Study, MOOCs, Certifications, Conf. Paper etc.,

Course Designers		
Experts from Industry	Experts from Higher Technical Institutions	Internal Experts
1. Dr.R.Kalimuthu, ISRO, Mahendragirir_kalimuthu@vssc.gov.in	*Dr. G Kumaresan Associate Professor Institute for Energy StudiesCollege of Engineering Guindy Anna University E-Mail : gkumaresan@annauniv.edu*	*Mr. Joji Johnson Assistant Professor, Department of Mechanical Engineering SRM ISTEmail: joji.j@ktr.srmuniv.ac.in*
2. Dr.A.Velayutham, DRDO, Avadi,velayudham.a@cvrde.drdo.in	*Mr. SAI SANTHOSH SOMASUNDARAM Senior Designer – Solar Easi Engineering Chennai, Tamil Nadu, IndiaE-Mail : saisanthoshsomasundaram@gmail.com*	*Dr. S. Manikandan Research Assistant Professor, Department of Mechanical Engineering SRM IST Email: manikandan.su@ktr.srmuniv.ac.in*

Course Code	18MEE350T	Course Name	GAS DYNAMICS AND SPACE PROPULSION	Course Category	E	Professional Elective	L	T	P	C
							3	0	0	3

Pre-requisite Courses	18MEC201T, 18MEC202T	Co-requisite Courses	NIL	Progressive Courses	NIL
Course Offering Department	Mechanical Engineering	Data Book / Codes/Standards	Gas Tables		

Course Learning Rationale (CLR):	*The purpose of learning this course is to:*
CLR-1 :	*Familiarize the compressible fluid flow concepts*
CLR-2 :	*Understand the isentropic flow through variable area ducts and normal shocks.*
CLR-3 :	*Familiarize with the oblique shock and expansion waves*
CLR-4 :	*Understand the flow through constant area duct with friction and heat transfer*
CLR-5 :	*Understand the aircraft and rocket propulsion*
CLR-6 :	*Familiarize with the gas dynamics and space propulsion*

Course Learning Outcomes (CLO):	*At the end of this course, learners will be able to:*	Learning 1 Level of Thinking (Bloom)	2 Expected Proficiency (%)	3 Expected Attainment (%)	PLO 1 Engineering Knowledge	2 Problem Analysis	3 Design & Development	4 Analysis, Design, Research	5 Modern Tool Usage	6 Society & Culture	7 Environment & Sustainability	8 Ethics	9 Individual & Team Work	10 Communication	11 Project Mgt. & Finance	12 Life Long Learning	13 PSO - 1	14 PSO - 2	15 PSO - 3
CLO-1 :	*Analyse and evaluate the compressible flow problems*	*123*	*90*	*80*	*H*	*H*		*M*											
CLO-2 :	*Analyse and solve the engineering flow problems through the nozzles and diffusers with and without Normal shock.*	*123*	*90*	*80*	*H*	*H*		*M*											
CLO-3 :	*Analyse and solve problems related to oblique shock and expansion waves.*	*123*	*90*	*80*	*H*	*H*		*M*											
CLO-4 :	*Analyse and solve problems related to flow through constant area ducts with friction and heat transfer..*	*123*	*90*	*80*	*H*	*H*		*M*											
CLO-5 :	*Analyse and evaluate the performance of Aircraft and Rocket Engines.*	*123*	*90*	*80*	*H*	*H*		*M*											
CLO-6 :	*Understand the gas dynamics and space propulsion.*	*123*	*90*	*80*	*H*	*H*		*M*											

		Fundamentals of Compressible Flow	Isentropic Flow Through Variable Area Ducts	Oblique Shock And Expansion	Flow Through Constant Area Ducts	Aircraft and Rocket Propulsion
Duration (hour)		9	9	9	9	9
S-1	SLO-1 SLO-2	*Energy equation for compressible fluid flow*	*T-s and h-s diagrams for nozzles and diffusers*	*Introduction and oblique shock relations*	*Flow in constant area ducts with friction (Fanno flow), Fanno curves*	*Types of aircraft engines and Propulsion theory*
S-2	SLO-1 SLO-2	*Stagnation state and Mach number*	*Area ratio as a function of Mach number, Impulse function*	*Relation between wave angle and deflection angle*	*Fanno flow equations,*	*Performance of Turbojet, Turbofan ,Turboprop engines*
S-3	SLO-1 SLO-2	*Various regimes of flow*	*Mass flow rate through nozzles and diffusers*	*Supersonic flow over a wedge and weak oblique Shock*	*Variation of flow properties (no derivation)*	*Ramjet and pulse jet engine – construction and working.*
S-4	SLO-1 SLO-2	*Reference velocities , Critical states*	*Problems on variable area duct*	*Problems on the oblique shock wave*	*Variation of Mach number with duct length*	*Problems on Aircraft Engine Performance*
S-5	SLO-1 SLO-2	*Problems on energy equations*	*Flow with normal shock – Development, governing equations*	*Supersonic compression and expansion, Prandtl-Meyer expansion*	*Flow in constant area duct with heat transfer - Rayleigh line & curves*	*Types and applications of rocket engines*
S-6	SLO-1 SLO-2	*Equivalent of Bernoulli's equation for compressible flow*	*Derivation of Prandtl – Meyer equation*	*Problems on Prandtl-Meyer expansion and compression*	*Rayleigh flow equations*	*Solid ,Liquid and Hybrid propellant rockets – construction and fuels-oxidizers*
S-7	SLO-1 SLO-2	*Effect of Mach number on compressibility*	*Variation of flow parameters -static pressure & temperature, density, stagnation pressure and entropy across the shock (no derivations)*	*Detached shock waves, reflection and intersection of shocks and expansion waves*	*Variation of flow properties (no derivate ion)*	*Performance of Rocket engines.*
S-8	SLO-1 SLO-2	*Velocity of sound and wave propagation-subsonic, sonic and supersonic waves*	*Impossibility of shock in subsonic flows, strength of a shock wave*	*Problems on intersection of shocks and expansion waves*	*Maximum heat transfer concept*	*Problems on Rocket engines*
S-9	SLO-1 SLO-2	*Problems on energy equations*	*Problems on Normal shock*	*Underexpanded and overexpanded nozzles*	*Tables and charts for Fanno flow and Rayleigh flow.*	*Types and applications of rocket engines*

Learning Resources	1. *Yahya.S.M, "Fundamentals of Compressible Flow with Aircraft and Rocket Propulsion", New Age International (P) Ltd, New Delhi, 3rd edition, 2012.*
	2. *Radhakrishnan.E, "Gas Dynamics", PHI Learning Pvt. Ltd, 4th edition, 2012.*
	3. *Mattingly.J.D, "Elements of Propulsion: Gas turbines and Rockets", McGraw Hill, 2012.*
	4. *Balachandran.P, "Fundamentals of compressible fluid dynamics", PHI Learning, 2012*
	5. *Robert.D.Zucker, "Oscar Biblarz, Fundamentals of Gas Dynamics",John Wiley and Sons, 2nd edition, 2011.* 6. *Ascher H.Shapiro , 'The dynamics and thermodynamics of compressible flow",R.R.Kreiger Publishers, Volume 2, 1983.*
	Databook
	7. *Yahya.S.M, "Gas Tables for compressible flow calculations", New Age International (P) Ltd, New Delhi, 6th edition, 2011.*

Learning Assessment											
	Bloom's Level of Thinking	Continuous Learning Assessment (50% weightage)								Final Examination (50% weightage)	
		CLA – 1 (10%)		CLA – 2 (15%)		CLA – 3 (15%)		CLA – 4 (10%)#			
		Theory	Practice	Theory	Practice	Theory	Practice	Theory	Practice	Theory	Practice
Level 1	Remember Understand	40 %	-	30 %	-	30 %	-	30 %	-	30%	-
Level 2	Apply Analyze	40 %	-	40 %	-	40 %	-	40 %	-	40%	-
Level 3	Evaluate Create	20 %	-	30 %	-	30 %	-	30 %	-	30%	-
	Total	100 %		100 %		100 %		100 %		100 %	

CLA – 4 can be from any combination of these: Assignments, Seminars, Tech Talks, Mini-Projects, Case-Studies, Self-Study, MOOCs, Certifications, Conf. Paper etc.,

Course Designers		
Experts from Industry	Experts from Higher Technical Institutions	Internal Experts
1. Dr.R.Kalimuthu, ISRO, Mahendragiri,r_kalimuthu@vssc.gov.in	*Dr. R.Velraj, Professor, Institute for Energy Studies, Anna University, Chennai, India - 600025*	*Dr. P.Chandrasekaran, Associate Professor, SRMIST*
2. Dr.A.Velayutham, DRDO, Avadi, velayudham.a@cvrde.drdo.in	*Dr.Raju Abraham, Scientist –F, National Institute of Ocean Technology Chennai – 600 100*	*Mr.G.Manigandaraja, Assistant Professor, SRMIST*

Course Code	18MEE441T	Course Name	COMPUTATIONAL FLUID DYNAMICS	Course Category	E	Professional Elective	L	T	P	C
							3	0	0	3

Pre-requisite Courses	18MEC101T,18MEC105T	Co-requisite Courses	Nil	Progressive Courses	Nil
Course Offering Department	Mechanical Engineering	Data Book / Codes/Standards	NIL		

Course Learning Rationale (CLR):	*The purpose of learning this course is to:*
CLR-1 :	*Be familiar with the basic governing equations of fluid mechanics and behavior of PDE.*
CLR-2 :	*Be familiar with the different discretization techniques*
CLR-3 :	*Know the CFD solution techniques in compressible flow*
CLR-4 :	*Be familiar with incompressible fluid flow problems solution techniques*
CLR-5 :	*Be familiar with the basics of turbulence modeling.*
CLR-6 :	*Be familiar to solve fluid flow problems*

Course Learning Outcomes (CLO):	*At the end of this course, learners will be able to:*	Learning 1: Level of Thinking (Bloom)	2: Expected Proficiency (%)	3: Expected Attainment (%)	PLO 1: Engineering Knowledge	2: Problem Analysis	3: Design & Development	4: Analysis, Design, Research	5: Modern Tool Usage	6: Society & Culture	7: Environment & Sustainability	8: Ethics	9: Individual & Team Work	10: Communication	11: Project Mgt. & Finance	12: Life Long Learning	13: PSO - 1	14: PSO - 2	15: PSO - 3
CLO-1 :	*Understand and apply basic governing equations to different problems.*	*1& 2*	*90*	*85*	*H*	*H*	*H*	*H*			*L*		*M*						
CLO-2 :	*Choose and apply different discretization techniques in solving problems.*	*1*	*90*	*85*	*H*	*H*	*H*	*H*			*L*		*H*						
CLO-3 :	*Choosing different solution techniques to solve numerical problems.*	*123*	*90*	*85*	*H*	*H*	*H*				*L*		*H*						
CLO-4 :	*Solving different incompressible flow problems with appropriate pressure correction and solution techniques.*	*123*	*90*	*85*	*H*	*H*	*H*				*L*		*H*						
CLO-5 :	*Apply turbulence modeling in solving high Reynolds number flows*	*1&2*	*90*	*85*	*H*	*H*	*H*				*L*		*H*						
CLO-6 :	*Choose and apply different discretization and solution techniques to solve fluid flow problems*	*123*	*90*	*85*	*H*	*H*	*H*				*L*		*H*						

		Governing Equations	Dicretisation Techniques	Soluton Techniques And Numerical Methods For Compressible Flow	Finite Volume Method And Techniques For Incompressible Flow	Turbulence Modeling
Duration (hour)		9	9	9	9	9
S-1	SLO 1	*Introduction, various application of computational fluid dynamics*	*Discretization techniques and principles*	*Solution techniques for linear system of equations- Gauss elimination method.*	*Introduction to finite volume method(FVM)*	*Concept of boundary layer*
S-2	SLO 1	*Conservation and Non conservation form of governing equations. Models of fluid flow*	*Finite difference method – Forward, Backward difference methods*	*Numerical solution – Gauss Siedel and Tri-diagonal matrix algorithm*	*Discretization of one dimensional steady state heat conduction convection equation using FVM*	*Laminar sub layer logarithmic layer Velocity defect law*
S-3	SLO 1	*Continuity equation derivation in all forms*	*Finite difference method – central difference methods*	*Numerical solution – Jacobie and relaxation techniques*	*Discretization of incompressible Naviers Stokes Equations using finite differences*	*Concept of turbulence, Reynolds averaging*
S-4	SLO 1	*Momentum equation derivation*	*One dimensional steady state heat conduction problem -Explicit method*	*Solution techniques for ordinary differential equations, Linear multistep method*	*Concept of staggered grid.*	*Time average equations for turbulent flow*
S-5	SLO 1	*Energy equation derivation*	*One dimensional steady state heat conduction problem -Implicit method*	*Predictor and corrector scheme – McCormack technique*	*Pressure correction method*	*Boissuniq approximation method, Types of turbulence models –*
S-6	SLO 1	*Different types of boundary conditions – Dirichlet, Neumann ,Cauchy and Robbins boundary conditions with examples*	*Discretization of one dimensional wave equation*	*Solution of supersonic flow through converging-diverging nozzle with predictor and corrector method: Governing equations*	*SIMPLE algorithm and boundary conditions*	*Prandtl mixing length model, One-equation models*
S-7	SLO 1	*Classification of Partial differential equations –elliptic ,parabolic, hyperbolic*	*Stability analysis of different equations, consistency and convergence*	*Numerical method*	*Solution of Couette flow using SIMPLE algorithm*	*Two-equation models*
S-8	SLO 1	*Mathematical behavior of Partial differential equations - Elliptic ,Parabolic equation*	*Problems on stability analysis*	*Boundary conditions, case set-up and results*	*Problems in Couette flow using SIMPLE algorithm*	*Energy cascade mechanism in turbulent flows*
S-9	SLO 1	*Mathematical behavior of Partial differential equations - Hyperbolic equations –well posed problems*	*Discussion on CFL condition*	*Problems in supersonic flow through converging-diverging nozzle*	*Alternating direction implicit method and application to unsteady two dimensional heat conduction*	*Comparison of merits and demerits of different turbulent models*

Learning Resources	*1. Anderson J.D., "Computational Fluid dynamics", McGraw Hill Int., New York, 2010.* *2. Versteeg H.K., and Malalasekera W., An introduction to computational fluid dynamics, "The finite volume method", Longman, 2007.* *3. Suhas.V. Patankar, "Numerical Heat Transfer and Fluid Flow", Hemisphere Publishing Corporation, 2009.* *4.. Muralidhar.K, and Sundararajan.T, "Computational Fluid Flow and Heat Transfer", Narosa Publishing House, New Delhi, Second Edition, 2008.* *5. Ghoshdasdidar.P.S, "Computer simulation of fluid flow and heat transfer", Tata McGraw Hill Publishing Company Ltd., 1998.*

Learning Assessment

	Bloom's Level of Thinking	Continuous Learning Assessment (50% weightage)								Final Examination (50% weightage)	
		CLA – 1 (10%)		CLA – 2 (15%)		CLA – 3 (15%)		CLA – 4 (10%)#			
		Theory	Practice	Theory	Practice	Theory	Practice	Theory	Practice	Theory	Practice
Level 1	Remember Understand	40 %	-	30 %	-	30 %	-	30 %	-	30%	-
Level 2	Apply Analyze	40 %	-	40 %	-	40 %	-	40 %	-	40%	-
Level 3	Evaluate Create	20 %	-	30 %	-	30 %	-	30 %	-	30%	-
	Total	100 %		100 %		100 %		100 %		100 %	

CLA – 4 can be from any combination of these: Assignments, Seminars, Tech Talks, Mini-Projects, Case-Studies, Self-Study, MOOCs, Certifications, Conf. Paper etc.,

Course Designers		
Experts from Industry	Experts from Higher Technical Institutions	Internal Experts
1. Dr.R.Kalimuthu, ISRO, Mahendragiri, r_kalimuthu@vssc.gov.in	*Dr.R.Sivakumar ,Professor and Dean SMBS, VIT, Chennai*	*P.Sudhakar, SRMIST*
2. Dr.A.Velayutham, DRDO, Avadi, velayudham.a@cvrde.drdo.in	*Mr.P.Sivaganga kumar,Support Manager,Siemens Industry software Compiutational Dynamics India(P) ltd Bengaluru*	*Dr.D.Siva Krishna reddy SRMIST*

Course Code	18MEE442T	Course Name	ADVANCED ENGINEERING THERMODYNAMICS	Course Category	P	Professional Elective	L	T	P	C
							3	0	0	3

Pre-requisite Courses	Engineering Thermodynamics (18MEC101T)	Co-requisite Courses	Nil	Progressive Courses	Nil
Course Offering Department	Mechanical Engineering	Data Book / Codes/Standards	Steam tables, Mollier and generalized compressibility chart		

Course Learning Rationale (CLR):	*The purpose of learning this course is to:*
CLR-1 :	*Familiarize with entropy, exergy and thermodynamics properties.*
CLR-2 :	*Be familiar with the relationship between thermodynamic properties*
CLR-3 :	*To attain the knowledge about chemical thermodynamics*
CLR-4 :	*To attain the knowledge about statistical thermodynamics*
CLR-5 :	*To attain the knowledge of irreversibility in Thermodynamics*
CLR-6 :	*To attain the knowledge of thermodynamics for various engineering systems*

Course Learning Outcomes (CLO):	*At the end of this course, learners will be able to:*	Learning 1	2	3	Program Learning Outcomes (PLO) 1	2	3	4	5	6	7	8	9	10	11	12	13	14	15
		Level of Thinking (Bloom)	Expected Proficiency (%)	Expected Attainment (%)	Engineering Knowledge	Problem Analysis	Design & Development	Analysis, Design, Research	Modern Tool Usage	Society & Culture	Environment & Sustainability	Ethics	Individual & Team Work	Communication	Project Mgt. & Finance	Life Long Learning	PSO - 1	PSO - 2	PSO - 3
CLO-1 :	*Understand the application of exergy and entropy in varies engineering devices.*	*1, 2, 3*	*95*	*85*	*H*	*H*	*L*	*H*										*H*	
CLO-2 :	*Understand the concept of Real gas behaviour and multicomponent systems.*	*1, 2, 3*	*95*	*85*	*H*	*H*	*L*	*M*										*H*	
CLO-3 :	*Understand the concept Chemical thermodynamics and equilibrium.*	*1, 2, 3*	*95*	*85*	*H*	*H*	*L*	*M*										*H*	
CLO-4 :	*Understand the concept Statistical thermodynamics.*	*1, 2, 3*	*95*	*85*	*H*	*H*	*L*	*M*										*H*	
CLO-5 :	*Understand the concept of irreversible thermodynamics.*	*1, 2, 3*	*95*	*85*	*H*	*H*	*L*	*M*										*H*	
CLO-6 :	*Understand the concept of thermodynamics to various engineering systems.*	*1, 2, 3*	*95*	*85*	*H*	*H*	*L*	*M*										*H*	

		Entropy, Exergy Analysis And Property Relations	Real Gas Behaviour And Multicomponent Systems	Chemical Thermodynamics And Equilibrium	Statistical Thermodynamics	Irreversible Thermodynamics
Duration (hour)		9	9	9	9	9
S-1	SLO-1	Entropy principle and its applications, Entropy transfer mechanisms phase diagram, phase changes, various properties diagram, 1st order phasetransition and 2nd order phase transition	Law of corresponding states, Generalized compressibility chart, Reduced coordinate Phase transition, types of equilibrium and stability, multi-component and multi-phase systems, equations of state.	Degree of reaction, reaction equilibrium, law of mass action, heat reaction Chemical equilibrium, Thermodynamic equation for phase	Statistical thermodynamics: Introduction, energy states and energy levels	Introduction to Steady-state thermodynamics,
S-2	SLO-1	Exergy transfer by heat, work and mass	Stability of thermodynamic systems, Le Chatelier's Principle, Other equation of state: Vander Waals equation of state, Beattie-Bridgeman equation of state	Temperature dependence of the heat of reaction and equilibrium constant, thermal ionization of a monatomic gas	Micro and Macro state, Maxwell-Boltzmann statistics	Irreversibility and causes of irreversibility
S-3	SLO-1	Exergy destruction, exergy balance in closed and open systems	Benedict-Webb-Rubin equation of state, Virial equation of state	Gibbs function change, Fugacity and Activity, heat capacity of reacting gases in equilibrium	Sterling's approximation, Maxwell-Boltzmann distribution function	Thermodynamics forces and thermodynamics velocities
S-4	SLO-1	Exergy analysis of industrial systems: power system and refrigeration systems	Use of generalized charts for enthalphy and entropy departure	Enthalpy of formation, 1st law for reactive system	Bose-Einstein statistics, Femi-Dirac statistics	Onsager's reciprocal relations
S-5	SLO-1	Maxwell relations, Generalized relations for changes in entropy, internal energy and enthalpy.	Fugacity coefficient, lee-kesler generalized three parameter tables	Adiabatic flame temperature, Enthalpy and energy of combustion	Distribution of particles over energy levels, partition function	Calculation of entropy production
S-6	SLO-1	General thermodynamic consideration an equations of state, Evolution of thermodynamics properties from equation of state	Fundamental property relations for systems of variable composition.	Entropy change for reactive system	Microscopic interpretation of heat and work	Thermoelectricity: Application of irreversible thermodynamics to a thermocouple
S-7	SLO-1	Type of equilibrium, local equilibrium condition	Partial molar properties, Real gas mixture.	Absolute entropy, third law of thermodynamics	Statistical interpretation of entropy	Uncoupled effects in thermoelectricity
S-8	SLO-1	condition of equilibrium for a heterogeneous system, Gibbs phase rule	Ideal solution of real gases and liquid, activity, equilibrium in multi-phase systems	2nd law analysis for reactive system	Application of statistics to gases-mono-atomic ideal gas	The coupled equations of thermoelectricity

S-9	SLO-1	Condition of stability and Third law of thermodynamics	Gibbs phase rule for non-reactive components.	chemical exergy, 2nd law efficiency of a reactive system	Principle of equipartition of energy, thermodynamics properties, specific heat of solids	Other effects in Thermocouples

Learning Resources	*Yunus, A. C., and Boles, A.," Thermodynamics-An engineering approach, 8th edition", Tata McGraw Hill- Education New Delhi, 2015.*
	Nag, P. K., "Engineering Thermodynamics", 5th edition, Tata McGrew Hill education New Delhi, 2013.
	Bejan, A., "Advance Engineering Thermodynamics, 3rd edition, John Wiley and sons, 2006.
	Smith, J. M. etal, "Introduction to chemical engineering thermodynamics" Tata McGrew Hill, 2005
	Puri, I. K., and Annamalai, K., "Advance Engineering Thermodynamics", CRC Press, 2001.

Learning Assessment

	Bloom's Level of Thinking	Continuous Learning Assessment (50% weightage)								Final Examination (50% weightage)	
		CLA – 1 (10%)		CLA – 2 (15%)		CLA – 3 (15%)		CLA – 4 (10%)#			
		Theory	Practice	Theory	Practice	Theory	Practice	Theory	Practice	Theory	Practice
Level 1	Remember Understand	40 %	-	30 %	-	30 %	-	30 %	-	30%	-
Level 2	Apply Analyze	40 %	-	40 %	-	40 %	-	40 %	-	40%	-
Level 3	Evaluate Create	20 %	-	30 %	-	30 %	-	30 %	-	30%	-
	Total	100 %		100 %		100 %		100 %		100 %	

CLA – 4 can be from any combination of these: Assignments, Seminars, Tech Talks, Mini-Projects, Case-Studies, Self-Study, MOOCs, Certifications, Conf. Paper etc.,

Course Designers

Expert from Industry	Experts from Higher Technical Institute	Internal Experts
1. Dr.R.Kalimuthu, ISRO, Mahendragiri,r_kalimuthu@vssc.gov.in	*1. Dr. Laltu Chandra Indian Institute of Technology (BHU)*	*1. Dr. Piyush Sharma, Asst. Prof.*
2. Dr.A.Velayutham, DRDO, Avadi, velayudham.a@cvrde.drdo.in	*Dr. Amit Gupta (ABSTC) Aditya Birla Science and Technology Company*	*Dr. Pankaj Kumar Research Asst. Prof.*

Course Code	18MEE443T	Course Name	ADVANCED FLUID MECHANICS	Course Category	P	Professional Elective	L	T	P	C
							3	0	0	3

Pre-requisite Courses	Fluid Mechanics (18MEC102T)	Co-requisite Courses	Nil	Progressive Courses	Nil
Course Offering Department	Mechanical Engineering	Data Book / Codes/Standards			

Course Learning Rationale (CLR):	*The purpose of learning this course is to:*
CLR-1 :	*Familiarize with fundamental fluid flow pattern*
CLR-2 :	*Be familiar with the concept of potential flow*
CLR-3 :	*To attain the knowledge about the exact solution of Navier-Stokes Equations*
CLR-4 :	*Be familiar with laminar boundary layers, turbulent flows, turbulence modeling and equations, Basic discretization method*
CLR-5 :	*To attain the knowledge of the various types of flow stability theory*
CLR-6 :	*Be familiar with the applications of N-S equation in internal and external flows*

		Learning			Program Learning Outcomes (PLO)														
		1	2	3	1	2	3	4	5	6	7	8	9	10	11	12	13	14	15
Course Learning Outcomes (CLO):	*At the end of this course, learners will be able to:*	Level of Thinking (Bloom)	Expected Proficiency (%)	Expected Attainment (%)	Engineering Knowledge	Problem Analysis	Design & Development	Analysis, Design, Research	Modern Tool Usage	Society & Culture	Environment & Sustainability	Ethics	Individual & Team Work	Communication	Project Mgt. & Finance	Life Long Learning	PSO - 1	PSO - 2	PSO - 3
CLO-1 :	*Analyze the different flow patterns, difference in rotational and irrotational flow, Stream and velocity potential function.*	*1, 2, 3*	*90*	*80*	*H*	*H*	*L*	*H*										*H*	
CLO-2 :	*Acquire knowledge on Source and Sink; Vortex flow, Doublet, Superposition of basic plane potential flows*	*1, 2, 3*	*90*	*80*	*H*	*H*	*L*	*M*										*H*	
CLO-3 :	*Understand the basic calculations for force and momentum calculations using N-S equations, understand the Couette flows, Poiseuille flows*	*1, 2, 3*	*90*	*80*	*H*	*H*	*L*	*M*										*H*	
CLO-4 :	*Understand the Integral form of boundary layer equations, Turbulent boundary layer equation, major turbulence modeling, finite element method, finite volume method*	*1, 2, 3*	*90*	*80*	*H*	*H*	*L*	*M*										*H*	
CLO-5 :	*Understand the concept of the Linear Stability theory*	*1, 2, 3*	*90*	*80*	*H*	*H*	*L*	*M*										*H*	
CLO-6 :	*Able to apply and solve N-S equation for different flow conditions.*	*1, 2, 3*	*90*	*80*	*H*	*H*	*L*	*M*										*H*	

		Analyze the different flow patterns, difference in rotational and irrotational flow, Stream and velocity potential function	Acquire knowledge on Source and Sink; Vortex flow, Doublet, Superposition of basic plane potential flows	Understand the basic calculations for force and momentum calculations using N-S equations, understand the Couette flows, Poiseuille flows	Understand the Integral form of boundary layer equations, Turbulent boundary layer equation, major turbulence modeling, Discretization	Understand the concept of the Linear Stability theory
Duration (hour)		9	9	9	9	9
S-1	SLO-1	*Continuity Equation, Streamlines, and Stream Function*	*Uniform flow, source flow, sink flow*	*Solutions to the Steady-State Navier-Stokes Equations*	*Boundary layer on a flat plate*	*Concept of small-disturbance stability,*
S-2	SLO-1	*Vorticity and Circulation*	*Free vortex flow*	*Problems based on Steady-State Navier-Stokes Equations*	*Similarity solutions, Integral form ofboundary layer equations Approximate Methods*	*Linear Stability Theory of Fluid Flows*
S-3	SLO-1	*Problem based on vorticity and circulation*	*Super imposed flow, source and sink pair*	*Poiseuille Flow in a Rectangular Conduit*	*General equations of turbulent flow, Turbulent boundary layer equation*	*Orr-Sommerfeld equation,*
S-4	SLO-1	*Irrotational Flows and the Velocity Potential*	*Doublet*	*Couette Flow Between Concentric Circular Cylinders*	*Flat plate turbulent boundary layer*	*Boundary layer stability*
S-5	SLO-1	*Problems based on irrotational Flows and the Velocity Potential*	*Flow past a Rankine oval body*	*Creeping flows*	*Turbulent Models-zero, one and two*	*Thermal Instability*
S-6	SLO-1	*Lagrangian and Eulerian description*	*doublet in a uniform flow*	*Fully developed flows in non- circular cross-sections*	*Prandtl mixing hypothesis,*	*Transition to turbulence*
S-7	SLO-1	*Reynolds transport theorem*	*Flow past a cylinder with circulation*	*Unsteady Flows: Impulsive Motion of a Plate—Stokes's First Problem*	*Basic discretization – Finite difference method*	*Inviscid stability theory*
S-8	SLO-1	*Derivation of continuity and momentum equations using Reynolds transport theorem*	*Magnus effect; Kutta-Joukowski lift theorem*	*Oscillation of a Plate—Stokes's Second Problem*	*Finite volume method*	*Problems based on Navier-Stoke's equation for steady incompressible flows*
S-9	SLO-1	*Problem based on Reynolds transport theorem*	*Concept of lift and drag.*	*Flow in Convergent and Divergent Channels*	*Finite element method*	*Favorable and adverse pressure gradients, flow separation*

Learning Resources	1. *Graebel. W.P, "Advanced Fluid Mechancis", 1st Edition, Academic Press, Elsevier Inc., 2007*
	2. *Muralidhar and G. Biswas, " Advanced Engineering Fluid Mechanics", 3rd Edition, Narosa Publishers, 2015*
	3. *Stevan A Jones, "Advanced Methods for Practical Applications in Fluid Mechanics", InTech Publishers, 2012*
	4. *Kundu P., Cohen I and Dowling D,"Fluid Mechanics" 6th edition,2015*
	5. *Schlichting H., K. Gersten, Boundary Layer Theory, 8/e, Springer 2000*

Learning Assessment

	Bloom's Level of Thinking	Continuous Learning Assessment (50% weightage)								Final Examination (50% weightage)	
		CLA – 1 (10%)		CLA – 2 (15%)		CLA – 3 (15%)		CLA – 4 (10%)#			
		Theory	Practice	Theory	Practice	Theory	Practice	Theory	Practice	Theory	Practice
Level 1	Remember Understand	40 %	-	30 %	-	30 %	-	30 %	-	30%	-
Level 2	Apply Analyze	40 %	-	40 %	-	40 %	-	40 %	-	40%	-
Level 3	Evaluate Create	20 %	-	30 %	-	30 %	-	30 %	-	30%	-
	Total	100 %		100 %		100 %		100 %		100 %	

CLA – 4 can be from any combination of these: Assignments, Seminars, Tech Talks, Mini-Projects, Case-Studies, Self-Study, MOOCs, Certifications, Conf. Paper etc.,

Course Designers

Expert from Industry	Experts from Higher Technical Institute	Internal Experts
1. Dr.R.Kalimuthu, ISRO, Mahendragiri,r_kalimuthu@vssc.gov.in	*Dr. Dhiman Chatterjee, Professor, Dept. of Mechanical Engineering, IIT Madras*	*1. Dr. Pankaj Kumar*
2. Dr.A.Velayutham, DRDO, Avadi, velayudham.a@cvrde.drdo.in	*1. Dr Parag Deshpande, senior scientist,NAL*	*Dr. M. Cheralathan, SRMIST*

Course Code	18MEE444T	Course Name	DESIGN OF PUMPS AND TURBINES	Course Category	E	Professional Elective	L	T	P	C
							3	0	0	3

Pre-requisite Courses	18MEC102T	Co-requisite Courses	~~Nil~~	Progressive Courses	Nil
Course Offering Department	Mechanical Engineering	Data Book / Codes/Standards	NIL		

Course Learning Rationale (CLR):	The purpose of learning this course is to:
CLR-1 :	*Acquire the knowledge on basic flow concepts in turbines and pumps*
CLR-2 :	*Understand the design principles of simple radial flow pumps*
CLR-3 :	*Know the design principles of various turbines*
CLR-4 :	*Understand the phenomenon of cavitation in hydraulic machines*
CLR-5 :	*Know the hydro machine applicability from the cavitation point of view.*
CLR-6:	*Familiarize with the performance and design of turbines and pumps*

Course Learning Outcomes (CLO):	At the end of this course, learners will be able to:	Learning 1: Level of Thinking (Bloom)	Learning 2: Expected Proficiency (%)	Learning 3: Expected Attainment (%)	PLO 1: Engineering Knowledge	PLO 2: Problem Analysis	PLO 3: Design & Development	PLO 4: Analysis, Design, Research	PLO 5: Modern Tool Usage	PLO 6: Society & Culture	PLO 7: Environment & Sustainability	PLO 8: Ethics	PLO 9: Individual & Team Work	PLO 10: Communication	PLO 11: Project Mgt. & Finance	PLO 12: Life Long Learning	PLO 13: PSO - 1	PLO 14: PSO - 2	PLO 15: PSO - 3
CLO-1 :	*Appreciate the basic flow concepts in turbines and pumps.*	1&2	90	85	H	H	H	-	-	-	-	-	-	-	-	-	-	-	-
CLO-2 :	*Know the design principles of simple radial flow pumps*	1	90	85	H	H	H	M	-	-	-	-	-	-	-	-	-	-	-
CLO-3 :	*Appreciate the design principles of various turbines*	123	90	85	H	H	H	M	-	-	-	-	-	-	-	-	-	-	-
CLO-4 :	*Familiarize with the effects of cavitation in hydraulic machines*	123	90	85	H	H	H	-	-	-	-	-	-	-	-	-	-	-	-
CLO-5 :	*Become familiar with hydro machine applicability from the cavitation point of view.*	1&2	90	85	H	H	H	-	-	-	-	-	-	-	-	-	-	-	-
CLO-6 :	*To solve practical fluid flow problems in turbines and pumps*	123	90	85	H	H	H	-	-	-	-	-	-	-	-	-	-	-	-

		Basic principles of fluid machinery	Theory of Pumps	Design of pumps	Theory and design of turbines	Cavitation
Duration (hour)		9	9	9	9	9
S-1	SLO 1	*Definition, classification and stages of turbines and pumps*	*Introduction to mixed flow centrifugal pumps*	*Design procedure for pumps*	*Theory of turbines , specific speed, Euler's turbine equation*	*Introduction to cavitation*
S-2	SLO 1	*Basic equations of energy transfer between the fluid and the rotor*	*Calculation of thrust In mixed flow centrifugal pumps*	*Thermal design of pumps -*	*Introduction to Pelton wheel (impulse turbine) - single jet and multiple jet units*	*Cavitation in pumps*
S-3	SLO 1	*Performance characteristics of various turbines and pumps*	*Impellers, Pump casings – volute casing and vortex casing*	*Selection of materials for withstanding high temperature and corrosive fluids*	*Velocity diagrams at the inlet and exit of the buckets*	*Cavitation in turbines*
S-4	SLO 1	*Dimensional analysis*	*Velocity diagrams for mixed flow centrifugal pumps*	*Hydraulic design of pumps*	*Performance calculations considering the losses in the nozzle and the buckets*	*Thomas cavitation factor*
S-5	SLO 1	*Dimensionless parameters in turbines and pumps*	*Calculation of work input to mixed flow centrifugal pumps*	*Selection of the impeller for pumps*	*Introduction to reaction turbine (mixed flow and axial flow) and Degree of reaction*	*Net positive suction head (NPSH)*
S-6	SLO 1	*Specific speed in turbines and pumps*	*Head, Losses and efficiency of mixed flow centrifugal pumps*	*Calculation of casing dimension*	*Francis turbine – Velocity diagrams and Design procedure*	*Effects of cavitation on the performance of turbines and pumps*
S-7	SLO 1	*Velocity triangles of a stage*	*Specific speed, Power requirement and operating characteristics*	*Introduction to computer programs for iterative and interactive design*	*Introduction to Kaplan / Propeller Turbine – axial flow reaction type*	*Cavitation – damage to equipments*
S-8	SLO 1	*Calculation of work output of turbine*	*Minimum starting speed of centrifugal pump*	*System head, Net positive suction head,*	*Velocity diagrams and design procedure for Kaplan turbine*	*Design considerations to avoid cavitation*
S-9	SLO 1	*Computation of efficiency*	*Multi stage pump*	*Priming of pumps*	*Governing of turbines*	*Cavitation and energy harvesting*

Learning Resources	1. *Dixon.S.L, "Fluid Mechanics and Thermodynamics of Turbomachinery", 6th Edition, Butterworth* 2. *Heinemann, U.K.,2010* 3. *Viktor Gelpke, "Hydraulic turbines their design and installation", Research press, 2010* 4. *Seppo A. Korpela., "Priniciple of Turbomachinery", John Wiley and Sons Ltd, 2012* 5. *Yahya.S.M, "Turbines, Fans and Compressors", 3rd Edition, Tata McGraw Hill Publications, 2010* 6. *Venkanna. B.K, "Fundamentals of Turbomachinery", 4th Edition, New Delhi, PHI Learning Pvt. Ltd, 2011.*

Learning Assessment											
	Bloom's Level of Thinking	Continuous Learning Assessment (50% weightage)								Final Examination (50% weightage)	
		CLA – 1 (10%)		CLA – 2 (15%)		CLA – 3 (15%)		CLA – 4 (10%)#			
		Theory	Practice	Theory	Practice	Theory	Practice	Theory	Practice	Theory	Practice
Level 1	Remember Understand	40 %	-	30 %	-	30 %	-	30 %	-	30%	-
Level 2	Apply Analyze	40 %	-	40 %	-	40 %	-	40 %	-	40%	-
Level 3	Evaluate Create	20 %	-	30 %	-	30 %	-	30 %	-	30%	-
	Total	100 %		100 %		100 %		100 %		100 %	

CLA – 4 can be from any combination of these: Assignments, Seminars, Tech Talks, Mini-Projects, Case-Studies, Self-Study, MOOCs, Certifications, Conf. Paper etc.,

Course Designers		
Experts from Industry	Experts from Higher Technical Institutions	Internal Experts
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Course Code	18MEE445T	Course Name	THERMAL ENERGY STORAGE SYSTEMS	Course Category	E	Professional Elective	L	T	P	C
							3	0	0	3

Pre-requisite Courses	18MEC101T-Thermodynamics	Co-requisite Courses	NIL	Progressive Courses	NIL
Course Offering Department	Mechanical Engineering	Data Book / Codes/Standards	NIL		

Course Learning Rationale (CLR):	*The purpose of learning this course is to:*
CLR-1 :	*Familiarize with the techniques used for storing various forms of energy*
CLR-2 :	*Understand the sensible thermal energy storage systems and materials*
CLR-3 :	*Understand the latent and thermochemical energy storage systems.*
CLR-4 :	*Understand the properties of storage materials and heat transfer fluids*
CLR-5 :	*Know the various techniques used for storing thermal energy in heating/cooling applications and energy savings*
CLR-6 :	*Be familiar with the Thermal energy storage systems and its applications.*

Course Learning Outcomes (CLO):	*At the end of this course, learners will be able to:*	Learning 1: Level of Thinking (Bloom)	Learning 2: Expected Proficiency (%)	Learning 3: Expected Attainment (%)	PLO 1: Engineering Knowledge	PLO 2: Problem Analysis	PLO 3: Design & Development	PLO 4: Analysis, Design, Research	PLO 5: Modern Tool Usage	PLO 6: Society & Culture	PLO 7: Environment & Sustainability	PLO 8: Ethics	PLO 9: Individual & Team Work	PLO 10: Communication	PLO 11: Project Mgt. & Finance	PLO 12: Life Long Learning	PLO 13: PSO - 1	PLO 14: PSO - 2	PLO 15: PSO - 3
CLO-1 :	*Familiarize with the techniques used for storing various forms of energy*	*1*	*90*	*80*	*H*						*L*							*H*	
CLO-2 :	*Understand the sensible thermal energy storage, material and methodology*	*12&3*	*90*	*80*	*H*	*M*					*L*							*H*	
CLO-3 :	*Understand the latent and thermochemical energy storage systems.*	*12&3*	*90*	*80*	*H*	*M*					*M*							*H*	
CLO-4 :	*Understand the properties of storage materials and heat transfer fluids*	*1&2*	*90*	*80*	*H*				*H*		*M*							*H*	
CLO-5 :	*Know the various techniques used for storing thermal energy in heating/cooling applications and energy savings*	*1&2*	*90*	*80*	*H*	*L*			*L*		*H*							*H*	
CLO-6 :	*Be familiar with various techniques used for storing thermal energy in heating/cooling applications and energy savings*	*12&3*	*90*	*80*	*H*	*L*			*M*		*M*							*H*	

		Energy Storage	Sensible Thermal Energy Storage Systems	Latent Thermal And Thermochemical Energy Storage Systems	Thermal Energy Storage Materials	Thermal Storage Applications And Energy Savings
Duration (hour)		9	9	9	9	9
S-1	SLO-1	*Basics of Energy storage and its types*	*Sensible Thermal Energy Storage (STES) system and its types*	*Latent Thermal Energy Storage (LTES) system and its types*	*Thermal energy storage materials - Classification, thermosphysical properties*	*Cool Thermal Energy Storage (CTES) concept and comparison of storage technologies*
S-2	SLO-1	*Energy storage by mechanical medium*	*Selection of sensible thermal energy storage materials and methodologies*	*Types and properties of latent heat storage materials and cooling/Heating load calculations*	*Various methods to improve the thermophysical properties of PCM*	*Cool thermal energy storage in process cooling*
S-3	SLO-1	*Energy storage by chemical medium*	*Properties of sensible heat storage materials*	*Encapsulation techniques of LTES (PCM) materials*	*selection criteria for thermal energy storage materials*	*CTES systems building air conditioning applications*
S-4	SLO-1	*Low and Medium temperature thermal storage systems*	*Sensible cooling and heating load calculations*	*Performance assessment of LTES system in building*	*Phase Change Materials – classifications and properties*	*Solar energy storage – passive heating and cooling, green house heating*
S-5	SLO-1	*High temperature thermal storage systems*	*STES Technologies, storage tanks using water and rock bed thermal storage*	*Passive and active LTES systems*	*PCM selection for heating and cooling applications*	*Drying and heating for process industries*
S-6	SLO-1	*Necessity of TES, types of TES technologies and Comparison of thermal energy storage technologies*	*Solar pond thermal storage and building structure thermal storage*	*Thermochemical energy storage principles and materials*	*Heat transfer fluids and properties*	*Solar power plant applications.*
S-7	SLO-1	*Seasonal thermal energy storage Principle*	*Passive solar heating storage*	*Thermochemical energy storage systems - open adsorption energy storage system and closed adsorption energy storage system*	*Selection of heat transfer fluid for heating and cooling applications*	*TES and Energy Savings - utilization of waste or surplus energy, reduction of demand charges and deferring equipment purchases*
S-8	SLO-1	*Seasonal (Source) TES technologies - aquifer thermal storage, borehole thermal storage and cavern thermal storage*	*Active solar heating storage*	*Closed absorption energy storage system solid/gas, thermochemical energy storage system and thermochemical accumulator energy storage system*	*Measuring instruments for thermophysical properties*	*Additional energy savings considerations for TES*

S-9	SLO-1	*Earth-to-air thermal storage, energy piles thermal storage, sea water thermal storage, rock thermal storage and roof pond thermal storage*	*High temperature Sensible Thermal Energy Storage system*	*Floor heating system using thermochemical energy storage and thermochemical energy storage for building heating applications*	*Necessity of improving thermophysical properties*	*Case studies for TES energy savings*

Learning Resources	*1. R. Parameshwaran and S. Kalaiselvam, "Thermal Energy Storage Technologies for Sustainability: Systems Design, Assessment and Applications", Academic Press Inc, 23 September 2014.* *2. Ibrahim Dincer and Marc A. Rosen, "Thermal Energy Storage Systems and Applications", 2nd Edition, John Wiley and Sons Ltd., 2011.* *3. Luisa F. Cabeza, "Advances in Thermal Energy Storage Systems: Methods and Applications", October 31, 2014* *4. Charles E. Dorgan, James S. Elleson, "Design Guide for Cool Thermal Storage", ASHRAE, Atlanda, 1993.* *5. R. Velraj"Sensible heat Storage for solar heating and cooling systems" in the book titled "Advances in Solar Heating and Cooling - Pages 399 - 428, Elsevier Publication, 2016* *6. ASHRAE, "Handbook of Fundamentals", American Society of Heating Refrigeration and Air Conditioning Engineers, New York, 1993.* *7. Alternate fuels for IC Engines: Liquid fuels, Gaseous fuels - properties, advantages and disadvantages, Emissions from engines – Emission standards – Euro, BS*

Learning Assessment

	Bloom's Level of Thinking	Continuous Learning Assessment (50% weightage)								Final Examination (50% weightage)	
		CLA – 1 (10%)		CLA – 2 (15%)		CLA – 3 (15%)		CLA – 4 (10%)#			
		Theory	Practice	Theory	Practice	Theory	Practice	Theory	Practice	Theory	Practice
Level 1	Remember Understand	40 %	-	30 %	-	30 %	-	30 %	-	30%	-
Level 2	Apply Analyze	40 %	-	40 %	-	40 %	-	40 %	-	40%	-
Level 3	Evaluate Create	20 %	-	30 %	-	30 %	-	30 %	-	30%	-
	Total	100 %		100 %		100 %		100 %		100 %	

CLA – 4 can be from any combination of these: Assignments, Seminars, Tech Talks, Mini-Projects, Case-Studies, Self-Study, MOOCs, Certifications, Conf. Paper etc.,

Course Designers		
Experts from Industry	Experts from Higher Technical Institutions	Internal Experts
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2. Dr.A.Velayutham, DRDO, Avadi, velayudham.a@cvrde.drdo.in	*Raju Abraham,Sc-F National Institute of Ocean Technology Chennai 600 100 Ph 044-6678 3339 Email: abraham@niot.res.i*	*Dr. M. Cheralathan Professor, Department of Mechanical Engineering SRM IST Email: cheralathan.m@ktr.srmuniv.ac.in*

Course Code	18MEE446T	Course Name	Design of Heat exchangers	Course Category	E	Professional Elective	L	T	P	C
							3	0	0	3

Pre-requisite Courses	NIL	Co-requisite Courses	Heat and mass Transfer	Progressive Courses	NIL
Course Offering Department	Mechanical Engineering	Data Book / Codes/Standards	NIL		

Course Learning Rationale (CLR):	*The purpose of learning this course is to:*
CLR-1 :	*Gain knowledge on the basics of Heat Exchanger*
CLR-2 :	*Familiarize with Design Aspects of heat exchangers*
CLR-3 :	*Acquire the basic skills acquired to design the double pipe and shell and tube heat exchangers*
CLR-4 :	*Acquire the basic skills acquired to design the compact and plate heat exchangers*
CLR-5	*familiarize with the condensers and evaporators*
CLR-6	*familiarize with the design of heat exchangers*

Course Learning Outcomes (CLO):	*At the end of this course, learners will be able to:*	Learning 1	Learning 2	Learning 3	PLO 1	PLO 2	PLO 3	PLO 4	PLO 5	PLO 6	PLO 7	PLO 8	PLO 9	PLO 10	PLO 11	PLO 12	PLO 13	PLO 14	PLO 15
		Level of Thinking (Bloom)	Expected Proficiency (%)	Expected Attainment (%)	Engineering Knowledge	Problem Analysis	Design & Development	Analysis, Design, Research	Modern Tool Usage	Society & Culture	Environment & Sustainability	Ethics	Individual & Team Work	Communication	Project Mgt. & Finance	Life Long Learning	PSO - 1	PSO - 2	PSO - 3
CLO-1 :	*understand the fundamentals of heat exchanger*	*1 2 3*	*90*	*85*	*H*			*M*											
CLO-2 :	*Understand the various design aspects of heat exchangers*	*1 2 3*	*90*	*85*	*H*		*H*	*M*											
CLO-3 :	*Evaluate the design of double pipe and shell and tube heat exchangers*	*1 2 3*	*90*	*85*	*H*	*H*	*H*	*M*											
CLO-4 :	*Evaluate the design of compact and plate type heat exchangers*	*1 2 3*	*90*	*85*	*H*	*H*	*H*	*M*											
CLO-5:	*Familiarize with design of various types of condensers and evaporators*	*1 2 3*	*90*	*85*	*H*	*H*	*H*	*M*											
CLO-4:	*To understand with the design of heat exchangers*	*1 2 3*	*90*	*85*	*H*	*H*	*H*	*M*											

		Fundamentals Of Heat Exchanger	Design Aspects Of Heat Exchangers	Double Pipe Heat Exchangers And Shell & Tube Heat Exchangers	Compact And Plate Heat Exchanger	Condensers And Evaporators
Duration (hour)		9	9	9	9	9
S-1	SLO-1	*Introduction, classification of heat exchangers, Recuperator and Regenerator*	*Introduction, effect of turbulence,*	*Introduction, Thermal design and analysis of inner tube and outer tube*	*Classification of compact heat exchangers, Merits and Demerits of Compact heat exchangers*	*Types of Condensers,*
S-2	SLO-1	*Geometry of Construction, Tubular, Plate heat exchangers*	*Effect of friction factor, pressure drop in tube side,*	*hydraulic design and analysis of inner tube and outer tube*	*Design of compact heat exchangers*	*Design of surface condensers- Down-flow*
S-3	SLO-1	*Effect of Extended Surface Heat Exchangers Heat transfer Mechanisms,*	*Effect of Pressure drop in tube bundles.*	*Design of Double Pipe Heat Exchangers- parallel flow & counter flow-problems*	*Factors affecting of compact heat exchangers*	*Types of Condensers, Design of surface condensers- Central-flow*
S-4	SLO-1	*Flow arrangements, Application, Selection of Heat Exchangers.*	*Heat Transfer and pumping power relationship*	*Design of Double Pipe Heat Exchangers- cross flow heat exchanger-*	*Design of plate heat exchangers*	*Design of evaporative condensers- Inverted flow &Regenerative*
S-5	SLO-1	*Overall Heat transfer coefficient, LMTD method for Heat Exchanger analysis for parallel flow heat exchanger*	*Pressure Drop in Bends and fittings*	*Basic components of shell & tube heat exchangers*	*Factors affecting Design of plate heat exchangers*	*Design of evaporative condensers*
S-6	SLO-1	*Overall Heat transfer coefficient, LMTD method for Heat Exchanger analysis for COUNTER flow heat exchanger*	*Effect of fins arrangement ant its geometry on heat transfer*	*Design of shell & tube heat exchangers*	*Operational characteristics of plate heat exchanger*	*Types of Evaporators,*
S-7	SLO-1	*Overall Heat transfer coefficient, LMTD method for Heat Exchanger analysis for CROSS heat exchanger*	*Fouling of Heat exchangers, effect on heat transfer*	*Factors affecting in shell & tube heat exchangers*	*flow arrangements in plate heat exchangers*	*calculation of Evaporator surface and multiple evaporator*
S-8	SLO-1	*ε NTU method for Heat Exchanger analysis*	*Problems in pressure drop and fouling in Heat exchangers*	*Shell side heat transfer. Pressure drop*	*Heat transfer and pressure drop calculations*	*calculation of Evaporator multiple effect*
S-9	SLO-1	*Heat Exchanger design considerations - Material requirement Design codes and its requirement*	*Factors affecting performance of HE/PHE/Condensers/Evaporator*	*Problems on design of shell and tube heat exchangers and its applications*	*Applications of compact and plate heat exchanger*	*Factors affecting in condensers and evaporators of heat changers*

Learning Resources	
	1. *SadikKakac and Hongtan Liu, "Heat Exchangers Selection, Rating and Thermal Design", CRC Press,2002* 2. *Kern D.Q, "Process Heat Transfer", Tata McGraw Hill , 1997, Reprint 2008* 3. *Ramesh K. Shah, "Fundamentals of Heat Exchanger Design", John Wiley & Sons,2003* 4. *Arthur. P Frass, "Heat Exchanger Design", John Wiley & Sons, 1988.* 5. *Taborek.T, Hewitt.G.F and Afgan.N, "Heat Exchangers, Theory and Practice", McGraw-Hill Book Co.2018* 6. *Kuppan T, "Heat Exchanger design handbook", Marcel Dekker INC, 2000.* 7. *Standards of Tubular Exchanger Manufacturers Association(TEMA), 9th Edition,2007 – www.tema.org* 8. *Wolverine Heat Transfer Data book – III by Wolverine Tube Inc.,*

Learning Assessment

	Bloom's Level of Thinking	Continuous Learning Assessment (50% weightage)								Final Examination (50% weightage)	
		CLA – 1 (10%)		CLA – 2 (15%)		CLA – 3 (15%)		CLA – 4 (10%)#			
		Theory	Practice	Theory	Practice	Theory	Practice	Theory	Practice	Theory	Practice
Level 1	Remember Understand	40 %	-	30 %	-	30 %	-	30 %	-	30%	-
Level 2	Apply Analyze	40 %	-	40 %	-	40 %	-	40 %	-	40%	-
Level 3	Evaluate Create	20 %	-	30 %	-	30 %	-	30 %	-	30%	-
	Total	100 %		100 %		100 %		100 %		100 %	

CLA – 4 can be from any combination of these: Assignments, Seminars, Tech Talks, Mini-Projects, Case-Studies, Self-Study, MOOCs, Certifications, Conf. Paper etc.,

Course Designers		
Experts from Industry	Experts from Higher Technical Institutions	Internal Experts
1. Dr.R.Kalimuthu, ISRO, Mahendragiri, r_kalimuthu@vssc.gov.in	Dr. K Karuppasamy Assistant Professor Department of Mechanical Engineering Anna University Regional Campus Tirunelveli - 627 007	Mr. G.Manikandaraja Assistant Professor, Department of Mechanical Engineering SRM IST Email: manikandaraja.g@ktr.srmuniv.ac.in
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Course Code	18MEE447T	Course Name	COMBUSTION ENGINEERING	Course Category	E	Professional elective	L	T	P	C
							3	0	0	3

Pre-requisite Courses	18MEC101T Thermodynamics	Co-requisite Courses	NIL	Progressive Courses	NIL
Course Offering Department	Mechanical Engineering	Data Book / Codes/Standards	NIL		

Course Learning Rationale (CLR):	*The purpose of learning this course is to:*
CLR-1 :	*Acquire the fundamental knowledge of combustion*
CLR-2 :	*Gain knowledge on thermodynamics of combustion*
CLR-3 :	*Understand the kinetics of combustion*
CLR-4 :	*Understand the types of flames*
CLR-5 :	*Familiarize with combustion aspects in SI and CI engines*
CLR-6 :	*Acquire knowledge on combustion reactions and its stages in internal combustion engines*

		Learning			Program Learning Outcomes (PLO)														
		1	2	3	1	2	3	4	5	6	7	8	9	10	11	12	13	14	15
Course Learning Outcomes (CLO):	*At the end of this course, learners will be able to:*	Level of Thinking (Bloom)	Expected Proficiency (%)	Expected Attainment (%)	Engineering Knowledge	Problem Analysis	Design & Development	Analysis, Design, Research	Modern Tool Usage	Society & Culture	Environment & Sustainability	Ethics	Individual & Team Work	Communication	Project Mgt. & Finance	Life Long Learning	PSO - 1	PSO - 2	PSO - 3
CLO-1 :	*Acquire the knowledge of combustion equations for different air fuel ratios*	*1&2*	*90*	*80*	*H*	*M*												*H*	
CLO-2 :	*Analyzecombustions based on first law and second law of thermodynamics in reacting systems*	*1*	*90*	*80*	*H*	*H*												*H*	
CLO-3 :	*Evaluate the kinetic of combustion and reaction order and its theory*	*1*	*90*	*80*	*H*	*H*		*M*										*H*	
CLO-4 :	*Acquire the knowledge of flames characteristics and its types*	*1&2*	*90*	*80*	*H*	*H*		*M*										*H*	
CLO-5 :	*Understand the stages of combustion in SI and CI engines and acquire knowledge with normal and abnormal combustion.*	*1&2*	*90*	*80*	*H*													*H*	
CLO-6 :	*Understand the emission norms and its control method*	*1*	*90*	*80*	*H*						*H*							*H*	

		Combustion Of Fuels	Thermodynamics Of Combustion	Kinetics Of Combustion	Flames	Engine Combustion
Duration (hour)		9	9	9	9	9
S-1	SLO-1	*Combustion engineering and its importance*	*Thermo-chemistry first law analysis of reacting systems*	*Rates of reaction*	*Different types of flames Laminar and turbulent*	*Combustion in SI and CI engines*
S-2	SLO-1	*Combustion behavior with different air composition*	*To understand the reacting system and calculations on first law of thermodynamics*	*Determination of rates of reaction*	*Premixed and diffusion flames*	*Stages of combustion in SI and CI engines,*
S-3	SLO-1	*Combustion equations for Theoretical air*	*Acquire knowledge on Adiabatic combustion Temperature*	*Reaction order and molecularity complex reactions*	*Laminar Jet Flame Height – Turbulent flame Lift-Off Height and Blowout Limit.*	*Advanced techniques of combustion in IC engines-learn burn engine –HCCI engine*
S-4	SLO-1	*Combustion equations for excess air*	*Adiabatic combustion Temperature calculations*	*Determination of reaction order and molecularity complex reactions*	*Fuel burning velocity, Determination of Burning velocity, Factors affecting burning velocity*	*Normal combustion and abnormal combustion*
S-5	SLO-1	*Proper Air fuel ratio for combustion*	*Second law analysis of reacting systems*	*Chainreactions - Arrhenius rate equation, collection theory*	*Droplet Evaporation and Combustion*	*Emission norms in Heavy duty and light duty vehicles and its standards BS and Euro norms*
S-6	SLO-1	*Equivalence Ratio*	*Criterion for chemical Equilibrium*	*Calculation on Chain reactions - Arrhenius rate equation, collection theory*	*Flame Quenching, flammability*	*Emissions from premixed combustion*
S-7	SLO-1	*Exhaust gas composition*	*Determination of equilibrium constant for gaseous mixtures*	*Activated complex theory*	*Flame by ignition*	*Emission from non-premixed combustion*
S-8	SLO-1	*Air fuel ratio from exhaust gas composition*	*Evaluation of equilibrium composition*	*Explosive and general oxidative*	*Flame stabilization in open burners*	*Reasons of HC, sulphur , PM, $NO_x$and CO emissions in engines*
S-9	SLO-1	*Heating value of fuels*	*Chemical availability*	*Characteristics of fuels on Explosive and general oxidative*	*Methods to stabilize the flame in open burner*	*Control of HC, sulphur , PM, NO_x and CO emissions in engines*

Learning Resources	1. Stephen.R.Turns, *"An Introduction to Combustion concepts and applications", 2nd Edition, McGraw Hill Book Company, Boston, Edition 3,2011.* 2. *Ganesan.V, "Internal Combustion Engines", Tata McGraw-Hill, New Delhi,2009.* 3. *Ramalingam.K.K, "Internal Combustion Engines - Theory and practice",SciTech Publications India Pvt. Ltd., Chennai, 2010.* 4. *Thipse.S.S, "Internal Combustion Engines", Jaico Publication House, 2010.* 5. *Thipse.S.S, "Alternate Fuels", Jaico Publication House., 2010.* 6. *Mathur.M.L, and Sharma.R.P, "A course in Internal Combustion Engines",Dhanpat Rai & Sons, New Delhi, 2010.* 7. *Heywood.J.B, "Internal Combustion Engine Fundamentals", McGraw Hill International, New York, 2008.* 8. *Domkundwar.V.M, "A course inInternal Combustion Engines", Dhanpat Rai & Sons, 2010.*

Learning Assessment

	Bloom's Level of Thinking	Continuous Learning Assessment (50% weightage)								Final Examination (50% weightage)	
		CLA – 1 (10%)		CLA – 2 (15%)		CLA – 3 (15%)		CLA – 4 (10%)#			
		Theory	Practice	Theory	Practice	Theory	Practice	Theory	Practice	Theory	Practice
Level 1	Remember Understand	40 %	-	30 %	-	30 %	-	30 %	-	30%	-
Level 2	Apply Analyze	40 %	-	40 %	-	40 %	-	40 %	-	40%	-
Level 3	Evaluate Create	20 %	-	30 %	-	30 %	-	30 %	-	30%	-
	Total	100 %		100 %		100 %		100 %		100 %	

CLA – 4 can be from any combination of these: Assignments, Seminars, Tech Talks, Mini-Projects, Case-Studies, Self-Study, MOOCs, Certifications, Conf. Paper etc.,

Course Designers		
Experts from Industry	Experts from Higher Technical Institutions	Internal Experts
1. Dr.R.Kalimuthu, ISRO, Mahendragiri, r_kalimuthu@vssc.gov.in	*Dr. K.KarunamurthyAssociate Professor, Department of Mechanical Engineering VIT –Chennai campus*	*Mr. M.Sivashankar Assistant Professor, Department of Mechanical Engineering SRM IST –KTR campus*
2. Dr.A.Velayutham, DRDO, Avadi, velayudham.a@cvrde.drdo.in	*Mr.P.Balaji Manager Product Development HVAC Division Ashok LeylandChennai*	*Dr. M. Cheralathan, SRMIST*

Course Code	18MEE448T	Course Name	SUSTAINABLE ENERGY SYSTEMS	Course Category	E	Professional Elective	L	T	P	C
							3	0	0	3

Pre-requisite Courses	NIL	Co-requisite Courses	NIL	Progressive Courses	NIL
Course Offering Department	Mechanical Engineering	Data Book / Codes/Standards	NIL		

Course Learning Rationale (CLR):	The purpose of learning this course is to:
CLR-1 :	*be familiar with the energy scenario*
CLR-2 :	*be familiar with environmental impactof energy generation*
CLR-3 :	*understand the various energy conservation options and measures*
CLR-4:	*be familiar with the energy policies*
CLR-5:	*be familiarwith the sustainable development and life-cycle analysis*
CLR-6:	*be familiar with energy conservation, policies and sustainability of energy systems.*

Course Learning Outcomes (CLO):	At the end of this course, learners will be able to:	Learning 1: Level of Thinking (Bloom)	2: Expected Proficiency (%)	3: Expected Attainment (%)	PLO 1: Engineering Knowledge	2: Problem Analysis	3: Design & Development	4: Analysis, Design, Research	5: Modern Tool Usage	6: Society & Culture	7: Environment & Sustainability	8: Ethics	9: Individual & Team Work	10: Communication	11: Project Mgt. & Finance	12: Life Long Learning	13: PSO - 1	14: PSO - 2	15: PSO - 3
CLO-1 :	*acquire knowledge on the energy scenario.*	*1&2*	*90*	*80*	*H*						*M*								
CLO-2 :	*acquire knowledge on environmental impactof energy generation*	*1,2&3*	*90*	*80*	*H*			*M*			*H*								
CLO-3 :	*acquire knowledge on basic the energy conservation measures*	*1,2&3*	*90*	*80*	*H*			*M*			*H*					*L*			
CLO-4:	*understand the basic energy policies*	*1*	*90*	*80*	*H*						*H*					*L*			
CLO-5:	*acquire knowledge on basic the sustainable development and life-cycle analysis*	*1*	*90*	*80*	*H*						*H*					*L*			
CLO-6:	*acquire knowledge on energy conservation, policies and sustainability of energy systems.*	*1,2&3*	*90*	*80*	*H*			*M*			*H*								

		Energy scenario	Environmental impact ofenergy generation and utilization	Energy conservation	Sustainable development and Energy policies	Life-cycle assessment and Ecology
Duration (hour)		9	9	9	9	9
S-1	SLO-1	*Basics of sustainability and sustainable energy sources*	*Global warming and acid precipitation,*	*Energy conservation measures*	*Sustainable energy strategies*	*General description of LCA*
S-2	SLO-1	*Introduction to conventional energy resources*	*Analysis of modeling of earth's climate,*	*Improvement Factors of Energy Conservation*	*Key expectations from implementation of green energy strategies and policies*	*LCA methodology*
S-3	SLO-1	*Introduction to non-conventional energy resources*	*Radiation balance of earth planet*	*Energy conservationcase studies*	*Interdependence of the factors affecting sustainable development*	*Energetic life-cycle analysis*
S-4	SLO-1	*World energy scenario – Conventional energy sources.*	*Greenhouse gases and radiative forcing Concept*	*Energy management-understanding energy costs, Bench marking,Energy performance*	*Modeling instruments and case studies*	
S-5	SLO-1	*World energy scenario – Non-Conventional energy sources.*	*Global warming potentials*	*Energy management policies*	*Sustainable assessment of solar energy*	*LCA of solar PV and thermal systems*
S-6	SLO-1	*Indian energy scenario – Conventional energy sources.*	*Anthropogenic effect on climate and its control*	*Energy conversation in thermal systems*	*Sustainable assessment of fossil fuel*	*LCA of hydrogen-fuel cell vehicles*
S-7	SLO-1	*Indian energy scenario – Non-Conventional energy sources.*	*Impact of energy efficiency*	*Energy conversation in electrical systems*	*fossil fuelcombustion*	*LCA of gasoline vehicles*
S-8	SLO-1	*Energy forecasting*	*other environmental impact aspects and cogeneration*	*Introduction to energyaudit*	*Assessment of green energy strategies*	*Case study, comparative LCA of hydrogen-fuel cells vsgasoline vehicles*
S-9	SLO-1	*Energy security*	*Problems in cogeneration*	*Case study in energyaudit*	*Green energy–based sustainability ratio*	*Case study, comparative LCA of conventional and alternative vehicles*

Learning Resources	1. *Dincer, C. Zamfirescu, "Sustainable Energy Systems and Applications", Springer, 2012.* 2. *Frank Kreith, Susan Krumdieck , "Principles of Sustainable Energy Systems", 2nd Edition, Taylor & Francis, 2014.* 3. *Muthu, Subramanian Senthilkannan, "Social Life Cycle Assessment An Insight", Springer, 2015.* 4. *Demirel, Yaşar, "Energy Production, Conversion, Storage, Conservation, and Coupling", Springer, 2016.* 5. *https://beeindia.gov.in/sites/default/files/1Ch1.pdf* 6. *http://www.mospi.nic.in/sites/default/files/publication_reports/Energy_Statistics_2017r.pdf*

Learning Assessment

	Bloom's Level of Thinking	Continuous Learning Assessment (50% weightage)								Final Examination (50% weightage)	
		CLA – 1 (10%)		CLA – 2 (15%)		CLA – 3 (15%)		CLA – 4 (10%)#			
		Theory	Practice	Theory	Practice	Theory	Practice	Theory	Practice	Theory	Practice
Level 1	Remember Understand	40 %	-	30 %	-	30 %	-	30 %	-	30%	-
Level 2	Apply Analyze	40 %	-	40 %	-	40 %	-	40 %	-	40%	-
Level 3	Evaluate Create	20 %	-	30 %	-	30 %	-	30 %	-	30%	-
	Total	100 %		100 %		100 %		100 %		100 %	

CLA – 4 can be from any combination of these: Assignments, Seminars, Tech Talks, Mini-Projects, Case-Studies, Self-Study, MOOCs, Certifications, Conf. Paper etc.,

Course Designers

Experts from Industry	Experts from Higher Technical Institutions	Internal Experts
1. Dr.R.Kalimuthu, ISRO, Mahendragiri,r_kalimuthu@vssc.gov.in	*Dr. R.Velraj, Professor, Institute for Energy Studies,Anna University, Chennai, India - 600025*	*S. Arul Kumar, SRMIST.*
2. Dr.A.Velayutham, DRDO, Avadi, velayudham.a@cvrde.drdo.in	*Dr.Raju Abraham, Scientist –F, National Institute of Ocean Technology Chennai – 600 100*	*Dr.S. Manikandan, SRMIST.*

Course Code	18MEE449T	Course Name	FUEL CELL TECHNOLOGY	Course Category	E	Professional Elective	L	T	P	C
							3	0	0	3

Pre-requisite Courses	Nil	Co-requisite Courses	Nil	Progressive Courses	Nil
Course Offering Department	Mechanical Engineering	Data Book / Codes/Standards	Nil		

Course Learning Rationale (CLR):	The purpose of learning this course is to learn:
CLR-1:	*The basics of fuel cell technology*
CLR-2:	*The concepts of fuel cell electrochemistry*
CLR-3:	*The major types of fuel cells and their modes of operation*
CLR-4:	*The methods of production, storage and utilization of hydrogen as a fuel*
CLR-5:	*The application of fuel cells in power cogeneration*
CLR-6:	*The Safety issues and cost expectation*

Course Learning Outcomes (CLO):	At the end of this course, learners will be able to:	Learning 1: Level of Thinking (Bloom)	Learning 2: Expected Proficiency (%)	Learning 3: Expected Attainment (%)	PLO 1: Engineering Knowledge	PLO 2: Problem Analysis	PLO 3: Design & Development	PLO 4: Analysis, Design, Research	PLO 5: Modern Tool Usage	PLO 6: Society & Culture	PLO 7: Environment & Sustainability	PLO 8: Ethics	PLO 9: Individual & Team Work	PLO 10: Communication	PLO 11: Project Mgt. & Finance	PLO 12: Life Long Learning	PLO 13: PSO - 1	PLO 14: PSO - 2	PLO 15: PSO - 3
CLO-1:	*Understand the basics of fuel cell and fuel cell thermodynamics*	1&2	90	80	H														
CLO-2:	*Understand the fuel cell electrochemistry&Implications and use of fuel cell polarization curve.*	1&2	90	80	H						H								
CLO-3:	*The major types of fuel cells and their modes of operation such as Polymer electrolyte membrane fuel cell,Direct methanol fuel cells,Alkaline fuel cell,Molten Carbonate fuel cell&Solid oxide fuel cell*	1&2	90	80	H						H								
CLO-4:	*The methods of production, storage and utilization of hydrogen as afuel*	1&2	90	80	H														
CLO-5:	*The methods of production, storage and utilization of hydrogen as afuel*	1&2	90	80	H														
CLO-6:	*Understand the Fuel Processor &Safety issues and cost expectation*	1	90	80	H						H								

		Introduction to Fuel Cells And Fuel Cell Thermodynamics	Fuel Cell Electrochemistry	Types Of Fuel Cells	Hydrogen Production, Storage And Utilization	Application Of Fuel Cells In Power Cogeneration
Duration (hour)		9	9	9	9	9
S-1	SLO-1	*Introduction and overview of fuel cell technology: A simple fuel cell, fuel cell advantages and disadvantages*	*Fuel cell reaction kinetics*	*Classification of fuel cells*	*Hydrogen: Its merit as a fuel, Production methods: from fossil fuels, electrolysis, thermal decomposition*	*Fuel cell power plant, Balance of fuel cell power plant.*
S-2	SLO-1	*Basic fuel cell operation, Layout of a Real Fuel Cell: The Hydrogen–Oxygen Fuel Cell with Liquid Electrolyte.*	*Introduction to electrode Kinetics.*	*Polymer electrolyte membrane fuel cell (PEMFC)*	*Production method from photochemical.*	*Fuel cell power plantstructure.*
S-3	SLO-1	*Difference between fuel cell and batteries, fuel choice.*	*Electro Chemical Energy Conversion – Factors affects Electro Chemical Energy Conversion.*	*Direct methanol fuel cells (DMFC)*	*Production method from photocatalytic, hybrid.*	*Cogeneration*
S-4	SLO-1	*Overview of types of fuel cells (with emphasis on PEMFC and DMFC technology)*	*Conversion of chemical energy to electricity in a fuel cell*	*Alkaline fuel cell (PAFC)*	*Hydrogen storage methods: Onboard hydrogen storage.*	*Benefits and Drawbacks of fuel cell power plant.*
S-5	SLO-1	*Fuel cell thermodynamics: Thermodynamics review, Application of first and second law to fuel cells*	*Reaction rate*	*Molten Carbonate fuel cell (MCFC)*	*Chemical storage & physical storage.*	*Fuel cell electric vehicles.*
S-6	SLO-1	*Heat Potential of a fuel: Enthalpy of reaction, Work potential of a fuel: Gibbs free energy*	*Butler -Volmer equation.*	*Solid oxide fuel cell (SOFC)*	*In metal and alloy hydrides.*	*Motor cycles and bicycles, airplanes*
S-7	SLO-1	*Predicting reversible voltage of a fuel cell under nonstandard-stateconditions.*	*Fuel cell charge*	*Comparison of fuel cell,*	*Carbon nanotubes.*	*Fueling stations.*
S-8	SLO-1	*Basic Parameters of Fuel Cells. Fuel cell efficiency.*	*Mass transport.*	*Performance behavior*	*Glass capillary arrays - pipeline storage and hydrogenutilization.*	*Fuel processor and fuel cell stack.*
S-9	SLO-1	*Basic Parameters of Fuel Cells. Fuel cell efficiency., Comparison with Carnot efficiency.*	*Implications and use of fuel cell polarization curve.*	*Proton Exchange Membrane Fuel Cells.*	*Glass capillary arrays - pipeline storage and hydrogenutilization.*	*Safety issues and cost expectation.*

Learning Resources	1. *O'Hayre, R. P., S. Cha, W. Colella, F. B. Prinz, "Fuel Cell Fundamentals", Wiley, NY 2006.*
	2. *Viswanathan. B, AuliceScibioh, M, "Fuel Cells – Principles and Applications", Universities Press (India) Pvt., Ltd., 2009.*
	3. *Bagotsky .V.S, "Fuel Cells",Wiley, 2009.*
	4. *DetlefStolten, "Hydrogen and Fuel Cells: Fundamentals, Technologies and Applications", 2010*
	5. *Larminie .J, Dicks A. "Fuel Cell Systems", 2nd Edition, Wiley, 2003.*
	6. *Barclay .F.J. "Fuel Cells, Engines and Hydrogen", Wiley, 2009.*

Learning Assessment

	Bloom's Level of Thinking	Continuous Learning Assessment (50% weightage)								Final Examination (50% weightage)	
		CLA – 1 (10%)		CLA – 2 (15%)		CLA – 3 (15%)		CLA – 4 (10%)#			
		Theory	Practice	Theory	Practice	Theory	Practice	Theory	Practice	Theory	Practice
Level 1	Remember / Understand	40 %	-	30 %	-	30 %	-	30 %	-	30%	-
Level 2	Apply / Analyze	40 %	-	40 %	-	40 %	-	40 %	-	40%	-
Level 3	Evaluate / Create	20 %	-	30 %	-	30 %	-	30 %	-	30%	-
	Total	100 %		100 %		100 %		100 %		100 %	

CLA – 4 can be from any combination of these: Assignments, Seminars, Tech Talks, Mini-Projects, Case-Studies, Self-Study, MOOCs, Certifications, Conf. Paper etc.,

Course Designers

Experts from Industry	Experts from Higher Technical Institutions	Internal Experts
Babu C Chief Consultant Conserve Consultant private Limited Hyderabad	*Dr,Joseph Daniel, Associate Professor, School of Mechanical and Building Sciences, VIT Chennai*	*Mr. S. Rajendra Kumar, SRMIST*
C. Anand Raj, Head Green Initiative, Infosys Chennai	*Dr. Rayapati Subbarao, Associate Professor, NITTR Kolkata*	*Mr. V. Thirunavukkarasu, SRMIST*

Course Code	18MEE450T	Course Name	MODELING OF THERMAL SYSTEMS	Course Category	E	Professional Elective	L	T	P	C
							3	0	0	3

Pre-requisite Courses	Thermodynamics Fluid Mechanics Heat Transfer	Co-requisite Courses	NIL	Progressive Courses	NIL
Course Offering Department	Mechanical Engineering	Data Book / Codes/Standards	NIL		

Course Learning Rationale (CLR):	The purpose of learning this course is to:
CLR-1 :	*Understand the fundamentals of the thermal system design*
CLR-2 :	*DevelopMathematical models for the thermal systems*
CLR-3 :	*Apply numerical analysis to solve the mathematical models*
CLR-4 :	*Familiarize with different optimization methods*
CLR-5 :	*Apply optimization methods in problem solving of thermal systems*
CLR-6 :	*Evaluate the economic factors involved in design and application of thermal systems*

Course Learning Outcomes (CLO):	At the end of this course, learners will be able to:	Learning 1: Level of Thinking (Bloom)	Learning 2: Expected Proficiency (%)	Learning 3: Expected Attainment (%)	PLO 1: Engineering Knowledge	PLO 2: Problem Analysis	PLO 3: Design & Development	PLO 4: Analysis, Design, Research	PLO 5: Modern Tool Usage	PLO 6: Society & Culture	PLO 7: Environment & Sustainability	PLO 8: Ethics	PLO 9: Individual & Team Work	PLO 10: Communication	PLO 11: Project Mgt. & Finance	PLO 12: Life Long Learning	PLO 13: PSO - 1	PLO 14: PSO - 2	PLO 15: PSO - 3
CLO-1 :	*Understand system design and steps involved in the formulation of the design process*	1& 2	85	75	H	M	M	M							L				
CLO-2 :	*Development of mathematical models from the physical system*	1&2	85	75	H	H	M	H							M				
CLO-3 :	*Solve the mathematical models using numerical analysis*	1&2	85	75	H	H	M	H							M				
CLO-4 :	*Explore optimization methods to provide feasible solutions in the design of thermal systems*	1&2	85	75	H	H	M	H							H				
CLO-5 :	*Evaluate the economic factors in the design and application of thermal systems*	1,2& 3	85	75	H	H	H	H							H				
CLO-6 :	*familiarize with design and analysis of the thermal systems*	12&3	85	75	H	H	M	H							H				

Title of the module		Introduction to Thermal System Design	Mathematical Modeling of Thermal systems	Numerical Analysis of Thermal Systems	Optimization Methods	Economics and Financial Aspects of thermal system
Duration (hour)		9	9	9	9	9
S-1	SLO-1	*Engineering design;Design Versus Analysis, Synthesis for Design*	*Importance of Modeling in Design, Basic Features of Modeling*	*Numerical Model for a System*	*Optimization; basic concepts, optimization methods*	*Calculation of Interest, Simple Interest, Compound Interest, Effective Interest Rate*
S-2	SLO-1	*Need for optimization; Thermal system design*	*Types of Models; Analog Models, Mathematical Models, Physical Models, Numerical Models, Interaction Between Models*	*Modeling of Individual Components*	*Optimization of Thermal Systems, Practical Aspects in Optimal Design*	*Profitability estimate; Cost of return earnings*
S-3	SLO-1	*Basic Characteristics of thermal design; Analysis Types*	*Development of Mathematical Modeling, General Procedure, Final Model and Validation*	*System Simulation, Importance of Simulation Methods for Numerical analysis*	*The Lagrange Multiplier Method, Basic Approach, and Physical Interpretation,*	*Data requirements for calculation of various cash flow techniques*
S-4	SLO-1	*Formulation of the Design Problem, Variables, Constraints and Limitations*	*Physical Modeling, Dimensional Analysis, Modeling and Similitude*	*Simulation: Steady& Lumped Systems*	*Significance of the Multipliers, Optimization of Unconstrained Problems*	*Financial analysis; Discounted & non discounted cash flow techniques*
S-5	SLO-1	*Design Types; Conceptual Design, Innovative Conceptual Design ; Modifications in the Design of Existing Systems*	*Development of a Numerical Model Solution Procedures*	*Dynamic Simulation of Lumped Systems*	*Search Methods, Basic Considerations, Importance of SearchMethods,*	*Pay back period method; Average rate of return (ARR) method*
S-6	SLO-1	*Steps involved in the Design Process*	*Curve Fitting; Exact Fit, Best Fit*	*Distributed systems, simulation of large systems*	*Golden Search method and typical exercise problem*	*Simple problems on pay back and ARR*
S-7	SLO-1	*Problems on Thermal Resistance and Capacitance*	*Problems on exact fit*	*Numerical Simulation Versus Real System,*	*Fibonacci Search method*	*Net present value method (NPV); Profitablity Index method (PI) ; Simple problems*
S-8	SLO-1	*Problems on Building Heating with variable temperatures*	*Problems on best fit*	*Design of Systems for Different Application*	*Problems on Fibonacci Search method*	*Internal rate of return method (IRR) & Benefit cost method (BCR); Simple Problems*
S-9	SLO-1	*Problems on unsteady state heat transfer*	*Problems on nonlinear least squares*	*Problem on numerical modeling of fluid flow systems*	*Steepest Ascent/Descent Method*	*Comparison between NPV and IRR methods*

Learning Resources	1. *Y Jaluria, "Design and optimization of thermal systems", Tata McGraw Hill, 3rd Edition, New Delhi,2007* 2. *W F Stoecker, "Design of thermal systems", Tata McGraw Hill, 3rd Edition, New Delhi, 1989.* 3. *C Balaji, "Essentials of Thermal System Design and Optimization,", Ane Books, New Delhi 2014* 4. *J S Arora, "Introduction to optimum design", ElesiverPublication , 3rd Edition, 2012* 5. *Bender.E.A , "Introduction to Mathematical Modeling", Dover Publication, 2000*

Learning Assessment											
	Bloom's Level of Thinking	Continuous Learning Assessment (50% weightage)								Final Examination (50% weightage)	
		CLA – 1 (10%)		CLA – 2 (15%)		CLA – 3 (15%)		CLA – 4 (10%)#			
		Theory	Practice	Theory	Practice	Theory	Practice	Theory	Practice	Theory	Practice
Level 1	Remember Understand	40 %	-	30 %	-	30 %	-	30 %	-	30%	-
Level 2	Apply Analyze	40 %	-	40 %	-	40 %	-	40 %	-	40%	-
Level 3	Evaluate Create	20 %	-	30 %	-	30 %	-	30 %	-	30%	-
	Total	100 %		100 %		100 %		100 %		100 %	

CLA – 4 can be from any combination of these: Assignments, Seminars, Tech Talks, Mini-Projects, Case-Studies, Self-Study, MOOCs, Certifications, Conf. Paper etc.,

Course Designers		
Experts from Industry	Experts from Higher Technical Institutions	Internal Expert
R. Mohan Prabhu Senior Engineer, Compression GEA Group, Pune, India	*Dr. VenkataRamanan Professor, Institute of Energy Studies Anna University, Guindy Campus, Chennai – 600025*	*Dr. S. Shashi Kumar, SRMIST*
Joseph ShekharSanthappan Faculty Mechanical Section, Engg. Dept. Shinas College of Technology, Al-Agur, Shinas, Sultanate of Oman.	*Dr. R. Chandrasekhar Research Scientist Dept. of Electrical and Computer Engineering, Colorado State University Fort Collins, Colorando Area, USA*	*Dr. M. Cheralathan, SRMIST*

Course Code	18MEE701J	Course Name	SENSORS AND ACTUATORS FOR AUTOMATION	Course Category	E	Professional Elective	L	T	P	C
							2	0	2	3

Pre-requisite Course	Nil	Co-requisite Course	Nil	Progressive Courses	Nil
Course Offering Department	Mechanical Engineering	Data Book/Codes/Standards	Nil		

Course Learning Rationale (CLR):	*The purpose of learning this course is to:*
CLR-1 :	*Expose the basics of various sensors used in automation*
CLR-2 :	*Impart the fundamental concept of electro-mechanical and fluid power systems*
CLR-3 :	*Provide exposure on practical knowledge of sensors and its measurements*
CLR-4 :	*Impart knowledge in mechanical, magnetic and electromechanical sensors*
CLR-5 :	*Provide the knowledge on the working principle of hydraulic, pneumatic, mechanical and electrical actuators*
CLR-6 :	*Impart the fundamental concept of drives and control system*

		Learning			Program Learning Outcomes (PLO)														
		1	2	3	1	2	3	4	5	6	7	8	9	10	11	12	13	14	15
Course Learning Outcomes (CLO):	*At the end of this course, learners will be able to:*	Level of Thinking (Bloom)	Expected Proficiency (%)	Expected Attainment (%)	Engineering Knowledge	Problem Analysis	Design & Development	Analysis, Design, Research	Modern Tool Usage	Society & Culture	Environment & Sustainability	Ethics	Individual & Team Work	Communication	Project Mgt. & Finance	Life Long Learning	PSO - 1	PSO - 2	PSO - 3
CLO-1 :	*Understand the different types of sensors used in automation*	*1*	*85*	*80*	*H*	*-*	*M*	*-*	*H*	*-*	*-*	*-*	*-*	*-*	*-*	*-*	*L*	*-*	*L*
CLO-2 :	*Identify suitable sensor for the developments of automation processes*	*2*	*90*	*85*	*H*	*M*	*L*	*L*	*H*	*-*	*-*	*-*	*-*	*-*	*-*	*-*	*M*	*-*	*M*
CLO-3 :	*Develop the automation system by integration of electromechanical sensors and fluid power systems*	*3*	*90*	*80*	*H*	*H*	*H*	*M*	*H*	*-*	*-*	*-*	*-*	*-*	*-*	*M*	*H*	*-*	*H*
CLO-4 :	*Identify the type of actuators and its associated drivers for different application*	*2*	*85*	*80*	*H*	*M*	*-*	*-*	*H*	*-*	*-*	*-*	*-*	*-*	*-*	*M*	*M*	*-*	*M*
CLO-5 :	*Demonstrate effective use of actuators, its elements for the generation, control and conversion of energy for the typical automation system*	*2*	*90*	*80*	*H*	*-*	*-*	*-*	*H*	*-*	*-*	*-*	*-*	*-*	*-*	*M*	*L*	*-*	*L*
CLO-6 :	*Build real time automation system within realistic constraints such as industrial, economic, environmental, ethical, social, health and safety*	*3*	*95*	*85*	*H*	*M*	*M*	*M*	*H*	*M*	*M*	*L*	*L*	*-*	*-*	*M*	*H*	*-*	*H*

Duration (hour)		12	12	12	12	12
S-1	SLO-1	*Role of sensors in manufacturing: Importance of estimation in sensing*	*Resistive sensors: Potentiometer*	*Fiber optic sensors – Temperature sensors*	*Pneumatic systems – Types, components*	*Mechanical systems – Types of motion*
	SLO-2	*Role of sensors in manufacturing: Innovative sensor technologies*	*Resistive sensors: Strain gauge*	*Fiber optic sensors – Liquid level sensing*	*Pneumatic systems – working principle*	*kinematics chains*
S-2	SLO-1	*Physical transduction principles: Mechanical, Thermal*	*Inductive sensors: Methods of achieving inductance*	*Fluid flow level sensing*	*Hydraulic systems – Types, components*	*Cams, gears, ratchet and pawl*
	SLO-2	*Physical transduction principles: Electrical, Magnetic*	*Ferromagnetic plunger type, Transformer type*	*Micro bend sensing*	*Hydraulic systems – working principle*	*belt and chain drives*
S-3	SLO-1	*Classification of sensors: property based*	*Capacitive sensors: parallel plate capacitive sensor*	*Film sensors – Thick film sensors*	*Directional control of valves*	*Electrical systems – mechanical switches*
	SLO-2	*Classification of sensors: applications based*	*Serrated plate capacitive sensor*	*Thin film sensors*	*Valve symbols*	*solid state switches*
S-4	SLO-1	*Characterization: Electrical*	*Force/stress sensors using Quartz Resonators*	*Nano sensors - Introduction*	*Pressure control valves*	*Solenoids*
	SLO-2	*Characterization: Mechanical*	*Various beam designs*	*Nano structure, operation mechanism*	*Cylinders*	*DC motors*
S-5	SLO-1	*Characterization: Thermal, Optical*	*Ultrasonic sensors: introduction*	*Smart sensors –Introduction, properties*	*Rotary Actuators (Hydraulic type) components*	*Stepper motors – introduction, specifications*
	SLO-2	*Characterization: Biological and Chemical*	*Principles, Materials, Applications*	*Smart sensors – primary sensors, Compensation*	*Working principle*	*Stepper motors – types*
S-6	SLO-1	*Static characteristics of sensors*	*Magnetic sensors: Types*	*Functional integration of sensors*	*Rotary Actuators (Pneumatic type) components*	*Stepper motor – control*
	SLO-2	*Dynamic characteristics of sensors*	*Magnetic sensors: working principles*	*Smart sensors – information coding/processing*	*Working principle*	*Stepper motor - characteristics*
S 7-8	SLO-1 SLO-2	*Lab 1: Measurement of speed and displacement using linear and rotary sensors*	*Lab 4: Temperature measurement using RTD and thermocouple*	*Lab 7: Study on eddy current sensor for thickness measurement*	*Lab 10: Simulation of single and double acting cylinder circuits using different directional control valves*	*Lab 13: Speed and torque characterization and sequence control of stepper motor*

S 9-10	SLO-1	*Lab 2: Force and Torque measurement using strain gauge*	*Lab 5: Experimentation on voltage, current, power, and frequency measurement*	*Lab 8: Study on ultrasonic sensors for material fault diagnosis*	*Lab 11: Sequencing of pneumatic circuits*	*Lab 14: Closed loop position and velocity control of a DC servo motor*
	SLO-2					
S 11-12	SLO-1	*Lab 3: Pressure measurement system using sensors*	*Lab 6: Experimentation with tactile sensor for force and touch detection*	*Lab 9: Simulation of hydraulic circuits in a hydraulic trainer*	*Lab 12: Simulation of logic and electro-pneumatic circuits*	*Lab 15: Speed and torque characterization and control of DC motors*
	SLO-2					

Learning Resources	1. *Patranabis D., "Sensor and Actuators", Prentice Hall of India (Pvt) Ltd., 2013.* 2. *Bolton W., "Mechatronics", Fourth edition, Pearson publishers, 2010.* 3. *Andrzej M. Pawlak., "Sensors and Actuators in Mechatronics – Design and Applications", CRC press, Taylor and Francis group, 2007.*	4. *Clarence W de Silva, "Sensors and Actuators – Engineering system instrumentation", second edition, CRC press, Taylor and Francis group, 2016.* 5. *Ian R. Sinclair, "Sensors and Transducers", third edition, Newnes, 2001.* 6. *R.K.Rajput, "A text book of Mechatronics", S.Chand & Company Limited, Second edition, 2009.*

Learning Assessment

	Bloom's Level of Thinking	Continuous Learning Assessment (50% Weightage)								Final Examination (50% Weightage)	
		CLA – 1 (10%)		CLA – 2 (15%)		CLA – 3 (15%)		CLA – 4 (10%)			
		Theory	Practice	Theory	Practice	Theory	Practice	Theory	Practice	Theory	Practice
Level 1	Remember Understand	20%	20%	15%	15%	15%	15%	15%	15%	15%	15%
Level 2	Apply Analyze	20%	20%	20%	20%	20%	20%	20%	20%	20%	20%
Level 3	Evaluate Create	10%	10%	15%	15%	15%	15%	15%	15%	15%	15%
	Total	100%		100%		100%		100%		100%	

CLA – 4 can be from any combination of these: Assignments, Seminars, Tech Talks, Mini-Projects, Case-Studies, Self-Study, MOOCs, Certifications, Conf. Paper etc.,

Course Designers

Experts from Industry	Experts from Higher Technical Institutions	Internal Experts
1. Mr. P.Kartikeyan, Head – Operations Improvement, Nokia India, kartikeyan.p@nokia.com	*1. Dr.K.Senthilkumaran, Assistant professor, IIITDM, Kancheepuram. skumaran@iiitdm.ac.in*	*1. P.Haja Syeddu Masooth, SRM IST*
2. Dr. R. Kalimuthu, ISRO, Mahendragiri, r_kalimuthu@vssc.gov.in	*2. Dr.B.Mohan, Professor, Anna University, mohan@mitindia.edu*	*2. Dr.R.Rajaraman, SRM IST*
3. Dr. A. Velayutham, DRDO, Avadi, velayutham.a@cvrde.drdo.in		

Course Code	18MEE702J	Course Name	MICROPROCESSOR AND MICROCONTROLLERS	Course Category	E	Professional Elective	L	T	P	C
							2	0	2	3

Pre-requisite Course	Nil	Co-requisite Course	Nil	Progressive Courses	Nil
Course Offering Department	Mechanical Engineering	Data Book/Codes/Standards	Nil		

Course Learning Rationale (CLR):	*The purpose of learning this course is to:*
CLR-1 :	*Expose the basics of microprocessors*
CLR-2 :	*Introduce the need and use of Interrupt structure*
CLR-3 :	*Impart the applications of microprocessor*
CLR-4 :	*Enable to understand the architecture of microcontroller*
CLR-5 :	*Expose the instruction set and register set of microcontroller*
CLR-6 :	*Impart knowledge about different peripheral interfacing devices*

Course Learning Outcomes (CLO):	*At the end of this course, learners will be able to:*	Learning 1: Level of Thinking (Bloom)	2: Expected Proficiency (%)	3: Expected Attainment (%)	PLO 1: Engineering Knowledge	2: Problem Analysis	3: Design & Development	4: Analysis, Design, Research	5: Modern Tool Usage	6: Society & Culture	7: Environment & Sustainability	8: Ethics	9: Individual & Team Work	10: Communication	11: Project Mgt. & Finance	12: Life Long Learning	13: PSO - 1	14: PSO - 2	15: PSO - 3
CLO-1 :	*Understand the basics of microprocessors*	1	95	90	H	L	M	L	H	-	-	-	-	-	-	-	M	-	M
CLO-2 :	*Use the processors for various applications*	3	90	85	H	L	L	M	M	-	-	-	L	-	-	L	M	-	H
CLO-3 :	*Develop the assembly language programs*	1	85	80	H	L	L	L	M	-	-	-	M	-	-	L	M	-	L
CLO-4 :	*Understand the interfacing techniques*	3	80	75	H	L	L	M	H	-	-	-	M	-	-	L	M	-	M
CLO-5 :	*Understand the internal architecture of microcontroller*	2	80	75	H	L	L	M	M	-	-	-	M	-	-	L	M	-	L
CLO-6 :	*Use microcontroller with different peripherals*	3	90	85	H	L	M	M	H	-	-	-	H	-	-	L	H	-	M

Duration (hour)		12	12	12	12	12
S-1	SLO-1	*Introduction to 8086 microprocessor-Internal Architecture*	*Peripherals and Interfacing-Interfacing I/O Ports*	*Application of Microprocessor-Microprocessor based Aluminium Smelter Control, Process Description*	*Introduction to 8051 Microcontroller-Microcontroller Block Diagram*	*Microcontroller Interfacing and Applications- System Design - Traffic Light Control*
	SLO-2	*Physical Memory Organization*	*Interfacing I/O Ports*		*Microcontroller Block Diagram*	*Switching Circuit*
S-2	SLO-1	*Addressing Modes*	*8086 Interrupts*	*Microprocessor based Aluminium Smelter Control, Process Description*	*Instruction Set*	*8051 Hardware Interface - Operation Sequence*
	SLO-2		*Interrupt Responses*			
S-3	SLO-1	*Instruction Set*	*Direct Memory Access (DMA)*	*Lab 7: Program to perform following conversion : BCD to ASCII BCD to hexadecimal*	*Register Set*	*System Design - Washing Machine Control*
	SLO-2		*I/O Mode*			*Washing Cycle*
S-4	SLO-1	*Lab1: Basic arithmetic operations*	*Lab 4: Sorting of array in: Ascending order*		*Lab 10: A/D and D/A converter interface*	*Lab 13: Fabrication of 8-bit LED interfaces for 8085 kit through 8155 and 8255*
	SLO-2					
S-5	SLO-1		*Lab 4: Sorting of array in: Descending order*	*Design of Microprocessor based Pattern Scanner System BCD to hexadecimal*		
	SLO-2					
S-6	SLO-1	*I/O Addressing Capability*	*Interfacing Analog to Digital Data Converters*	*Design of Microprocessor based Pattern Scanner System BCD to hexadecimal*	*Memory*	*LCD Interfacing*
	SLO-2				*I/O Addressing*	*Keyboard Interfacing*
S-7	SLO-1	*General Bus Operation*	*Interfacing Digital to Analog Converters*	*Lab 8: Program to demonstrate decision making and looping operation*	*Interrupts*	*Relays and opt Isolators*
	SLO-2					*Stepper Motor Interfacing*
S-8	SLO-1	*Lab2: Basic Logical operations*	*Lab 5: Program to demonstrate string manipulations*		*Lab 11: Key board and Display*	*Lab 14: Interfacing and programming of 8255. (E.g. traffic light controller)*
	SLO-2					
S-9	SLO-1			*Design of an Electronic Weighing Bridge*		
	SLO-2					

S-10	SLO-1	*Assembler Directives*	*Stepper Motor Interfacing*	*Design of an Electronic Weighing Bridge*	*Design of Microcontroller based Length Measurement System for Continuously Rolling Paper*	*DC motor Interfacing*
	SLO-2	*Operators*				*PWM*
S-11	SLO-1	*Lab 3: Transfer of block to another location in reverse order*	*Lab 6: Program to demonstrate Factorial of given numbers*	*Lab 9: Program to demonstrate parameter passing methods*	*Lab 12: Stepper motor interface*	*Lab 15: Interfacing DC motor and Servo motor*
	SLO-2					
S-12	SLO-1					
	SLO-2					

Learning Resources	*1. A K Ray and K M Bhurchandi, "Advanced Microprocessor and Peripherals", McGraw Hill Education private Limited , 2011.* *2. Krishna Kant, "Microprocessors and Microcontrollers", Eastern Economy Edition, PHI learning private ltd, 2012.* *3. Douglas V Hall and SSSP Rao, "Microprocessors and Interfacing", Pearson Education, 2012.*	*4. Muhammad Ali Mazidi, Janice Gillispie Mazidi, Rolin D.Mckinlay, "The 8051 Microcontroller and Embedded Systems", McGraw Hill Education private Limited, 2008.* *5. Ramesh S. Gaonkar, Microprocessor Architecture. Programming and Applications with the 8085, 5th ed., Penram International Publishing (India) Private Limited. 2005*

Learning Assessment											
	Bloom's Level of Thinking	Continious Learning Assessment (50% Weightage)								Final Examination (50% Weightage)	
		CLA – 1 (10%)		CLA – 2 (15%)		CLA – 3 (15%)		CLA – 4 (10%)			
		Theory	Practice	Theory	Practice	Theory	Practice	Theory	Practice	Theory	Practice
Level 1	Remember Understand	20%	20%	15%	15%	15%	15%	15%	15%	15%	15%
Level 2	Apply Analyze	20%	20%	20%	20%	20%	20%	20%	20%	20%	20%
Level 3	Evaluate Create	10%	10%	15%	15%	15%	15%	15%	15%	15%	15%
	Total	100%		100%		100%		100%		100%	

Course Designers		
Experts from Industry	Experts from Higher Technical Institutions	Internal Experts
1. Mr. P.Kartikeyan, Head – Operations Improvement, Nokia India, kartikeyan.p@nokia.com	1. Dr.K.Senthilkumaran, Assistant professor, IIITDM, Kancheepuram. skumaran@iiitdm.ac.in	1. Eastus Russel, SRMIST
2. Dr. R. Kalimuthu, ISRO, Mahendragiri, r_kalimuthu@vssc.gov.in	2. Dr.B.Mohan, Professor, Anna University, mohan@mitindia.edu	2. Dr.R.Rajaraman, SRMIST
3. Dr. A. Velayutham, DRDO, Avadi, velayutham.a@cvrde.drdo.in		

Course Code	18MEE703T	Course Name	INDUSTRIAL ROBOTICS AND AUTOMATION	Course Category	E	Professional Elective	L	T	P	C
							3	0	0	3

Pre-requisite Course	Nil	Co-requisite Course	Nil	Progressive Courses	Nil
Course Offering Department	Mechanical Engineering	Data Book/Codes/Standards	Nil		

Course Learning Rationale (CLR):	*The purpose of learning this course is to:*
CLR-1 :	*Introduce the basics of robotic technology and its applications*
CLR-2 :	*Impart knowledge on robot motion analysis and control*
CLR-3 :	*Explore the application of robot in manufacturing and assembly*
CLR-4 :	*Impart knowledge on automation and control technologies in manufacturing*
CLR-5 :	*Introduce the concept of automated material transport systems*
CLR-6 :	*Impart knowledge on fundamentals and applications of automated production lines*

Course Learning Outcomes (CLO):	*At the end of this course, learners will be able to:*	Learning 1: Level of Thinking (Bloom)	2: Expected Proficiency (%)	3: Expected Attainment (%)	PLO 1: Engineering Knowledge	2: Problem Analysis	3: Design & Development	4: Analysis, Design, Research	5: Modern Tool Usage	6: Society & Culture	7: Environment & Sustainability	8: Ethics	9: Individual & Team Work	10: Communication	11: Project Mgt. & Finance	12: Life Long Learning	13: PSO - 1	14: PSO - 2	15: PSO - 3
CLO-1 :	*Understand the basics of robot anatomy, control and sensing system*	*1*	*90*	*85*	*M*	*L*	*L*	*L*	*M*	-	*L*	-	*M*	*L*	*L*	-	*H*	-	*H*
CLO-2 :	*Gain knowledge on robot manipulator kinematics, path control and dynamics*	*2*	*90*	*85*	*H*	*M*	*L*	*M*	*M*	-	*M*	-	*L*	*M*	*L*	-	*H*	-	*L*
CLO-3 :	*Understand the application of robot in manufacturing and assembly*	*2*	*90*	*85*	*M*	*M*	*M*	*L*	*M*	*L*	*M*	-	*M*	*H*	*L*	-	*H*	-	*M*
CLO-4 :	*Gain knowledge on various elements of automations in manufacturing*	*2*	*90*	*85*	*L*	*M*	*L*	*M*	*H*	-	*L*	-	*L*	*L*	*M*	-	*H*	-	*H*
CLO-5 :	*Understand the concept of automated guided vehicle system for shop floor application*	*2*	*90*	*85*	*M*	*L*	*L*	*M*	*H*	-	*L*	-	*L*	*L*	*M*	-	*H*	-	*M*
CLO-6 :	*Gain knowledge on automated storage and retrieval system and automated assembly system*	*2*	*90*	*85*	*M*	*M*	*L*	*M*	*M*	-	*L*	-	*M*	*H*	*M*	-	*H*	-	*H*

Duration (hour)		9	9	9	9	9
S-1	SLO-1	*Introduction to Robotics*	*Introduction to manipulator kinematics – position representation*	*Robot Applications in Manufacturing:*	*Automation in production systems*	*Automated material transport systems, storage system and assembly system : Introduction*
	SLO-2	*History of Robots*	*forward and reverse transformation of the 2 degree of freedom arm*	*General consideration in Robot Material Handling*	*Automated manufacturing system*	*Automated Guided Vehicle system*
S-2	SLO-1	*Robot Anatomy*	*3 degree of freedom arm in two dimensions*	*Material Transfer Application – pick and place operations*	*Computerized manufacturing and support systems*	*AGV types*
	SLO-2	*Components*	*4 degree of freedom manipulator in three dimensions*	*Palletizing and related operations*	*Reasons for automating*	*Applications*
S-3	SLO-1	*Work Volume*	*Homogeneous transformations and Robot kinematics, parallel kinematics*	*Machine Loading and unloading*	*Automation principles and strategies – The USA principle*	*Vehicle Guidance*
	SLO-2	*Polar, cylindrical and cartesian*	*Kinematic equations using Homogeneous transformations*	*Die casting, plastic moulding*	*Strategies for Automation and process improvement*	*Routing*
S-4	SLO-1	*Robot drive systems*	*Solving the kinematic equations*	*Forging and related operations*	*Automation Migration strategy*	*Traffic Control*
	SLO-2	*Hydraulic drive*	*Examples*	*Machining operations, Stamping press operations*	*Manual, automated and automated integrated production*	*Safety*

S-5	SLO-1	*Electric drive*	*A discussion on orientation*	*Robots used in Spot welding*	*Basic elements of an Automated System*	*System Management*
	SLO-2	*Pneumatic drive*	*Roll, pitch and yaw for a manipulator wrist mechanism*	*Application and benefits*	*Power to accomplish the Automated Process*	*Autonomous intelligent vehicle*
S-6	SLO-1	*Control systems*	*Manipulator path control – motion types*	*Robots used in Continuous Arc welding*	*Program of instructions*	*Automated storage Systems*
	SLO-2	*Dynamic performance*	*joint space schemes*	*Problems for Robots in Arc welding, applications, features of the welding robot, sensors, advantage and benefits*	*Control system*	*Retrieval Systems*
S-7	SLO-1	*Precision of Movement, Spatial resolution*	*Robot dynamics analysis,*	*Robots used in Spray Coating, and additive manufacturing*	*Advanced automation functions –*	*Carousel Storage Systems.*
	SLO-2	*Accuracy, Repeatability*	*Static analysis,*	*Application and benefits*	*Safety monitoring,*	
S-8	SLO-1	*End Effectors – grippers*	*Compensating for gravity,*	*Other Processing operation using Robots*	*Maintenance and repair diagnostics,*	*Automated assembly system –*
	SLO-2	*tools*	*Robot arm dynamics*	*Drilling, Grinding, Riveting*	*Error detection and recovery*	*system configuration,*
S-9	SLO-1	*Robotic sensors*	*Configuration of a Robot controller*	*Assembly system configurations - Single work station assembly,*	*Levels of automation*	*parts delivery at work stations,*
	SLO-2	*Types of sensors*	*General robot controller elements*	*series assembly system, parallel assembly system*	*Device, machine, cell or system, plant, enterprise levels.*	*applications.*

Learning Resources	1. *"Industrial Robotics Technology, Programmming, and Applications" - Mikell P Groover, Mitchell Weiss, Rogen N Nagel, Nicholas G Odrey, AshishDutta, Tata McGraw Hill Special Indian Edition, 2012.* 2. *"Computer Aided Design and Manufacturing" - K.Lalit Narayan, K.MallikarjunaRao, Prentice Hall of India, 2008.* 3. *"Automation, Production systems, and Computer intergrated Manufacturing"- Mikell P. Groover, Prentice Hall of India, 2008.*	4. *"Industrial Robotics Technology, Programming, and Applications"- Mikell P Groover, Mitchell Weiss, Roger N Nagel 2008* 5. *"Robotics Technology & Flexible Automation" - S.R.Deb, S.Deb 2012* 6. *"Introduction to Robotics in CIM system" - James A Rehg 2002*

Learning Assessment											
	Bloom's Level of Thinking	Continious Learning Assessment (50% Weightage)								Final Examination (50% Weightage)	
		CLA – 1 (10%)		CLA – 2 (15%)		CLA – 3 (15%)		CLA – 4 (10%)			
		Theory	Practice	Theory	Practice	Theory	Practice	Theory	Practice	Theory	Practice
Level 1	Remember Understand	40%	-	30%	-	30%	-	30%	-	30%	-
Level 2	Apply Analyze	40%	-	40%	-	40%	-	40%	-	40%	-
Level 3	Evaluate Create	20%	-	30%	-	30%	-	30%	-	30%	-
	Total	100%		100%		100%		100%		100%	

Course Designers		
Experts from Industry	Experts from Higher Technical Institutions	Internal Experts
1. Mr. P.Kartikeyan, Head – Operations Improvement, Nokia India, kartikeyan.p@nokia.com	*1. Dr.K.Senthilkumaran, Assistant professor, IIITDM, Kancheepuram. skumaran@iiitdm.ac.in*	*1. E. Sankar, SRMIST*
2. Dr. R. Kalimuthu, ISRO, Mahendragiri, r_kalimuthu@vssc.gov.in	*2. Dr.B.Mohan, Professor, Anna University, mohan@mitindia.edu*	*2. Dr.R.Rajaraman, SRMIST*
3. Dr. A. Velayutham, DRDO, Avadi, velayutham.a@cvrde.drdo.in		

Course Code	18MEE704T	Course Name	PLC AND ITS APPLICATIONS	Course Category	E	Professional Elective	L	T	P	C
							3	0	0	3

Pre-requisite Course	Nil	Co-requisite Course	Nil	Progressive Courses	Nil
Course Offering Department	Mechanical Engineering	Data Book/Codes/Standards	Nil		

Course Learning Rationale (CLR):	*The purpose of learning this course is to:*
CLR-1 :	*Impart PLC principle to reduce the human efforts by means of automation*
CLR-2 :	*Identify the main parts of PLC and hardware components*
CLR-3 :	*Analyze and interpret typical PLC timer ladder logic programs*
CLR-4 :	*Acquire knowledge on HMI remote control monitoring in industrial automation*
CLR-5 :	*Learn PLC process – control design and PID configuration*
CLR-6 :	*Design PLC control system I/O and its applications*

Course Learning Outcomes (CLO):	*At the end of this course, learners will be able to:*	Learning 1: Level of Thinking (Bloom)	2: Expected Proficiency (%)	3: Expected Attainment (%)	PLO 1: Engineering Knowledge	2: Problem Analysis	3: Design & Development	4: Analysis, Design, Research	5: Modern Tool Usage	6: Society & Culture	7: Environment & Sustainability	8: Ethics	9: Individual & Team Work	10: Communication	11: Project Mgt. & Finance	12: Life Long Learning	13: PSO - 1	14: PSO - 2	15: PSO - 3
CLO-1 :	*Utilize the parts of machine controller diagram including rungs, branches of PLC*	2	85	80	M	-	-	-	M	-	-	-	-	-	-	-	L	-	L
CLO-2 :	*Understand the equipment used to program a PLC and mnemonic code*	2	90	85	M	-	-	-	-	-	-	-	-	-	-	-	M	-	L
CLO-3 :	*Gain knowledge on hardwired and Human Machine Interface communicate with PLC*	2	85	80	H	-	M-	M	-	-	-	-	-	-	-	-	L	-	M
CLO-4 :	*Learn the functions of PLC process – control design and elements*	2	85	80	H	-	-	-	-	-	-	-	-	-	-	-	L	-	L
CLO-5 :	*Understand basic knowledge of PLCs concepts and its application in industries*	3	90	85	H	-	M	M	-	-	-	-	-	-	-	-	M	-	H
CLO-6 :	*Develop complete system of PLC to meet industrial tasks*	2	85	80	H	M	H	H	M	-	-	-	M	-	M	-	H	-	H

Duration (hour)		9	9	9	9	9
S-1	SLO-1	*Introduction*	*Control system classifications*	*Advanced program techniques-Introduction*	*Introduction: level of lontrol & automation*	*Case studies of manufacturing and process automation*
	SLO-2	*History of the PLC*	*Manual and auto control system*	*Physical components vs program components*	*Components of control system*	*PLC interface to a robot*
S-2	SLO-1	*Principles of operation*	*Automated system building block*	*RS Flip Flop, one shot,*	*Control elements of industrial automation*	*Case studies of on - off control*
	SLO-2	*Benefits of PLC*	*Requirements for industrial control*	*D Flip Flop, T Flip Flop*	*Examples of control requirements*	*Automatic control in manufacturing*
S-3	SLO-1	*Various parts of PLC*	*Motor magnetic starter*	*Forms of counters*	*Selection criteria for control elements*	*Water tank level control*
	SLO-2	*Hardwired system replacement*	*Process control choices*	*Counter application*	*Standardization*	*Irrigation - Canal water level control & logic diagram*
S-4	SLO-1	*Functions of PLC*	*Components of modularized PLC*	*Sequencers*	*Signal conversion*	*Filling of bottle - Case study*
	SLO-2	*Need for PLCs and its advantages*	*PLC configuration*	*Sequential functional chart*	*Quantification errors and resolution*	
S-5	SLO-1	*Inputs & Outputs of PLC*	*Introduction to human machine interface*	*NAND logic function*	*Process control system*	*Conveyor System Speed Control - Case Study*
	SLO-2	*Common types of mechanical design for PLCs*	*Device and PLC / HMI configuration*	*NOR logic function*	*Control Strategy and types*	
S-6	SLO-1	*PLC Architecture and Wiring Diagrams*	*Fundamentals of human machine interfacing*	*AND ladder Rung*	*PLC Selection factors*	*Coal Handling System- Case Study*
	SLO-2	*Internal structure Architecture of PLC*	*HMI-PLC application*	*OR ladder Rung*	*PLC Families*	
S-7	SLO-1	*Basic components and their symbols of Ladder diagram*	*Network standards*	*Types of timer*	*Feedback control of continuous systems*	*Multi-Unit Chemical Process- Case Study*

	SLO-2	*Functions & function blocks of Ladder diagram*	*Network systems role in industry*	*On/off cyclic timer*	*PLC systems and safety*	
S-8	SLO-1	*Switches& Its types*	*Number systems*	*Simple and complex branches*	*PID control configuration*	*Commissioning of PLC systems*
	SLO-2	*Relay systems*	*PLC data*	*standard format program*	*PID control systems*	*Fault Finding Techniques*
S-9	SLO-1	*PLC size and Applications*	*PLC in automation technology*	*Logical Actuators: solenoid, valves cylinders*	*Design cases: Oven temperature control, supervisory control and data acquisition*	*Power Plant Monitoring and Control*
	SLO-2	*PLCs versus other technologies*	*Examples of commercial systems involving PLC*	*Logical Actuators: hydraulics and pneumatics*	*Position measurement*	*Other Applications of PLC*

Learning Resources	1. *Khaled Kamel, Eman Kamel, "Programmable Logic Controllers, Industrial C", Mc Graw Hill private Ltd, 2014.* 2. *Gar Dunning, "Programmable Logic Controllers, Industrial Control", Mc Graw Hill private Ltd, 2009.* 3. *John R. Hackworth, Federick D. Hackworth , Jr., "Programmable Logic Controllers : Programming Methods and Applications" Prentice Hall Publishing, 2003* 4. *W. Bolton, "Programmable Logic Controllers", Newnes Education private Limited, 2009.* 5. *Frank D, Petruzella, "Programmable Logic Controllers", Mc Graw Hill private Ltd, 2011.* 6. *Hugh Jack, "Automating Manufacturing Systems with PLCs" Mc Graw Hill private Ltd 2007.*	7. *Kelvin T. Erickson, "Programmable Logic Controllers: An Emphasis on Design and Application" Mc Graw Hill private Ltd 2007.* 8. *R. Bliesener, F. Ebel, C. Loffler, "Programmable Logic Controllers", Festo Dicactic, Ltd, 2002.* 9. *Kevin Collins, "PLC Programming for Industrial Automation", Newnes Education private Limited, 2009.*

Learning Assessment

	Bloom's Level of Thinking	Continious Learning Assessment (50% Weightage)								Final Examination (50% Weightage)	
		CLA – 1 (10%)		CLA – 2 (15%)		CLA – 3 (15%)		CLA – 4 (10%)			
		Theory	Practice	Theory	Practice	Theory	Practice	Theory	Practice	Theory	Practice
Level 1	Remember Understand	40%	-	30%	-	30%	-	30%	-	30%	-
Level 2	Apply Analyze	40%	-	40%	-	40%	-	40%	-	40%	-
Level 3	Evaluate Create	20%	-	30%	-	30%	-	30%	-	30%	-
	Total	100%		100%		100%		100%		100%	

Course Designers

Experts from Industry	Experts from Higher Technical Institutions	Internal Experts
1. Mr. P.Kartikeyan, Head – Operations Improvement, Nokia India, kartikeyan.p@nokia.com	*1. Dr.K.Senthilkumaran, Assistant professor, IIITDM, Kancheepuram. skumaran@iiitdm.ac.in*	*1. A. Arunnath, SRMIST*
2. Dr. R. Kalimuthu, ISRO, Mahendragiri, r_kalimuthu@vssc.gov.in	*2. Dr.B.Mohan, Professor, Anna University, mohan@mitindia.edu*	*2. Dr.R.Rajaraman, SRMIST*
3. Dr. A. Velayutham, DRDO, Avadi, velayutham.a@cvrde.drdo.in		

Course Code	18MEE705T	Course Name	FLEXIBLE MANUFACTURING SYSTEM	Course Category	E	Professional Elective	L	T	P	C
							3	0	0	3

Pre-requisite Course	Nil	Co-requisite Course	Nil	Progressive Courses	Nil
Course Offering Department	Mechanical Engineering	Data Book/Codes/Standards	Nil		

Course Learning Rationale (CLR):	*The purpose of learning this course is to:*
CLR-1 :	*Introduce the concepts that can be flexible to the modern competitive environment.*
CLR-2 :	*To impart knowledge of Group Technology*
CLR-3 :	*To impart knowledge about flexible manufacturing systems and its concepts*
CLR-4 :	*Introduce the concepts of manufacturing cell and its systems*
CLR-5 :	*Introduce the concepts JIT and KANBAN system*
CLR-6 :	*To impart knowledge about FMS software structure and description*

Course Learning Outcomes (CLO):	*At the end of this course, learners will be able to:*	Learning 1: Level of Thinking (Bloom)	Learning 2: Expected Proficiency (%)	Learning 3: Expected Attainment (%)	PLO 1: Engineering Knowledge	PLO 2: Problem Analysis	PLO 3: Design & Development	PLO 4: Analysis, Design, Research	PLO 5: Modern Tool Usage	PLO 6: Society & Culture	PLO 7: Environment & Sustainability	PLO 8: Ethics	PLO 9: Individual & Team Work	PLO 10: Communication	PLO 11: Project Mgt. & Finance	PLO 12: Life Long Learning	PLO 13: PSO - 1	PLO 14: PSO - 2	PLO 15: PSO - 3
CLO-1 :	*Understand the concepts of FMS in the modern competitive environment*	*1*	*90*	*85*	*M*	-	*H*	*L*	*M*	-	*L*	-	*M*	-	*M*	-	*H*	-	*H*
CLO-2 :	*Understand the concepts about Group Technology and various coding schemes*	*2*	*90*	*85*	*H*	-	-	*L*	*M*	-	*M*	-	-	*M*	*M*	-	*H*	-	*H*
CLO-3 :	*Understand the need of FMS layout, applications with scheduling concepts*	*2*	*90*	*85*	*M*	-	*M*	*L*	*M*	-	*M*	-	*M*	*H*	*L*	-	*H*	-	*H*
CLO-4 :	*Understand the concepts of cell, Unattended machining, JIT in detail*	*2*	*90*	*85*	*L*	-	*L*	*L*	*L*	-	-	-	*L*	*L*	*M*	-	*H*	-	*H*
CLO-5 :	*Understand the FMS software modules, ideas in data exchanges*	*2*	*90*	*85*	*M*	-	*H*	*L*	*H*	-	-	-	*L*	-	*H*	-	*H*	-	*H*
CLO-6 :	*Ability to perform Planning, Scheduling and control of FMS*	*2*	*90*	*85*	*M*	-	*H*	*L*	*M*	-	-	-	*M*	*H*	*H*	-	*H*	-	*H*

Duration (hour)		9	9	9	9	9
S-1	SLO-1	*Traditional production planning, forecasting, process planning*	*Introduction to Group Technology*	*Introduction to FMS*	*Manufacturing Cell, Product flow from cell to cell*	*FMS software – Introduction*
	SLO-2	*Estimating, master scheduling, and various steps involved in planning and control*	*Part families*	*Basic components of FMS*	*Classification of Cell*	*General structure and requirements*
S-2	SLO-1	*Problems in production planning and control*	*Introduction to parts classification and coding*	*Application Characteristics of FMS*	*Unattended machining*	*Advantages of FMS software*
	SLO-2	*Cycle of activities*	*Coding system architecture*	*Significance of FMS*	*Features and requirement*	*Activities and functions to be performed by FMS software, within the system*
S-3	SLO-1	*Computer Integrated production management systems*	*Opitz system structure, classification system*	*Types of FMS*	*Differences between FMS and FMC*	*Types of FMS software modules*
	SLO-2	*Cycle of activities in CIPMS*	*MICLASS system*	*Types of FMS layouts*	*Introduction to JIT, Goals*	*Work-order processing*
S-4	SLO-1	*Cost Planning*	*Code system*	*Factors influencing FMS layout*	*Objectives of JIT, Ingredients*	*Data distribution and collection*
	SLO-2	*Cost Control*	*Group Technology machine cells*	*Objectives, AIMS of FMS*	*Quality and Quantity Principles of JIT*	*System diagnostics and maintenance*
S-5	SLO-1	*Inventory types*	*Types of GT machine cells*	*Advantages of FMS*	*Primary quantity JIT principles*	*Tool management*
	SLO-2	*Inventory Management*	*Benefits of Group technology*	*Disadvantages of FMS*	*Benefits of JIT*	*Traffic management and control*
S-6	SLO-1	*Material Requirements Planning*	*Product design benefits, tooling and setups*	*Area of Application of FMS in an Industry*	*JIT implementation*	*Quality control management*
	SLO-2	*Basic MRP concepts*	*Material handling*	*Various equipment and their functions required for an FMS*	*KANBAN/CARD system introduction*	*Fixtures and work piece control*

S-7	SLO-1	*Inputs to MRP*	*Production and inventory control*	*CIM technology*	*Push Vs pull system*	*Planning scheduling and simulation*
	SLO-2	*Master production schedule, bill of materials, Inventory record file*	*Employee satisfaction*	*Hierarchy of CIM*	*Dual card KANBAN*	*Computer simulation*
S-8	SLO-1	*Principles of MRP*	*Process planning procedures*	*Direct Real Time schedule control*	*Dual card KANBAN for milling and drilling*	*General phases of simulation analysis*
	SLO-2	*MRP output reports*	*System planning-objective, guideline,*	*Major functions of FMS host*	*Single card KANBAN concept*	*Functions*
S-9	SLO-1	*Benefits of MRP*	*System definition and sizing-*	*FMS concepts*	*Single card KANBAN- Example*	*FMS hosts*
	SLO-2	*MRP-II*	*Human resources*	*Process routings in an FMS*	*Benefits of KANBAN system*	*Data exchanges*

Learning Resources	1. *"CAD/CAM Computer Aided Design and Manufacturing" - M.Groover&E.Zimmers, Pearson Prentice Hall, 2012* 2. *"Flexible Manufacturing System"- H.K.Shivanand, M.M.Benal, V.Koti, New Age International Pvt Limited, 2006* 3. *"Computer Aided Manufacturing" - P.N RAO, N.K.TIWARI, T.K.KUNDRA, McGraw Hill Education India private Ltd, 2014*	4. *"CAD/CAM Theory and Practice"- Ibrahim Zyed, Sivasubramaniam Tata McGraw Hill International 2011* 5. *"Flexible Manufacturing Cells and Systems" - William .W.LuggenPrentice Hall 1991* 6. *"Automation production Systems & Computer Integrated Manufacturing" - MikellP Groover 1989* 7. *"Handbook of Flexible of Manufacturing Systems" - JHA N.K 1991*

Learning Assessment

	Bloom's Level of Thinking	Continious Learning Assessment (50% Weightage)								Final Examination (50% Weightage)	
		CLA – 1 (10%)		CLA – 2 (15%)		CLA – 3 (15%)		CLA – 4 (10%)			
		Theory	Practice	Theory	Practice	Theory	Practice	Theory	Practice	Theory	Practice
Level 1	Remember Understand	40%	-	30%	-	30%	-	30%	-	30%	-
Level 2	Apply Analyze	40%	-	40%	-	40%	-	40%	-	40%	-
Level 3	Evaluate Create	20%	-	30%	-	30%	-	30%	-	30%	-
	Total	100%		100%		100%		100%		100%	

Course Designers

Experts from Industry	Experts from Higher Technical Institutions	Internal Experts
1. Mr. P.Kartikeyan, Head – Operations Improvement, Nokia India, kartikeyan.p@nokia.com	*1. Dr.K.Senthilkumaran, Assistant professor, IIITDM, Kancheepuram. skumaran@iiitdm.ac.in*	*1. M.Kamatchi Hariharan SRMIST*
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3. Dr. A. Velayutham, DRDO, Avadi, velayutham.a@cvrde.drdo.in		

Course Code	18MEE706T	Course Name	IOT IN AUTOMATION	Course Category	E	Professional Elective	L	T	P	C
							3	0	0	3

Pre-requisite Courses	NIL	Co-requisite Courses	NIL	Progressive Courses	NIL
Course Offering Department	Mechanical Engineering	Data Book / Codes / Standards	NIL		

Course Learning Rationale (CLR):	*The purpose of learning this course is to:*	Learning			Program Learning Outcomes (PLO)														
		1	2	3	1	2	3	4	5	6	7	8	9	10	11	12	13	14	15
CLR-1 :	*Acquire knowledge on IoT enabling technologies*																		
CLR-2 :	*Impart knowledge on work logic of IoT in manufacturing system*																		
CLR-3 :	*Acquire knowledge on prototyping and production*																		
CLR-4 :	*To know the role of IoT in laser cutting, 3D printing, CNC milling*																		
CLR-5 :	*To know the use of smart objects for smart applications*																		
CLR-6 :	*Track and trace real time manufacturing information*																		
Course Learning Outcomes (CLO):	*At the end of this course, learners will be able to:*	Level of Thinking (Bloom)	Expected Proficiency (%)	Expected Attainment (%)	Engineering Knowledge	Problem Analysis	Design & Development	Analysis, Design, Research	Modern Tool Usage	Society & Culture	Environment & Sustainability	Ethics	Individual & Team Work	Communication	Project Mgt. & Finance	Life Long Learning	PSO - 1	PSO - 2	PSO - 3
CLO-1 :	*Understand the design principles of connected devices*	*2*	*90*	*80*	*H*	*M*	*M*	*L*	*L*	-	-	-	-	-	-	*M*	*H*	-	*H*
CLO-2 :	*Apply IoT models in manufacturing technologies*	*2*	*85*	*80*	*H*	*M*	*L*	*L*	-	-	-	-	-	-	-	*M*	*H*	-	*H*
CLO-3 :	*Understand the importance of standardization in IoT*	*1*	*90*	*85*	*H*	*L*	*L*	-	*M*	-	-	-	-	-	-	*M*	*H*	-	*H*
CLO-4 :	*Understand the capabilities and application of IoT*	*2*	*90*	*85*	*H*	*L*	-	-	*L*	-	-	-	-	-	-	*M*	*M*	-	*M*
CLO-5 :	*Become master of IoT for business model*	*1*	*85*	*80*	*H*	*L*	-	-	-	-	-	-	-	-	*M*	*M*	*M*	-	*M*
CLO-6 :	*Acquire the real time manufacturing information*	*2*	*85*	*80*	*H*	*L*	-	-	-	-	-	-	-	-	-	*M*	*M*	-	*M*

Duration (Hour)		9	9	9	9	9
S-1	SLO – 1	*Introduction to IoT*	*Existing manufacturing paradigms and their limitations*	*Real time status monitoring and Real time production guiding*	*IoT application for industry value creation and challenges*	*Configuration of smart shop floor*
	SLO – 2	*Definition and characteristic of IoT*	*Agile manufacturing, Networked manufacturing*	*Real time production data sharing, Real time production requeuing*		
S-2	SLO – 1	*Physical design of IoT*	*Reconfigurable manufacturing system*	*Deployment of multi-sensors, multiple sensor selection, multiple sensor manager*	*IoT application requirement and capabilities*	*The logical flow of the prototype system*
	SLO – 2	*Physical design of IoT*	*Product service system and industrial product service system,*	*Multisource manufacturing information capturing and sharing*	*Challenges faced by IoT industries application*	*The framework of the prototype system*
S-3	SLO – 1	*Logical design of IoT*	*Manufacturing grid*	*Information encapsulation*	*Future factory concepts*	*The framework of the prototype system*
	SLO – 2	*Logical design of IoT*	*Cloud manufacturing*	*Case study – hardware device, software system*	*The smart factory initiative*	*Deployment of hardware devices*
S-4	SLO – 1	*IoT enabling technologies*	*Limitations of agile manufacturing system*	*IoT standardization*		*Workflow of the prototype system*
	SLO – 2	*IoT enabling technologies*	*Applications of IoT in manufacturing system*	*Importance of standardization – beginning of everything*	*From technologies to technology concept*	*Task driven manufacturing resource configuration model*
S-5	SLO – 1	*IoT levels and deployment models*	*Key features and limitations of IoT in manufacturing system*	*The need of methods and tools and corresponding research*		*Production scheduling / rescheduling model*
	SLO – 2	*IoT levels and deployment models*	*Integration framework of real time manufacturing information – sharing and integration*	*Gaps between IoT standardization, IoT research, IoT development and IoT innovation*	*Brownfield IoT : Technologies for retrofitting*	*The scheduling and rescheduling method*

S-6	SLO – 1	*Design principles for connected devices*		*M2M service layer standardization*		*IoT enabled smart materials handling module*
	SLO – 2	*Design principles for connected devices*	*Real time manufacturing data processing*	*Prototype and production*	*Smart objects and smart applications*	
S-7	SLO – 1	*Calm and ambient technology*		*Physical prototypes and mass personalization*		*IoT enabled smart station*
	SLO – 2	*Calm and ambient technology*	*Sharing and exchange service*	*Open source versus closed source*	*Four aspects in your business to master IoT*	
S-8	SLO – 1	*Internet principles*	*IoT enabled smart assembly station*	*Prototyping embedded devices, sensors, actuators*		*Operation guidance from the system*
	SLO – 2	*Internet Communication – overview*	*Overall architecture of IoT enabled smart assembly station*	*Embedded computer basics, Arduino, Raspberry Pi, sketch, iterate and explore*	*Value creation from big data and serialization from pharmaceutical industry*	*Real time queuing under exceptions*
S-9	SLO – 1	*Overall architecture of IoT manufacturing system (MS)*	*IoT enabled smart trolley*	*Non digital methods, Laser cutting, 3D printing, types of 3D printing*		*Real time manufacturing information track and trace*
	SLO – 2	*The work logic of IoT MS, Description of core technologies of IoT MS*	*IoT enabled materials handling*	*Moving to manufacture, Moving to manufacture, CNC milling, recycling*	*IoT for oil and gas industries*	*Real time production performances monitor module*

Learning Resources	*1. ArshdeepBahga, Vijay Madisetti, "Internet of Things – A hands on approach", ArshdeepBahga& Vijay Madisetti 2014* *2. Yingfeng Zhang, Fei Tao, "Optimization of manufacturing using internet of things", Academic Press Elsevier 2017.* *3. Adrian McEwen, Hakim Cassimally, "Designing the internet of things", Springer International Publishing 2018.*	*4. Dr. Ovidiu Vermesan, Dr. Peter Friess, "Internet of Things – Covering technologies for smart environments and ecosystem", River Publishers 2013.* *5. Christoph Jan Bartodziej, "The concept of industry 4.0" – An empirical analysis of technologies and applications in production logistics", Springer Gabler 2017* *6. Francis daCosta, "Rethinking the internet of things – A scalable approach to connecting everything", Apress 2013.*

Learning Assessment

	Bloom's Level of Thinking	Continuous Learning Assessment								Final Examination (50% weightage)	
		CLA-1 (10%)		CLA-2 (15%)		CLA-3 (15%)		CLA-4 (10%) #			
		Theory	Practice	Theory	Practice	Theory	Practice	Theory	Practice	Theory	Practice
Level 1	Remember Understand	40%	-	30%	-	30%	-	30%	-	30%	-
Level 2	Apply Analyze	40%	-	40%	-	40%	-	40%	-	40%	-
Level 3	Evaluate Create	20%	-	30%	-	30%	-	30%	-	30%	-
	Total	100%	-	100%	-	100%	-	100%	-	100%	-

CLA – 4 can be from any combination of these: Assignments, Seminars, Tech Talks, Mini-Projects, Case-Studies, Self-Study, MOOCs, Certifications, Conf. Paper etc.,

Course Designers

Experts from industry	Expert from higher technical institution	Internal Expert
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2. Dr. R. Kalimuthu, ISRO, Mahendragiri, r_kalimuthu@vssc.gov.in	*2. Dr.B.Mohan, Professor, Anna University, mohan@mitindia.edu*	*2. Dr.R.Rajaraman, SRMIST*
3. Dr. A. Velayutham, DRDO, Avadi, velayutham.a@cvrde.drdo.in		

Course Code	18MEE707T	Course Name	VIRTUAL INSTRUMENTATION	Course Category	E	Professional Elective	L	T	P	C
							3	0	0	3

Pre-requisite Course	Nil	Co-requisite Course	Nil	Progressive Courses	Nil
Course Offering Department	Mechanical Engineering	Data Book/Codes/Standards	Nil		

Course Learning Rationale (CLR):	The purpose of learning this course is to:
CLR-1 :	*Impart knowledge on virtual instrumentation and differentiate it from conventional instruments*
CLR-2 :	*Learn the basic programming concepts*
CLR-3 :	*Learn different Data Acquisition System*
CLR-4 :	*Impart knowledge on interfacing of virtual instrumentation*
CLR-5 :	*Provide knowledge in process analysis by virtual instrumentation tool.*
CLR-6 :	*Develop real time applications using LabVIEW*

Course Learning Outcomes (CLO):	At the end of this course, learners will be able to:	Level of Thinking (Bloom)	Expected Proficiency (%)	Expected Attainment (%)	Engineering Knowledge	Problem Analysis	Design & Development	Analysis, Design, Research	Modern Tool Usage	Society & Culture	Environment & Sustainability	Ethics	Individual & Team Work	Communication	Project Mgt. & Finance	Life Long Learning	PSO - 1	PSO - 2	PSO - 3
		Learning 1	2	3	PLO 1	2	3	4	5	6	7	8	9	10	11	12	13	14	15
CLO-1 :	*Describe about virtual instrumentation*	1	90	85	M	-	M	L	H	-	L	-	-	-	-	L	H	-	H
CLO-2 :	*Get adequate knowledge on virtual instrumentation tool sets*	2	90	85	H	-	-	L	H	-	L	-	-	-	-	L	H	-	H
CLO-3 :	*Describe data acquisition*	2	90	85	H	-	M	M	H	-	L	-	M	-	-	L	H	-	H
CLO-4 :	*Understand virtual instrumentation programming techniques*	2	90	85	H	-	M	L	H	-	-	-	L	-	-	L-	H	-	H
CLO-5 :	*Gain knowledge on interfacing and networking of virtual instrumentation*	2	90	85	H	-	M	M	H	-	-	-	L	-	-	-	H	-	H
CLO-6 :	*Use virtual instrumentation tool for process monitoring*	2	90	85	H	-	M	L	H	-	L	-	M	-	-	-	H	-	H

Duration (hour)		9	9	9	9	9
S-1	SLO-1	*Historical perspective, advantages of virtual instrumentation*	*Modular Programming in Lab-VIEW*	*Introduction to PC based data acquisition*	*Common Instrument Interfaces*	*Use of Analysis tools*
	SLO-2	*Block diagram of a virtual instrument*	*Building a connector pane*	*Sampling fundamentals*	*Current loop*	*Fourier transforms*
S-2	SLO-1	*Architecture of a virtual instrument*	*VIs and sub-Vis*	*Analog Input/output techniques*	*Serial port Communication*	*Power spectrum*
	SLO-2	*Conventional instruments versus Traditional instruments*	*Opening and editing sub-Vis*	*Digital Input/output techniques*	*Instrument driver VIs*	*correlation methods*
S-3	SLO-1	*Hardware in virtual instrumentation*	*Placing sub-VIs, Saving sub VIs*	*Buses*	*RS 232C/ RS485*	*Windowing and filtering*
	SLO-2	*Software in virtual instrumentation*	*Loops and charts, Terminals inside or outside loops*	*ADC, DAC*	*GPIB*	*Distributed I/O modules*
S-4	SLO-1	*Layers of virtual instrumentation software*	*Shift Registers*	*Counters and timers*	*Using other interfaces*	*Virtual Laboratory, Simulation of level*
	SLO-2	*Graphical system design model*	*Arrays, creating arrays*	*DMA*	*Bus Interfaces: USB, PCMCIA*	*Major equipments- Oscilloscope, Digital Multi-meter*
S-5	SLO-1	*Virtual instrumentation for test*	*Deleting, inserting and replacing elements*	*Software and hardware installation*	*VXI, SCSI*	*Temperature data acquisition system*
	SLO-2	*Virtual instrumentation for industrial I/O and control*	*Clusters and graphs*	*Calibration, resolution*	*PCI, PXI, Fire wire*	*Image acquisition and processing*
S-6	SLO-1	*Virtual instrumentation for design*	*Case and sequence structures*	*Signal conditioning*	*PXI system controllers*	*Image acquisition using line sensor*
	SLO-2	*Graphical programming in data flow*	*formula nodes, feedback nodes*	*Computer based measurements system*	*Ethernet control of PXI.*	*Image acquisition using a single sensor*
S-7	SLO-1	*Comparison with conventional programming*	*Control timing*	*Selecting and configuring data acquisition system*	*Networking basics for office*	*Motion control employing stepper motor*

	SLO-2	*Virtual instrumentation in the engineering processes*	*Local and global variables*	*Concept of universal data acquisition card*	*Networking basis for industrial applications*	*On-Off controller PID Controller*
S-8	SLO-1	*Virtual instrumentation personal computers*	*State machine*	*Data acquisition interface requirements*	*VISA and IVI.*	*PID controller theory*
	SLO-2	*Graphical programming and textual programming*	*String and file I/O*	*Use of timers/counters*	*VISA Programming terminology*	*PID tuning software*
S-9	SLO-1	*Development of Virtual Instrument using Graphical user interface (GUI)*	*Instrument Drivers*	*Signal sources, measurement system*	*VISA and Serial*	*Advantages and Limitations of PID controller*
	SLO-2	*Real-time systems*	*Publishing measurement data in the web, cable news network*	*Increasing the measurement quality*	*IVI software technology*	*Advantages and Limitations of On-Off controller*

Learning Resources	1. *Robert H.Bishop, "Learning with LabVIEW 2009", Pearson Education 2010.* 2. *Jovitha Jerome, "Virtual Instrumentation Using LabVIEW", Eastern Economy Edition,PHI learning private ltd, 2010.* 3. *Sanjay Gupta and Joseph john, "Virtual Instrumentation Using LabVIEW",McGraw Hill Education private Limited, 2013.*	4. *N.Mathivanan, "PC-based Instrumentation: Concepts and Practice", Eastern Economy Edition, PHI Learning private Ltd, 2007.* 5. *Kevin James, "PC Interfacing and Data Acquisition: Techniques for Measurement, Instrumentation and Control", Newnes, 2000.*

Learning Assessment

	Bloom's Level of Thinking	Continuous Learning Assessment (50% Weightage)								Final Examination (50% Weightage)	
		CLA – 1 (10%)		CLA – 2 (15%)		CLA – 3 (15%)		CLA – 4 (10%)			
		Theory	Practice	Theory	Practice	Theory	Practice	Theory	Practice	Theory	Practice
Level 1	Remember Understand	40%	-	30%	-	30%	-	30%	-	30%	-
Level 2	Apply Analyze	40%	-	40%	-	40%	-	40%	-	40%	-
Level 3	Evaluate Create	20%	-	30%	-	30%	-	30%	-	30%	-
	Total	100%		100%		100%		100%		100%	

Course Designers

Experts from Industry	Experts from Higher Technical Institutions	Internal Experts
1. Mr. P.Kartikeyan, Head – Operations Improvement, Nokia India, kartikeyan.p@nokia.com	*1. Dr.K.Senthilkumaran, Assistant professor, IIITDM, Kancheepuram. skumaran@iiitdm.ac.in*	*1. Dr.R.Rajaraman, SRMIST*
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3. Dr. A. Velayutham, DRDO, Avadi, velayutham.a@cvrde.drdo.in		

Course Code	18MEE708T	Course Name	NEURAL NETWORK AND FUZZY SYSTEMS	Course Category	E	Professional Elective	L	T	P	C
							3	0	0	3

Pre-requisite Course	Nil	Co-requisite Course	Nil	Progressive Courses	Nil
Course Offering Department	Mechanical Engineering			Data Book/Codes/Standards	Nil

Course Learning Rationale (CLR):	The purpose of learning this course is to:
CLR-1 :	*Acquire knowledge on the fundamental of neural networks*
CLR-2 :	*Apply the neural network recurrence for automation*
CLR-3 :	*Utilize the practical applications of neural networks in automation*
CLR-4 :	*Understand the principles of Clustering approaches to automation*
CLR-5 :	*Understand various applications of fuzzy in automation*
CLR-6 :	*Understand the Neural Network approach to Pattern Recognition*

Course Learning Outcomes (CLO):	At the end of this course, learners will be able to:	Learning 1	2	3	Program Learning Outcomes (PLO) 1	2	3	4	5	6	7	8	9	10	11	12	13	14	15
		Level of Thinking (Bloom)	Expected Proficiency (%)	Expected Attainment (%)	Engineering Knowledge	Problem Analysis	Design & Development	Analysis, Design, Research	Modern Tool Usage	Society & Culture	Environment & Sustainability	Ethics	Individual & Team Work	Communication	Project Mgt. & Finance	Life Long Learning	PSO - 1	PSO - 2	PSO - 3
CLO-1 :	*Acquire basic understanding of the various algorithms involved in Neural Networks & Fuzzy Systems*	3	90	80	H	H	H	H	-	-	-	-	H	-	-	H	H	-	H
CLO-2 :	*Analyze the neuron model and fundamentals on learning algorithms*	3	90	80	M	-	-	-	-	-	-	--	-	-	-	H	M	-	M
CLO-3 :	*Understand various Fuzzy algorithms.*	3	90	80	H	H	L	H	H	-	-	-	M	-	-	H	H	-	M
CLO-4 :	*Analyze how to apply the concept of fuzzy & neural in automation*	3	90	80	H	M	M	H	H	-	-	-	M	-	-	H	H	-	M
CLO-5 :	*Application of Neural and Neuro fuzzy concepts*	3	90	80	H	L	L	H	-	-	-	-	M	-	-	H	H	-	M
CLO-6 :	*Analyze and compare a variety of automation techniques to real-world problems*	3	90	80	H	H	L	H	-	-	-		M	-	-	H	H	-	M

Duration (hour)		9	9	9	9	9
S-1	SLO-1	*Introduction to ANN*	*Counter propagation*	*Introduction to Fuzzy Sets*	*Fuzzy Relations on Sets and Fuzzy Sets*	*Application of neural networks and fuzzy logic*
	SLO-2	*History of neural networks*	*Self-organization Map*	*Crispness, Vagueness, Fuzziness, Uncertainty*		
S-2	SLO-1	*Biological Neurons and its Artificial Models*	*Cognitron and Neocognitron*	*Fuzzy Set Theory*	*Compositions of Fuzzy Relations*	*Applications of Fuzzy Set Theory*
	SLO-2	*Models of Artificial Neural Networks*		*Fuzzy Sets-Basic Definitions*		
S-3	SLO-1	*Learning and Adaptation*	*Hopfield Net- kohonnen Nets*	*Basic Set-Theoretic Operations for Fuzzy Sets*	*Properties of the Min-Max Composition*	*Support Logic Programming and Fril*
	SLO-2	*Neural Network Learning Rules*		*Types of Fuzzy Sets*		
S-4	SLO-1	*Hebbian Learning Rule*	*Mathematical foundations of Discrete-Time hopfield networks*	*Further Operations on Fuzzy Sets*	*Fuzzy Graphs*	*Application in Measurement, Control*
	SLO-2	*Perceptron Learning Rule*		*Algebraic Operations*		
S-5	SLO-1	*Types of activation Functions*	*Mathematical foundations of gradient type hopfield networks*	*Set-Theoretic Operations*	*Fuzzy Functions on Fuzzy Sets*	*Linguistic Evaluation and Ranking of Machine Tools*
	SLO-2			*Criteria for Selecting Appropriate Aggregation Operators*		
S-6	SLO-1	*Multilayer perceptron*	*Grossberg nets*	*Fuzzification and Defuzzification*	*Integration of Fuzzy Functions*	*Application in Flexible Manufacturing Systems*
	SLO-2	*Batch Learning and On-Line Learning*				
S-7	SLO-1	*Supervised Learning Viewed as an Optimization Problem*	*Transient response of continuous-Time Networks*	*Fuzzy Measures and Measures of Fuzziness*	*Performance index – Modification of rule base*	*Adaptive Neural Controllers*
	SLO-2					

S-8	SLO-1	*Back propagation algorithm and its variants*	*Relaxation Modeling in Single-Layer Feedback Networks*	*The Extension Principle and Applications*	*Genetic algorithms*	*Signal Processing and Image Processing*
	SLO-2				*Adaptive fuzzy system*	
S-9	SLO -1	*Different types of learning, examples*	*Art-I, Art-II reinforcement learning*	*Algebraic Operations with Fuzzy Numbers*	*Neuro fuzzy systems*	*Case studies*
	SLO -2					

Learning Resources	1. *Vallum B. R And Hayagriva V.R C++, Neural networks and Fuzzy logic, BPB Publications.* 2. *Simon Haykins, "Neural Networks - A comprehensive foundation", Macmillan College, Proc. Con. Inc. New York, 2005* 3. *Zimmermann.H.J, "Fuzzy set theory and its applications", Allied Publication Ltd.,Chennai, 2001.New Delhi, 1996* 4. *Fuzzy logic &Neural Networks/ Chennakesava R. Alavala/ New Age International, 2008* 5. *Neural Networks for control, Millon W. T, Sutton R.S and Werbos P.J, MIT Press 1992*	6. *Fuzzy sets Fuzzy logic, Klir, G.J anfd Yuan B.B Prentice Hall of India Pvt. Ltd.,, New Delhi* 7. *Neural Networks and Fuzzy systems, Kosko.. Prentice hall of India Pvt. Ltd.,, New Delhi 1994* 8. *Introduction to Fuzzy control, Dirankov D. Hellendoorn H, Reinfrank M., Narosa Publications House, New Delhi 1996* 9. *Introduction to Artificial Neural systems, Zurada J. M Jaico Publishing House, New Delhi 1994*

Learning Assessment

	Bloom's Level of Thinking	Continuous Learning Assessment (50% Weightage)								Final Examination (50% Weightage)	
		CLA – 1 (10%)		CLA – 2 (15%)		CLA – 3 (15%)		CLA – 4 (10%)#			
		Theory	Practice	Theory	Practice	Theory	Practice	Theory	Practice	Theory	Practice
Level 1	Remember Understand	40%	-	30%	-	30%	-	30%	-	30%	-
Level 2	Apply Analyze	40%	-	40%	-	40%	-	40%	-	40%	-
Level 3	Evaluate Create	20%	-	30%	-	30%	-	30%	-	30%	-
	Total	100%		100%		100%		100%		100%	

CLA – 4 can be from any combination of these: Assignments, Seminars, Tech Talks, Mini-Projects, Case-Studies, Self-Study, MOOCs, Certifications, Conf. Paper etc.,

Course Designers		
Experts from Industry	Experts from Higher Technical Institutions	Internal Experts
1. Mr. P.Kartikeyan, Head – Operations Improvement, Nokia India, kartikeyan.p@nokia.com	*1. Dr.K.Senthilkumaran, Assistant professor, IIITDM, Kancheepuram. skumaran@iiitdm.ac.in*	*1. S.Thamilarasu, SRMIST*
2. Dr. R. Kalimuthu, ISRO, Mahendragiri, r_kalimuthu@vssc.gov.in	*2. Dr.B.Mohan, Professor, Anna University, mohan@mitindia.edu*	*2. Dr.R.Rajaraman, SRMIST*
3. Dr. A. Velayutham, DRDO, Avadi, velayutham.a@cvrde.drdo.in		

Course Code	18MEE709T	Course Name	ELEMENTS OF MECHATRONICS	Course Category	E	Professional Elective	L	T	P	C
							3	0	0	3

Pre-requisite Course	Nil	Co-requisite Course	Nil	Progressive Courses	Nil
Course Offering Department	Mechanical Engineering			Data Book/Codes/Standards	Nil

Course Learning Rationale (CLR):	*The purpose of learning this course is to:*
CLR-1 :	*Understand the basic key elements of mechatronics systems*
CLR-2 :	*Have cognizance on performance of sensors and transducers.*
CLR-3 :	*Understand different actuation systems, signal processing and Controllers*
CLR-4 :	*Program the PLC*
CLR-5 :	*Design mechatronics system and its applications*
CLR-6 :	*Case studies*

Course Learning Outcomes (CLO):	*At the end of this course, learners will be able to:*	Learning 1: Level of Thinking (Bloom)	2: Expected Proficiency (%)	3: Expected Attainment (%)	PLO 1: Engineering Knowledge	2: Problem Analysis	3: Design & Development	4: Analysis, Design, Research	5: Modern Tool Usage	6: Society & Culture	7: Environment & Sustainability	8: Ethics	9: Individual & Team Work	10: Communication	11: Project Mgt. & Finance	12: Life Long Learning	13: PSO - 1	14: PSO - 2	15: PSO - 3
CLO-1 :	*To discuss mechanical systems used in Mechatronics*	1	90	85	H	L	H	H	-	-	L	-	-	-	-	-	H	-	H
CLO-2 :	*To integrate mechanical, electronics, control and computer engineering in the design of mechatronics systems*	2	85	80	H	L	H	M	L	-	L	-	-	H	-	-	M	-	M
CLO-3 :	*Use mathematical methods and tools to analyse and develop electrical and mechanical engineering systems*	3	85	80	L	M	L	-	L	-	-	-	-	-	-	L	M	-	H
CLO-4 :	*Identify, define, formulate and solve complex mechatronics engineering problems*	2	85	80	H	M	H	H	H	-	L	-	-	-	M	-	H	-	H
CLO-5 :	*Ability to work in design, implementation and integration of mechatronics engineering applications*	2	85	80	H	-	H	-	M	-	L	-	-	L	-	-	M	-	M
CLO-6 :	*Conduct feasibility study for using mechatronics systems for solving assistive technology applications*	2	85	80	M	M	-	H	L	-	-	-	-	L	M	L	M	-	H

Duration (hour)		9	9	9	9	9
S-1	SLO-1	*Mechatronics*	*Mathematical models*	*Microprocessor systems*	*Introduction of basic structure*	*Stepper motor*
	SLO-2	*Engineering Design*				
S-2	SLO-1	*Classification of Sensors*	*Building Blocks : Mechanical*	*Basic elements of control systems*	*Input and output processing*	*Stepper motor - types*
	SLO-2	*Classification of transducers*	*Building Blocks : Electrical*			
S-3	SLO-1	*Thermal and electrical sensors*	*Building Blocks : Fluid*	*Microcontrollers*	*Programming*	*Servo motor*
	SLO-2	*Optical sensor*	*Building Blocks : thermal system*			
S-4	SLO-1	*Acoustic sensor*	*System models*	*Microprocessor architecture and terminology*	*Mnemonics*	*Servo motor - types*
	SLO-2	*Pneumatic sensor*				
S-5	SLO-1	*Magnetic sensor*	*Dynamic response of systems*	*Closed loop controllers*	*Timers*	*Case studies of mechatronics system-pick and place robot*
	SLO-2	*Piezo electric sensor*				
S-6	SLO-1	*Transducers: Static characteristics*	*first and second order systems*	*Proportional, derivative and integral controls*	*counters and internal relays*	*automatic car park barrier*
	SLO-2	*Transducers: Dynamic characteristics*		*Derivative and integral controls*		
S-7	SLO-1	*Open loop control systems*	*Modeling dynamic systems*	*PID controller*	*Data handling*	*Engine management system*
	SLO-2	*Closed loop control systems*				
S-8	SLO-1	*Servo mechanism*	*System transfer functions*	*Controllers*	*Selection of PLC*	*Digital camera*
	SLO-2			*Tuning of controller*		
S-9	SLO-1		*Frequency response*	*Adaptive control of machine tools*	*Development of simple ladder programs for specific purposes*	*A PC based computer numerically controlled drilling machine*
	SLO=2					

Learning Resources	1. W.Bolton, "Mechatronics electronic control systems in mechanical and electrical engineering", Pearson Education 2013. 2. Godfrey C.Onwubolu, "Mechatronics principles and applications", Elsevier, 2011.	3. Devdas Shetty & Richard A.Kolk, "Mechatronics system design", Indian Edition, Cenage Learning, 2009. 4. Nitaigour Premchand Mahalik, "Mechatronics principles, concepts and applications", Tata McGraw-Hill, 2008. 5. R.K.Rajput, "A textbook of Mechatronics", Revised Edition, S.Chand Company,2009.

Learning Assessment

	Bloom's Level of Thinking	Continious Learning Assessment (50% Weightage)								Final Examination (50% Weightage)	
		CLA – 1 (10%)		CLA – 2 (15%)		CLA – 3 (15%)		CLA – 4 (10%)			
		Theory	Practice	Theory	Practice	Theory	Practice	Theory	Practice	Theory	Practice
Level 1	Remember Understand	40%	-	30%	-	30%	-	30%	-	30%	-
Level 2	Apply Analyze	40%	-	40%	-	40%	-	40%	-	40%	-
Level 3	Evaluate Create	20%	-	30%	-	30%	-	30%	-	30%	-
	Total	100%		100%		100%		100%		100%	

Course Designers

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2. Dr. R. Kalimuthu, ISRO, Mahendragiri, r_kalimuthu@vssc.gov.in	2. Dr.B.Mohan, Professor, Anna University, mohan@mitindia.edu	2. Dr.R.Rajaraman, SRMIST
3. Dr. A. Velayutham, DRDO, Avadi, velayutham.a@cvrde.drdo.in		

Course Code	18MEE801J	Course Name	ARTIFICIAL INTELLIGENCE AND MACHINE LEARNING	Course Category	E	Professional Elective	L	T	P	C
							2	0	2	3

Pre-requisite Course	Nil	Co-requisite Course	Nil	Progressive Courses	Nil
Course Offering Department	Mechanical Engineering	Data Book/Codes/Standards	Nil		

Course Learning Rationale (CLR):	*The purpose of learning this course is to:*
CLR-1 :	*Learn about Artificial Intelligence and identify the need of AI in Mechanical Engineering*
CLR-2 :	*Learn about different search algorithms*
CLR-3 :	*Learn about Logic controllers, Microprocessors*
CLR-4 :	*Learn about Python Programming*
CLR-5 :	*Apply the concept of Machine Learning for mechanical applications*
CLR-6 :	*Apply Mechanical concepts in AI and build an efficient working environment*

Course Learning Outcomes (CLO):	*At the end of this course, learners will be able to:*	Learning 1: Level of Thinking (Bloom)	Learning 2: Expected Proficiency (%)	Learning 3: Expected Attainment (%)	PLO 1: Engineering Knowledge	PLO 2: Problem Analysis	PLO 3: Design & Development	PLO 4: Analysis, Design, Research	PLO 5: Modern Tool Usage	PLO 6: Society & Culture	PLO 7: Environment & Sustainability	PLO 8: Ethics	PLO 9: Individual & Team Work	PLO 10: Communication	PLO 11: Project Mgt. & Finance	PLO 12: Life Long Learning	PLO 13: PSO - 1	PLO 14: PSO - 2	PLO 15: PSO - 3
CLO-1 :	*Understand the concept of Artificial Intelligence*	1	90	85	H	L	M	M	H	-	M	H	M	-	-	M	-	-	-
CLO-2 :	*Characterize the concepts of Machine Learning*	1	90	85	H	-	M	M	H	-	M	L	M	-	-	M	-	-	-
CLO-3 :	*Identify the different concepts in Heuristic methods*	1	90	85	H	-	-	M	L	-	-	H	M	L	-	-	M	L	M
CLO-4 :	*Understand MATLAB and Python programming*	2	90	85	H	H	L	M	M	-	L	L	M	L	-	M	M	L	M
CLO-5 :	*Solve problems in Genetic programming*	2	90	85	H	H	-	M	M	-	-	L	M	L	-	L	M	L	M
CLO-6 :	*Apply the basic knowledge of Mechanical in smart manufacturing*	2	90	85	H	M	-	M	H	-	L	L	M	L	-	H	M	L	M

Duration (hour)		12	12	12	12	10
S-1	SLO-1	*Artificial Intelligence and its foundations*	*Lab-4: MATLAB- Optimization methods GA, Fuzzy, Neural & PSO*	*Tutorial 4: Artificial Intelligence in Manufacturing Industry*	*Fuzzy matching techniques*	*Syntax programming for optimization*
	SLO-2	*History of AI, LISP and PROLOG*		*Hebb's Rule, McCulloch and Pitts Neurons*	*Tutorial 6: Microcontrollers*	*Reduced environmental impact by ML*
S-2	SLO-1	*Blind search, Breadth first*	*Formalized symbolic logics*	*Evolutionary Learning: Genetic Algorithm and Problems in GA*	*Lab-12: FLEXSIM Software*	*Harnessing useful data using AI and ML*
	SLO-2	*Lab-1: Python Programming*	*Syntax and semantics for Logics Representing knowledge using rules and rules-based deduction systems*	*Genetic Programming*	*RETE matching algorithm*	*Supply chain Communication*
S-3	SLO-1	*Heuristic search techniques*	*Reasoning under uncertainty*	*Lab-7: Image Processing, Object and Motion detection*	*Object-Oriented representations*	*Cutting waste using AI*
	SLO-2	*Hill climbing technique*	*Bayes' probabilistic inferences*		*Data mining for Mechanical Engineers*	*Integration of man machine system*
S-4	SLO-1	*Best first search technique, A* algorithm,*	*Heuristic methods*	*Markov Chain Monte Carlo (MCMC) methods, Bayesian Networks*	*Lab-13:Hydraulic and Pneumatic simulator*	*Improved customer service using AI*
	SLO-2	*AO* algorithm*	*Fuzzy reasoning*	*Lab:8- Pick and place operation of ABB Robot in Manual Mode*	*Dimensionality Reduction PCA*	*Minimizing Equipment Failures*
S-5	SLO-1	*Lab-2: Machine Learning using python*	*Lab-5: Introduction to SIMULINK & Modelling of problems related to kinematics and dynamics of robot using MATLAB*	*Graphical models Markov Random Fields*	*Single Value Decomposition(SVD), t-Distributed Stochastic Neighbor Embedding (t-SNE) methods*	*Predictive Maintenance*
	SLO-2	*Tutorial:1 Python Programming in Mechanical applications*		*Hidden Markov Models (HMMs)*	*Ensemble Techniques Boosting Bagging*	*Multi-dimensional optimization*
S-6	SLO-1	*Game trees- Numerical*	*Expert system, Relationship between Artificial Intelligence and Mechanical Engineering*	*Lab-9: Pick and place operation of ABB Robot in Teach Pendent method, PLC Controlled material handling system*	*Data visualization in machine learning*	*Artificial Neural network*
	SLO-2	*Minimax algorithm*	*Expert system, Relationship between Artificial Intelligence and Mechanical Engineering*		*Text mining*	*Greedy algorithm*

S-7	SLO-1	*Game playing*	*Diagnosis of rule-based reasoning Case-based reasoning and fault-based tree fault diagnosis*	*Tracking Methods*	*Lab-14:Study on Microcontrollers*	*Greedy algorithm problems*
	SLO-2	*Alpha beta pruning*	*Diagnosis of rule-based reasoning Case-based reasoning and fault-based tree fault diagnosis*	*Python- Basics of coding, Writing and importing code*		*Robotic perception*
S-8	SLO-1	*Lab-3: Basics of MATLAB programming*	*Case study: Manufacturing scheduling*	*Tutorial 5: PLC controllers*	*Case study on driverless vehicles*	*Sensors and effectors*
	SLO-2		*Case study: Manufacturing scheduling*			*Types of sensors and acutators*
S-9	SLO-1	*Definition and importance of Knowledge Representation of knowledge*	*Tutorial 2: Case study in manufacturing industry Case study: Intelligent Diagnostic system for Rotating machinery*	*Lab-10: 8051 Micro controller-Temperature and Traffic control*	*Lab-15: Study on Driverless Vehicles*	*Dynamics and control*
	SLO-2	*Organization and Manipulation Logical Agents*	*Case study: Fault diagnosis to Hot Forging Press*			*Problems in Dynamics*
S-10	SLO-1	*Problems in Genetic Algorithm*	*Lab-6: Sensors and its applications*	*Python coding*	*Application of AI and ML in Inventory control*	*Robotic software architecture*
	SLO-2	*Programming GA in MATLAB*				*Writing Robotic software*
S-11	SLO-1	*Problems in Artificial Neural Network*	*Tutorial 3: Image Processing, Object and Motion detection*	*MATLAB and its applications in Fault detection and Optimization*	*Reducing time of production with AI*	*Robotic programming language*
	SLO-2	*Programming ANN in MATLAB*	*Basics of Machine Learning*		*Cost reduction of production with AI*	*Case study on Humanoid robot*
S-12	SLO-1	*Programming Particle swarm optimization (PSO)*	*Definition & uses of Machine Learning*	*Lab-11: 8051 Micro controller-Temperature and Traffic control*	*Automating quality control using AI and ML*	*Machine Learning in supply chain*
	SLO-2	*Problems in PSO*	*Decision Tree & Practical applications*			

Learning Resources	1. *Russell, Stuart J., and Peter Norvig. Artificial intelligence: a modern approach. Malaysia; Pearson Education Limited,, 2016.* 2. *Patterson, Dan W. Introduction to artificial intelligence and expert systems. Prentice-hall ofIndia, 2010.* 3. *Marsland, Stephen. Machine learning: an algorithmic perspective. Chapman and Hall/CRC, 2009.*	4. *Luger, George F., and William A. Stubblefield. Artificial intelligence and the design of expert systems. Benjamin-Cummings Publishing Co., Inc., 2009.* 5. *Charniak, Eugene. Introduction to artificial intelligence. Pearson Education India, 2000.* 6. *Nilsson, Nils J. Principles of artificial intelligence. Morgan Kaufmann, 2014.*

Learning Assessment

	Bloom,s Level of Thinking	Continuous Learning Assessment (50% Weightage)								Final Examination (50% Weightage)	
		CLA – 1 (10%)		CLA – 2 (15%)		CLA – 3 (15%)		CLA – 4 (10%)			
		Theory	Practice	Theory	Practice	Theory	Practice	Theory	Practice	Theory	Practice
Level 1	Remember Understand	20%	20%	15%	15%	15%	15%	15%	15%	15%	15%
Level 2	Apply Analyze	20%	20%	20%	20%	20%	20%	20%	20%	20%	20%
Level 3	Evaluate Create	10%	10%	15%	15%	15%	15%	15%	15%	15%	15%
	Total	100%		100%		100%		100%		100%	

CLA – 4 can be from any combination of these: Assignments, Seminars, Tech Talks, Mini-Projects, Case-Studies, Self-Study, MOOCs, Certifications, Conf. Paper etc.,

Course Designers		
Experts from Industry	Experts from Higher Technical Institutions	Internal Experts
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2. Dr. R. Kalimuthu, ISRO, Mahendragiri, r_kalimuthu@vssc.gov.in	*2. Dr.B.Mohan, Professor, Anna University, mohan@mitindia.edu*	*2. Dr. Suresh Kannan I, SRMIST*
3. Dr. A. Velayutham, DRDO, Avadi, velayutham.a@cvrde.drdo.in		

Course Code	18MEE802T	Course Name	DIGITAL IMAGE PROCESSING AND MACHINE VISION	Course Category	E	Professional Elective	L	T	P	C
							2	0	2	3

Pre-requisite Course	Nil	Co-requisite Course	Nil	Progressive Courses	Nil
Course Offering Department	Mechanical Engineering	Data Book/Codes/Standards	Nil		

Course Learning Rationale (CLR):	*The purpose of learning this course is to:*
CLR-1 :	*Study the image fundamentals transforms necessary for image processing.*
CLR-2 :	*Study the image enhancement techniques*
CLR-3 :	*Study basic image processing operations*
CLR-4 :	*Overview of image restoration techniques.*
CLR-5 :	*Understand the need for image compression and segmentation*
CLR-6 :	*Understand the rapid advances in Machine vision.*

Course Learning Outcomes (CLO):	*At the end of this course, learners will be able to:*	Learning 1 Level of Thinking (Bloom)	2 Expected Proficiency (%)	3 Expected Attainment (%)	PLO 1 Engineering Knowledge	2 Problem Analysis	3 Design & Development	4 Analysis, Design, Research	5 Modern Tool Usage	6 Society & Culture	7 Environment & Sustainability	8 Ethics	9 Individual & Team Work	10 Communication	11 Project Mgt. & Finance	12 Life Long Learning	13 PSO - 1	14 PSO - 2	15 PSO - 3
CLO-1 :	*Review the fundamental concepts of a digital image processing system*	2	85	90	M	-	-	M	-	-	-	-	-	-	-	L	L	-	L
CLO-2 :	*Analyze images in the frequency domain using various transforms*	2	85	80	M	L	M	M	-	-	-	-	-	L	-	L	M	-	M
CLO-3 :	*Evaluate the techniques for image enhancement and image restoration*	2	80	85	M	-	M	M	-	-	-	-	-	-	-	L	L	-	L
CLO-4 :	*Analysis different causes for image degradation*	2	90	85	M	-	-	M	L	-	-	-	-	-	-	L	M	-	M
CLO-5 :	*Interpret Image compression standards.*	2	80	80	M	L	-	M	-	-	M	-	-	-	-	L	M	-	L
CLO-6 :	*Interpret image segmentation and representation techniques.*	3	85	80	M	L	L	M	-	-	-	-	M	-	-	L	L		M

Duration (hour)		9	9	9	9	9
S-1	SLO-1	*Origins of digital image processing*	*Light used in Machine Vision*	*Image Enhancement Techniques:*	*Image Compression - Measuring image information*	*Types of task and production*
	SLO-2	*Origins of digital image processing*	*Basic Rules and Laws of Light Distribution*	*Spatial and Frequency domain*	*Spatial and temporal redundancy*	*Types of task and production*
S-2	SLO-1	*Fundamental steps in digital image processing*	*Light Filters*	*Spatial Domain*	*Image compression models - Huffman coding*	*System Categories - Common types of systems-sensors-vision sensors-*
	SLO-2	*Fundamental steps in digital image processing*	*Light Filters*	*Point operation &Maskoperation*	*Image compression models - Huffman coding*	*PC based system*
S-3	SLO-1	*Components of image processing system*	*Types of Light Filters*	*Histogram manipulation*	*Image compression models - Arithmetic coding*	*Mechanical Interfaces - Dimension and fixation-*
	SLO-2	*Components of image processing system*	*Types of Light Filters*	*Histogram equalization and procedure*	*Image compression models -Run length coding*	*Mechanical Interfaces - working distance-position tolerance*
S-4	SLO-1	*Elements of Visual Perception*	*Machine Vision versus Closed Circuit Television (CCTV)*	*Linear gray level transformation*	*Digital Image watermarking*	*Electrical interface- wiring and movement-*
	SLO-2	*Basics of Image Sensing and Acquisition*	*Machine Vision versus Closed Circuit Television (CCTV)*	*Linear gray level transformation*	*Digital Image watermarking*	*Power supply- Internal and External date connections.*
S-5	SLO-1	*Image Sampling*	*Imaging Sensors- CCD*	*Nonlinear gray level transformation*	*Image Segmentation- Point, line and edge Detection*	*Discrete Motion Production-*
	SLO-2	*Image Quantization*	*Imaging Sensors- CCD*	*Nonlinear gray level transformation*	*Image Segmentation- Point, line and edge Detection*	*Production-Continuous Motion Production-Line-Scan Processing*
S-6	SLO-1	*Basic Relationships between Pixels*	*Imaging Sensors- CMOS*	*Comparison between smoothing and sharpening spatial filters*	*Edge linking and Boundary Detection*	*Industrial Case Study- Glue Check under UV Light*

	SLO-2	*Basic Relationships between Pixels*	*Imaging Sensors-CMOS*	*Comparison between smoothing and sharpening spatial filters*	*Edge linking and Boundary Detection*	*Industrial Case Study- Glue Check under UV Light*
S-7	SLO-1	*Digital image file formats – GIF*	*Digital Cameras- B/W Sensor and Processing*	*Smoothing frequency domain filters (Ideal, Butterworth, Gaussian)*	*Thresholding, Basics of Global thresholding*	*Industrial Case StudyMultiple Position and Completeness Check*
	SLO-2	*Digital image file formats – JPEG*	*Digital Cameras- B/W Sensor and Processing*	*Smoothing frequency domain filters (Ideal, Butterworth, Gaussian)*	*Using edge to improve global thresholding*	*Industrial Case Study-Multiple Position and Completeness Check*
S-8	SLO-1	*Digital image file formats – PNG*	*Color Digital Cameras*	*Sharpening frequency domain filters (Ideal, Butterworth, Gaussian)*	*Multiple and variable thresholding*	*Industrial Case Study- Pin Type Verification*
	SLO-2	*Digital image file formats – TIFF, BMP*	*Camera Noise&Photon Noise.*	*Sharpening frequency domain filters (Ideal, Butterworth, Gaussian)*	*Multiple and variable thresholding*	*Industrial Case Study- Pin Type Verification*
S-9	SLO-1	*Applications of Digital Image Processing*	*Introduction to video analytics*	*Homomorphic filtering.*	*Region Based Segmentation*	*Industrial Case Study- Robot Guidance*
	SLO-2	*Applications of Digital Image Processing*	*Introduction to video analytics*	*Homomorphic filtering.*	*Pattern recognitions*	*Industrial Case Study-Robot Guidance*

Learning Resources	1. *Rafael C Gonzalez and Richard E Woods, Digital Image Processing, Pearson Education, 3rd Edition, 2009.* 2. *Jayarman.S, Esakkirajan.S and Veerakumar.T, Digital Image Processing, Tata McGraw Hill, 2010.* 3. *Alexander Hornberg , Handbook on Machine Vision , Wiley – VCH , 2008.* 4. *William K Pratt, Digital Image Processing, John Willey, 2007.*	5. *Myler, Harley R. Fundamentals of machine vision. SPIE Optical Engineering Press, 1999.* 6. *MillmanSonka, Vaclav Hlavac, Roger Boyle, and Broos Colic, Image Processing Analysis and Machine Vision, Thompson learning, 2014.*

Learning Assessment											
	Bloom's Level of Thinking	Continuous Learning Assessment (50% Weightage)								Final Examination (50% Weightage)	
		CLA – 1 (10%)		CLA – 2 (15%)		CLA – 3 (15%)		CLA – 4 (10%)			
		Theory	Practice	Theory	Practice	Theory	Practice	Theory	Practice	Theory	Practice
Level 1	Remember Understand	40%	-	30%	-	30%	-	30%	-	30%	-
Level 2	Apply Analyze	40%	-	40%	-	40%	-	40%	-	40%	-
Level 3	Evaluate Create	20%	-	30%	-	30%	-	30%	-	30%	-
	Total	100%		100%		100%		100%		100%	

Course Designers		
Experts from Industry	Experts from Higher Technical Institutions	Internal Experts
1. Mr. P.Kartikeyan, Head – Operations Improvement, Nokia India,. kartikeyan.p@nokia.com	*1. Dr.K.Senthilkumaran, Assistant professor, IIITDM, Kancheepuram, skumaran@iiitdm.ac.in*	*1. Mr. G. Leela Prasad, SRMIST*
2. Dr. R. Kalimuthu, ISRO, Mahendragiri, r_kalimuthu@vssc.gov.in	*2. Dr.B.Mohan, Professor, Anna University, mohan@mitindia.edu*	*2. Dr. Suresh Kannan I, SRMIST*
3. Dr. A. Velayutham, DRDO, Avadi, velayutham.a@cvrde.drdo.in		

Course Code	18MEE803J	Course Name	SENSORS FOR INTELLIGENT MANUFACTURING	Course Category	E	Professional Elective	L	T	P	C
							2	0	2	3

Pre-requisite Course	Nil	Co-requisite Course	Nil	Progressive Courses	Nil
Course Offering Department	Mechanical Engineering		Data Book/Codes/Standards	Nil	

Course Learning Rationale (CLR):	The purpose of learning this course is to:
CLR-1 :	*Expose the basics and working principle of sensors and Transducers*
CLR-2 :	*Impart knowledge on motion sensors*
CLR-3 :	*Learn the Packaging techniques of sensors*
CLR-4 :	*Provide knowledge on sensors used in Robotics*
CLR-5 :	*Provide insights on advanced sensors*
CLR-6 :	*Impart knowledge onsensor based control*

Course Learning Outcomes (CLO):	At the end of this course, learners will be able to:	Learning 1: Level of Thinking (Bloom)	2: Expected Proficiency (%)	3: Expected Attainment (%)	PLO 1: Engineering Knowledge	2: Problem Analysis	3: Design & Development	4: Analysis, Design, Research	5: Modern Tool Usage	6: Society & Culture	7: Environment & Sustainability	8: Ethics	9: Individual & Team Work	10: Communication	11: Project Mgt. & Finance	12: Life Long Learning	13: PSO - 1	14: PSO - 2	15: PSO - 3
CLO-1 :	*Describe about sensors and transducers*	1	90	85	H	-	L	L	M	-	-	-	M	-	-	-	M	-	M
CLO-2 :	*Familiarize to use motion sensors for various applications*	2	90	85	H	-	L	L	H	-	-	-	M	-	-	-	M	-	M
CLO-3 :	*Develop packaging of various sensors*	2	90	85	H	-	M	M	M	-	-	-	M	-	-	M	M	-	H
CLO-4 :	*Understand the use of sensors in Robotic application*	2	90	85	H	-	M	M	H	-	-	-	M	-	-	M	M	-	M
CLO-5 :	*Gain knowledge on advanced sensors*	2	90	85	H	-	L	M	H	-	-	-	M	-	-	M	M	-	M
CLO-6 :	*Develop a control scheme based on sensor feedback.*	2	90	85	H	-	L	M	M	-	-	-	H	-	-	L	M	-	M

Duration (hour)		12	12	12	12	12
S-1	SLO-1	*Role of sensors in manufacturing automation*	*Motion Sensors*	*Classification, characteristics*	*Semiconductor sensors*	*Types of controllers*
	SLO-2	*Active and passive sensors*	*Resistive strain gauge*	*Internal sensors – position*	*Hall elements*	*Electrical, pneumatic*
S-2	SLO-1	*Operating principles of different sensors electrical,*	*LVDT, RVDT*	*Velocity sensors*	*Silicon sensors for sensing radiation*	*Hydraulic prime movers and associated control hardware*
	SLO-2	*Operating principles of optical sensors*	*Capacitive, piezo*	*Acceleration sensors*	*Mechanical signals*	*Closed loop control of microcomputer based drives*
S-3	SLO-1	*Operating principles of acoustic sensors*	*Seismic pickups,*	*Force sensors*	*Magnetic signals*	*Relay control systems*
	SLO-2	*Operating principles of pneumatic sensors*	*Vibrometers and accelerometers*	*External sensors*	*Chemical and other signals*	*PLC systems and programming,*
S-4	SLO-1	*Lab 1:Study of the characteristics of a Piezo resistive Sensor for Pressure Measurement*	*Lab 4: Characteristics study of LVDT*	*Lab7: Study of the characteristics of a Photo reflective sensor for Speed Measurement*	*Lab 10: Study of PLC system and Programming*	*Lab 13: Study of Level sensors*
	SLO-2					
S-5	SLO-1					
	SLO-2					
S-6	SLO-1	*Operating principles of magnetic sensors*	*Sensors for CNC machine tools.*	*Proximity, touch Slip sensors.*	*Catalytic devices*	*Control including sequence control*
	SLO-2	*Operating principles of electro-optical sensors*	*Packaging techniques of mechanical sensors*	*Robotic vision.*	*Gas sensors*	*Sensor based control of various actuators.*
S-7	SLO-1	*Vision sensors, Active transducers, passive transducers*	*Electrical interconnection*	*Process of imaging, architecture of robotic vision systems*	*Acoustic sensors*	*Mechatronic devices*
	SLO-2	*Classification of transducers, Sensors and Transducers for: flow, temperature, pressure and torque,*	*Packaging processes*	*Image acquisition, components of vision system*	*Applications of sensors in Robotics*	*Uses of mechatronic devices in for Intelligent Manufacturing*

S-8	SLO-1	*Lab2: Characteristics study of Resistance Temperature Detector (RTD)*	*Lab 5: Characteristics study of RVDT*	*Lab:8 Characteristics study of Reflective Beam Sensor*	*Lab 11: Study of Force and torque sensors*	*Lab 14: Study of Smart material sensors*
	SLO-2					
S-9	SLO-1					
	SLO-2					
S-10	SLO-1	*Current and torque and speed measurements using digital measurement techniques*	*Mechanical transduction techniques*	*Image representation, image processing in robotic vision systems*	*Tactile sensors*	*Autonomous mobile robots*
	SLO-2				*Future Inertial Micro machined Sensors*	*Applications of autonomous mobile robots*
S-11	SLO-1	*Lab 3: Experiment on the Calibration of a Thermocouple*	*Lab 6: Characteristics study of an Electromagnetic Flow meter*	*Lab:9 Experiment on image acquisition and processing*	*Lab 12: Study of Acceleration sensors*	*Lab 15: Study of Micro and Nano sensors*
	SLO-2					
S-12	SLO-1					
	SLO-2					

Learning Resources	1. *Stephen Beeby, Graham Ensell, Michael Kraft, Neil White, MEMS Mechanical Sensors, Artech House, Inc. London, 2004.* 2. *J. Vetelino and A. Reghu, Introduction to sensors, CRC Press, 2010.* 3. *J. Fraden, Handbook of Modern Sensors: Physics, Designs and Applications, 4th edition, Springer, 2010.* 4. *T. G. Beckwith, R. D. Marangoni and J. H. Lienhard V., Mechanical Measurements, Pearson Prentice Hall, 2009. Doebelin, Measurement systems: Applications and Design, 5th edition, McGraw Hill Book, 2004.*	5. *Doebelin, Measurement systems: Applications and Design, 5th edition, McGraw Hill Book, 2004.* 6. *I. R. Sinclair, Sensors and Transducers, Elsevier, 2001.* 7. *J. S. Wilson, Sensor Technology Handbook, Newnes, 2004.* 8. *B. K. Ghosh, T. J. Tarn and N. Xi, Control in Robotics and Automation: Sensor-Based Integration, Academic Press, 1999.* 9. *C.W. de Silava, Sensors and Actuators, 2nd edition, CRC Press, 2016.*

Learning Assessment

	Bloom,s Level of Thinking	Continuous Learning Assessment (50% Weightage)								Final Examination (50% Weightage)	
		CLA – 1 (10%)		CLA – 2 (15%)		CLA – 3 (15%)		CLA – 4 (10%)			
		Theory	Practice	Theory	Practice	Theory	Practice	Theory	Practice	Theory	Practice
Level 1	Remember Understand	20%	20%	15%	15%	15%	15%	15%	15%	15%	15%
Level 2	Apply Analyze	20%	20%	20%	20%	20%	20%	20%	20%	20%	20%
Level 3	Evaluate Create	10%	10%	15%	15%	15%	15%	15%	15%	15%	15%
	Total	100%		100%		100%		100%		100%	

Course Designers

Experts from Industry	Experts from Higher Technical Institutions	Internal Experts
1. Mr. P.Kartikeyan, Head – Operations Improvement, Nokia India, kartikeyan.p@nokia.com	*1. Dr.K.Senthilkumaran, Assistant professor, IIITDM, Kancheepuram, skumaran@iiitdm.ac.in*	*1. Mr.ArulRaja . R A, SRMIST*
2. Dr. R. Kalimuthu, ISRO, Mahendragiri, r_kalimuthu@vssc.gov.in	*2. Dr.B.Mohan, Professor, Anna University, mohan@mitindia.edu*	*2. Dr Suresh Kannan I, SRMIST*
3. Dr. A. Velayutham, DRDO, Avadi, velayutham.a@cvrde.drdo.in		

Course Code	18MEE804T	Course Name	INDUSTRY 4.0	Course Category	E	Professional Elective	L	T	P	C
							3	0	0	3

Pre-requisite Courses	NIL	Co-requisite Courses	NIL	Progressive Courses	NIL
Course Offering Department	Mechanical Engineering	Data Book / Codes / Standards	NIL		

Course Learning Rationale (CLR):	*The purpose of learning this course is to:*
CLR-1 :	*Acquire knowledge on principles of industry 4.0 and building blocks of industry 4.0*
CLR-2 :	*Acquire knowledge on IoT enabled manufacturing systems*
CLR-3 :	*Understand cloud based cyber physical systems in manufacturing*
CLR-4 :	*Apply data analytics in manufacturing*
CLR-5 :	*Understand and apply additive manufacturing technologies*
CLR-6 :	*Acquire knowledge on technologies and application of industry 4.0*

Course Learning Outcomes (CLO):	*At the end of this course, learners will be able to:*	Learning 1: Level of Thinking (Bloom)	Learning 2: Expected Proficiency (%)	Learning 3: Expected Attainment (%)	PLO 1: Engineering Knowledge	PLO 2: Problem Analysis	PLO 3: Design & Development	PLO 4: Analysis, Design, Research	PLO 5: Modern Tool Usage	PLO 6: Society & Culture	PLO 7: Environment & Sustainability	PLO 8: Ethics	PLO 9: Individual & Team Work	PLO 10: Communication	PLO 11: Project Mgt. & Finance	PLO 12: Life Long Learning	PLO 13: PSO - 1	PLO 14: PSO - 2	PLO 15: PSO - 3
CLO-1 :	*Explain the evolution of industry 4.0*	2	90	80	H	-	M	-	-	-	-	-	-	-	-	M	H	---	H
CLO-2 :	*Explain the concept of IoT*	1	85	80	H	-	M	L	H	-	-	-	-	-	-	H	H	---	H
CLO-3 :	*Understand the application areas of IoT in manufacturing*	2	85	80	H	L	M	L	L	-	-	-	-	-	-	M	M	---	M
CLO-4 :	*Explain the concept of cloud manufacturing*	2	90	85	H	-	H	L	L	-	-	-	-	-	-	M	M	---	M
CLO-5 :	*Explain the advances in robotics in the era of industry 4.0*	1	90	85	H	-	H	L	L	-	-	-	M	L	-	L	M	---	M
CLO-6 :	*Identify advances in virtual factory research and application*	1	85	80	H	-	H	M	L	-	-	-	L	-	L	M	M	---	M

Duration (Hour)		9	9	9	9	9
S-1	SLO – 1	*Industry 4.0 – Definition*	*The concept of IoT*	*Concept of cloud manufacturing*	*Power consumption in manufacturing*	*Advances of robotics in the era of industry 4.0*
	SLO – 2	*Why industry 4.0 and why now?*	*Existing manufacturing paradigms and their limitations – agile manufacturing*	*Real time production information*	*Anomaly detection in air conditioner*	*Recent technological components of robots*
S-2	SLO – 1	*Phases of industrial developments*	*Networked manufacturing*	*Cloud service selection and composition*	*Anomaly detection in air conditioner*	*Artificial intelligence*
	SLO – 2	*Central features of the concept*	*Reconfigurable manufacturing system*	*Overall architecture of manufacturing resources configuration method*	*Smart remote machinery maintenance system*	*Internet of robot things, Cloud robotics*
S-3	SLO – 1	*Principles of industry 4.0*	*Product service system / industrial product service system*	*Cloud machine model*	*Smart remote machinery maintenance system*	*Cognitive approach of cyber physical robotics*
	SLO – 2	*Main characteristics of industry 4.0*	*Manufacturing grid Cloud manufacturing*	*Cloud machine model*	*Quality perdition in steel manufacturing*	*Industrial robotic application*
S-4	SLO – 1	*Building blocks of Industry 4.0*	*Limitations of agile manufacturing system*	*Cloud machine model*	*Quality perdition in steel manufacturing*	*Advances in virtual factory research and application*
	SLO – 2	*The value chain*	*Applications of IoT in Manufacturing system*	*Application of cyber physical system &IoT*	*Predicting drilling efficiency*	*Virtual factory software*
S-5	SLO – 1	*Creating the value chain*	*Key features and limitations of IoT in Manufacturing System*	*Cloud manufacturing framework*	*Techniques used for predictive analytics*	*Additive manufacturing technologies and application*
	SLO – 2	*Benefits of industry 4.0*	*Architecture of IoT – MS*	*Manufacturing capability and manufacturing resource*	*Techniques used for predictive analytics*	*Advantages and disadvantages of additive manufacturing*
S-6	SLO – 1	*Challenges of industry 4.0*	*Integration framework of real time manufacturing information – sharing and integration*	*Cloud architecture*	*Forecast accuracy calculation*	*Application areas of additive manufacturing*

	SLO – 2	Smart manufacturing	Real time manufacturing data processing, sharing and exchange service	Approaches to achieve product information sharing	Forecast accuracy calculation	Impact of additive manufacturing techniques on society
S-7	SLO – 1	Industrial internet of things	The work logic of IoT MS, Description of core technologies of IoT MS	Standardization for cloud manufacturing	Real world case study – definition	Impact on manufacturing and supply chain
	SLO – 2	Gateways	IoT enabled smart assembly station	Standardization for cloud manufacturing	Data gathering and cleaning	Digital traceability through production value chain
S-8	SLO – 1	Wireless Communication technologies	Overall architecture of IoT enabled smart assembly station	Overview of cyber security in industry 4.0 era	Automation based lean production	Digital traceability technologies
	SLO – 2	Industry 4.0 – the way forward	IoT enabled smart trolley	Overview of cyber security in industry 4.0 era	Automation based lean production	Architectural framework of the digital traceability system, Application of digital traceability
S-9	SLO – 1	Technology road map for industry 4.0	IoT enabled materials handling	Security threat and vulnerabilities of IoT	Model application	Project management in digital traceability, Examples for IoT in value creation in different industries
	SLO – 2	Technology road map for industry 4.0	Real time information enabled material handling strategy	Cases – cyber security	Model application	smart manufacturing – maturity model, Smart agriculture, Smart city Smart life and smart health

Learning Resources	1. ArshdeepBahga, Vijay Madisetti, Internet of Things – A hands on approach, ArshdeepBahga& Vijay Madisetti, 2014 2. Yingfeng Zhang, Fei Tao, Optimization of manufacturing using internet of things, Academic Press Elsevier, 2017. 3. Lihui Wang, Xi Vincent Wang, Cloud based cyber physical systems in manufacturing, Springer International Publishing, 2018.	4. Christoph Jan Bartodziej, The concept of industry 4.0 – An empirical analysis of technologies and applications in production logistics, Springer Gabler, 2017 5. Alp Ustundag, EmriChevikcan, Industry 4.0 - Managing the digital transformation, Springer International Publishing, 2018.

Learning Assessment

	Bloom's Level of Thinking	Continuous Learning Assessment (50% Weightage)								Final Examination (50% Weightage)	
		CLA – 1 (10%)		CLA – 2 (15%)		CLA – 3 (15%)		CLA – 4 (10%)			
		Theory	Practice	Theory	Practice	Theory	Practice	Theory	Practice	Theory	Practice
Level 1	Remember Understand	40%	-	30%	-	30%	-	30%	-	30%	-
Level 2	Apply Analyze	40%	-	40%	-	40%	-	40%	-	40%	-
Level 3	Evaluate Create	20%	-	30%	-	30%	-	30%	-	30%	-
	Total	100%		100%		100%		100%		100%	

CLA – 4 can be from any combination of these: Assignments, Seminars, Tech Talks, Mini-Projects, Case-Studies, Self-Study, MOOCs, Certifications, Conf. Paper etc.,

Course Designers

Experts from industry	Expert from higher technical institution	Internal Expert
1. Mr. P.Kartikeyan, Head – Operations Improvement, Nokia India, kartikeyan.p@nokia.com	1. Dr.K.Senthilkumaran, Assistant professor, IIITDM, Kancheepuram, skumaran@iiitdm.ac.in	1. Mr. Dinakar. N, SRMIST
2. Dr. R. Kalimuthu, ISRO, Mahendragiri, r_kalimuthu@vssc.gov.in	2. Dr.B.Mohan, Professor, Anna University, mohan@mitindia.edu	2. Dr. Suresh Kannan I, SRMIST
3. Dr. A. Velayutham, DRDO, Avadi, velayutham.a@cvrde.drdo.in		

Course Code	18MEE805T	Course Name	MANUFACTURING EXECUTION SYSTEMS	Course Category	E	Professional Elective	L	T	P	C
							3	0	0	3

Pre-requisite Course	Nil	Co-requisite Course	Nil	Progressive Courses	Nil
Course Offering Department	Mechanical Engineering			Data Book/Codes/Standards	Nil

Course Learning Rationale (CLR):	*The purpose of learning this course is to:*
CLR-1 :	*Identify the fundamental concepts of MES.*
CLR-2 :	*Utilize the core functions of MES.*
CLR-3 :	*Apply technical aspects of MES.*
CLR-4 :	*Identify the requirementsof the factory of the future.*
CLR-5 :	*Evaluation of Cost Effectiveness in MES.*
CLR-6 :	*Implementation in Production and its significance.*

Course Learning Outcomes (CLO):	*At the end of this course, learners will be able to:*	Learning 1	2	3	Program Learning Outcomes (PLO) 1	2	3	4	5	6	7	8	9	10	11	12	13	14	15
		Level of Thinking (Bloom)	Expected Proficiency (%)	Expected Attainment (%)	Engineering Knowledge	Problem Analysis	Design & Development	Analysis, Design, Research	Modern Tool Usage	Society & Culture	Environment & Sustainability	Ethics	Individual & Team Work	Communication	Project Mgt. & Finance	Life Long Learning	PSO - 1	PSO - 2	PSO - 3
CLO-1 :	*Apply the fundamental concepts and core function of MES*	3	90	80	H	H	H	H	-	-	-	-	M	M	M	H	H	-	H
CLO-2 :	*Understand what and why MES in modern production systems*	3	90	80	H	H	H	M	-	-	-	-	H	L	M	H	H	-	H
CLO-3 :	*Setup, analysis, and giving possible application of MES*	3	90	80	H	H	H	H	-	-	-	-	H	H	M	H	H	-	H
CLO-4 :	*Know the connection of function within production systems to MES*	3	90	80	H	M	M	M	-	-	-	-	H	M	H	H	H	-	H
CLO-5 :	*Identify the requirements of the factory of the future*	3	90	80	H	H	M	H	-	-	-	-	M	H	M	H	H	-	H
CLO-6 :	*Evaluate the Cost Effectiveness in MES*	3	90	80	H	H	L	M	-	-	-	-	L	H	M	H	H	-	H

Duration (hour)		9	9	9	9	9
S-1	SLO-1	*Historical Development of MES, Standards of MES*	*Core Function—Production Flow-OrientedDesign*	*Integration within the Overall Process*	*Software Architecture, Fundamental Variants*	*Implementing IT Systems in General*
	SLO-2	*Development of Business Data Processing*	*Cross-System Cohesiveness, Classification in the Overall System*	*Order Data Management*	*Overview of Central Components*	*Problems duringImplementation*
S-2	SLO-1	*Definitions of Terms - Classification of Terms*	*General and Complete Data Model, Origins of Master Data*	*Supply Management within the MES, Demand Planning*	*Platform Independence, Scalability*	*Preparation of the Implementation Project*
	SLO-2	*Company Management Level*	*Data Model for Product Definition, Relevant Concepts*	*Interaction between the ERP Systemand the MES, Material Warehousing Costs*	*Flexible Adjustment versus Suitability for Updates*	*Analysis of the Actual Situation*
S-3	SLO-1	*Production Management Level*	*The Operation, Work Plan, Parts List*	*The Planning Process and Planning Objectives*	*MES and Service-Oriented Architecture*	*Suitable Key Figures for SuccessMonitoring*
	SLO-2	*Control/Automation Level*	*Change Management and Product History*	*Forward Planning/Reverse Planning/Bottleneck Planning*	*Database, Resource Monitoring*	*Creation of a Project Plan*
S-4	SLO-1	*Shortfalls of ExistingArchitectures andSolutions*	*Data Model for Resource Management.*	*Collision-Free Planning of a Time Container*	*Scaling the Database System*	*Selection of a Suitable System*
	SLO-2	*Patchwork, No Common Database, Excessive Response Times*	*Description of ProductionEnvironment*	*The Importance of the Control Station*	*Data Management and Archiving, Running Maintenance*	*Implementation Process, Project Management*
S-5	SLO-1	*High Operating and ManagementOutlay*	*Description of ProductionEnvironment*	*Personnel Planning and Release of Orders*	*Interfaces with Other IT Systems*	*Training Management, Operating Concept*
	SLO-2	*Demands of Future Production ManagementSystems*	*Description of ProductionEnvironment*	*General Information on Order Processing and Classification*	*Usage and Visualization, Reporting, Automated Information Distribution*	*Sensient Technologies: Emulsions*
S-6	SLO-1	*Target Management, Integration of Applications and Data*	*Production Personnel*	*Order Preparation and Setup*	*Value-Benefit Analysis,General Information on CostEffectiveness*	*Basic Quantity Units and Production Units*
	SLO-2	*Real-Time Data Management*	*Operating Resources*	*Order Control,Managing the Production Bin, Material Flow Control*	*Performance Measurement*	*Realization and Implementation*

S-7	SLO-1	*Lean Sigma and MES*	*Materials and Preliminary Products*	*Order Processing and Operating DataRecording*	*General Information on Evaluation*	*Basic Quantity Units and ProductionUnits*
	SLO-2	*Commonalities between Existing Approachesand MES*	*Information and Documents*	*Process and Quality Assurance*	*The Benefits of an MES*	*Tasks of the MES, Challenges,*
S-8	SLO-1	*Norms and Guidelines, Recommendations*	*System and Auxiliary Data*	*Performance Data*	*Integrated Data Transparency, Reducing Time Usage*	*Realization and Implementation*
	SLO-2	*Adjacent Areas, Product Lifecycle Management*	*Order Fulfillment Data and Orders*	*Maintenance Management*	*Reducing Administration Expenses,Improved Customer Service*	*The MES as a Medium of Product-Development Management*
S-9	SLO -1	*Implementation Strategies*	*Production Data, Operating Data, andMachine Data*	*Preventive Maintenance and Repair*	*Early Warning System, Real-Time CostControl*	*Standardization of Function Modules*
	SLO -2	*Points of Contact with MES*	*Derived Performance Data and Figures*	*Alarm Management*	*The Costs of an MES*	*Merging Consultancy Activities andIT Systems*

Learning Resources	1. *Heiko Meyer, Franz Fuchs, Klaus Thiel, Manufacturing Execution Systems, McGraw-Hill, 2009.* 2. *Jürgen Kletti, Manufacturing Execution System – Springer, 2010.* 3. *Bianca Scholten, MES Guide for Executives – International society of Automation, 2009.*	*4. Michael McClellan, Applying Manufacturing Execution Systems, CRC Press, 2007.*

Learning Assessment

	Bloom's Level of Thinking	Continuous Learning Assessment (50% Weightage)								Final Examination (50% Weightage)	
		CLA – 1 (10%)		CLA – 2 (15%)		CLA – 3 (15%)		CLA – 4 (10%)#			
		Theory	Practice	Theory	Practice	Theory	Practice	Theory	Practice	Theory	Practice
Level 1	Remember Understand	40%	-	30%	-	30%	-	30%	-	30%	-
Level 2	Apply Analyze	40%	-	40%	-	40%	-	40%	-	40%	-
Level 3	Evaluate Create	20%	-	30%	-	30%	-	30%	-	30%	-
	Total	100%		100%		100%		100%		100%	

CLA – 4 can be from any combination of these: Assignments, Seminars, Tech Talks, Mini-Projects, Case-Studies, Self-Study, MOOCs, Certifications, Conf. Paper etc.,

Course Designers

Experts from Industry	Experts from Higher Technical Institutions	Internal Experts
1. Mr. P.Kartikeyan, Head – Operations Improvement, Nokia India, kartikeyan.p@nokia.com	*1. Dr.K.Senthilkumaran, Assistant professor, IIITDM, Kancheepuram, skumaran@iiitdm.ac.in*	*1. Mr.S.Thamilarasu, SRM IST*
2. Dr. R. Kalimuthu, ISRO, Mahendragiri, r_kalimuthu@vssc.gov.in	*2. Dr.B.Mohan, Professor, Anna University, mohan@mitindia.edu*	*2. Dr. Suresh Kannan I, SRMIST*
3. Dr. A. Velayutham, DRDO, Avadi, velayutham.a@cvrde.drdo.in		

Course Code	18MEE806T	Course Name	ADDITIVE MANUFACTURING TECHNOLOGY	Course Category	E	Professional Elective	L	T	P	C
							3	0	0	3

Pre-requisite Course	Nil	Co-requisite Course	Nil	Progressive Courses	Nil
Course Offering Department	Mechanical Engineering	Data Book/Codes/Standards	Nil		

Course Learning Rationale (CLR):	The purpose of learning this course is to:
CLR-1 :	*Learn about Sustainable and Green Manufacturing Techniques*
CLR-2 :	*Aspects of Green supply chain and clean energy in manufacturing*
CLR-3 :	*Understanding the principle of green manufacturing*
CLR-4 :	*Learn about green in Manufacturing Processes*
CLR-5 :	*Introduce the concept of life cycle analysis (LCA)*
CLR-6 :	*Sustainability aspects in modern manufacturing enterprises*

Course Learning Outcomes (CLO):	At the end of this course, learners will be able to:	Learning 1: Level of Thinking (Bloom)	2: Expected Proficiency (%)	3: Expected Attainment (%)	PLO 1: Engineering Knowledge	2: Problem Analysis	3: Design & Development	4: Analysis, Design, Research	5: Modern Tool Usage	6: Society & Culture	7: Environment & Sustainability	8: Ethics	9: Individual & Team Work	10: Communication	11: Project Mgt. & Finance	12: Life Long Learning	13: PSO - 1	14: PSO - 2	15: PSO - 3
CLO-1 :	*Understand the need for green and sustainable manufacturing*	1	80	70	M	-	M	-	-	-	-	-	-	-	-	-	-	-	-
CLO-2 :	*Identification of clean energy and green supply chain in manufacturing*	2	85	75	H	-	-	-	M	-	-	-	-	-	-	-	H		-
CLO-3 :	*Apply the concepts green principles and industrial ecology tools*	2	75	70	H	M	H	H	-	-	-	-	-	-	-	M	H	-	-
CLO-4 :	*Identification the strategies for green manufacturing*	2	80	75	H	-	M	-	M	-	-	-	-	-	-	-	H	-	M
CLO-5 :	*Analyze the technologies enabling green manufacturing*	1	75	70	H	-	-	M	-	-	-	-	-	-	-	M	M	-	H
CLO-6 :	*Apply the concepts of sustainability in modern manufacturing enterprises*	2	80	70	M	-	-	M	M	-	L	-	-	-	-	M	-	-	H

Duration (hour)		9	9	9	9	9
S-1	SLO-1	*History and Need of AM*	*Preparation of CAD Model:*	*Stereo lithography (SLA) : Introduction to SLA*	*Selective Laser Sintering (SLS): Introduction to SLS*	*Materials for AM: Metals, Biomaterials for AM*
	SLO-2	*Evolution of AM*	*Interfacing of CAD and AM , File formats used in AM*	*Basic concepts and Working Principle of SLA*	*Basic concepts and Working Principle of SLS*	*Polymers for AM*
S-2	SLO-1	*Basic concepts and working principle of AM*	*Introduction to STL File format*	*Constructional details for SLA*	*Constructional details for SLS*	*Ceramics for AM*
	SLO-2	*Additive Manufacturing vs Subtractive manufacturing*	*Problems (Errors) with STL file*	*Advantages of SLA*	*Advantages of SLS*	*Composites for AM*
S-3	SLO-1	*AM Process chain*	*.Reverse engineering: Need for Reverse engineering, Introduction to Co-ordinate Measuring machine (CMM)..*	*Limitations of SLA*	*Limitations of SLS*	*Applications of AM in Manufacturing and tooling*
	SLO-2	*AM Process chain*	*Reverse engineering: CMM measurement process – Data collection, Digitization from surface, Preprocessing, Surface fitting.*	*Applications of SLA*	*Applications of SLS*	*Applications of AM in Space*
S-4	SLO-1	*Rapid prototyping on product development*	*Rapid tooling*	*Fused deposition modelling (FDM) : Introduction to FDM*	*Laser Engineered Net Shaping (LENS): Introduction to LENS*	*Applications of AM in Automotive industry*
	SLO-2	*Rapid prototyping on product development*	*Rapid tooling*	*Basic concepts and Working Principle of FDM*	*Basic concepts and Working Principle of LENS*	*Applications of AM in Aerospace industry*
S-5	SLO-1	*Classification of AM processes*	*Design for AM: Part orientation*	*Constructional details for FDM*	*Constructional details for LENS*	*Applications of AM in Biomedical industry*
	SLO-2	*Classification of AM processes*	*Removal of supports*	*Advantages of FDM*	*Advantages of LENS*	*Applications of AM in Biomedical industry*

S-6	SLO-1	*Other Related technologies: Overview about other technologies related to AM*	*Hollowing out parts*	*Limitations of FDM*	*Limitations of LENS*	*Applications of AM in Jewellery industry*
	SLO-2	*Computer Aided Engineering (CAE)*	*Inclusion of Undercuts and other manufacturing constraints*	*Applications of FDM*	*Applications of LENS*	*Applications of AM in Various other fields.*
S-7	SLO-1	*Haptic based CAD*	*Interlocking features, Reduction of part count in assembly*	*Laminated Object Manufacturing (LOM) : Introduction to LOM*	*Electron Beam Melting (EBM): Introduction to EBM*	*Introduction to Direct digital manufacturing (DDM)*
	SLO-2	*Haptic based CAD*	*Identification markings / numbers*	*Basic concepts and Working Principle of LOM*	*Basic concepts and Working Principle of EBM*	*Rapid prototyping vs DDM*
S-8	SLO-1	*AM unique capabilities: Shape complexity, Hierarchical complexity*	*Engineering design rules for AM: Tolerances – Digital to Object*	*Constructional details for LOM*	*Constructional details for EBM*	*Future directions of AM*
	SLO-2	*AM unique capabilities: Functional complexity, Material complexity*	*Design freedom, Relative fit*	*Advantages of LOM*	*Advantages of EBM*	*Future directions of AM*
S-9	SLO-1	*Benefits of AM.*	*Flexures, Hinges, Snap fits*	*Limitations of LOM*	*Limitations of EBM*	*Digipronuership*
	SLO-2	*Limitations of AM.*	*Orientation and Clamping*	*Applications of LOM*	*Applications of EBM*	*Digipronuership*

Learning Resources	1. *Li Yang, Keng Hsu, Brian Baughman, Donald Godfrey, Francisco Medina, MamballykalathilMenon, Soeren Wiener, Additive Manufacturing of Metals The Technology, Materials, Design and Production", Springer 2017.* 2. *Ian Gibson, David Rosen, Brent Stucker, Additive Manufacturing Technologies_ 3D Printing, Rapid Prototyping, and Direct Digital Manufacturing", Springer 2015.*	3. *Andreas Gebhardt, Understanding Additive Manufacturing. Rapid Prototyping - Rapid Tooling - Rapid manufacturing, Hanser publications 2011.* 4. *T. S. Srivatsan and T. S. Sudarshan,"Additive Manufacturing Innovations, Advances, and Applications, Taylor & Francis group 2016.* 5. *Ali K Kamrani, EmadAbouel Nasr, Rapid prototyping - Theory and Practice", Springer 2005.*

Learning Assessment											
	Bloom's Level of Thinking	Continuous Learning Assessment (50% Weightage)								Final Examination (50% Weightage)	
		CLA – 1 (10%)		CLA – 2 (15%)		CLA – 3 (15%)		CLA – 4 (10%)#			
		Theory	Practice	Theory	Practice	Theory	Practice	Theory	Practice	Theory	Practice
Level 1	Remember Understand	40%	-	30%	-	30%	-	30%	-	30%	-
Level 2	Apply Analyze	40%	-	40%	-	40%	-	40%	-	40%	-
Level 3	Evaluate Create	20%	-	30%	-	30%	-	30%	-	30%	-
	Total	100%		100%		100%		100%		100%	

CLA – 4 can be from any combination of these: Assignments, Seminars, Tech Talks, Mini-Projects, Case-Studies, Self-Study, MOOCs, Certifications, Conf. Paper etc.,

Course Designers		
Experts from Industry	Experts from Higher Technical Institutions	Internal Experts
1. Mr. P.Kartikeyan, Head – Operations Improvement, Nokia India, kartikeyan.p@nokia.com	*1. Dr.K.Senthilkumaran, Assistant professor, IIITDM, Kancheepuram, skumaran@iiitdm.ac.in*	*1. Mr.T.Gopi, SRMIST*
2. Dr. R. Kalimuthu, ISRO, Mahendragiri, r_kalimuthu@vssc.gov.in	*2. Dr.B.Mohan, Professor, Anna University, mohan@mitindia.edu*	*2. Dr. Suresh Kannan I, SRMIST*
3. Dr. A. Velayutham, DRDO, Avadi, velayutham.a@cvrde.drdo.in		

Course Code	18MEE807T	Course Name	INDUSTRIAL ROBOTICS&MATERIAL HANDLING SYSTEMS	Course Category	E	Professional Elective	L	T	P	C
							3	0	0	3

Pre-requisite Course	Nil	Co-requisite Course	Nil	Progressive Courses	Nil
Course Offering Department	Mechanical Engineering			Data Book/Codes/Standards	Nil

Course Learning Rationale (CLR):	The purpose of learning this course is to:
CLR-1 :	*Introduce the basic concepts, parts of robots and types of robots*
CLR-2 :	*Familiar with the various drive systems for robot, sensors and theirapplications in robots and programming of robots*
CLR-3 :	*Select the robots according to its usage*
CLR-4 :	*Know about the various applications of robots, justification and implementation of robot*
CLR-5 :	*Know about material handling in a system*
CLR-6 :	*Acquire knowledge on various material handling equipment used both in automated andnon-automated systems*

Course Learning Outcomes (CLO):	At the end of this course, learners will be able to:	Learning 1 Level of Thinking (Bloom)	2 Expected Proficiency (%)	3 Expected Attainment (%)	PLO 1 Engineering Knowledge	2 Problem Analysis	3 Design & Development	4 Analysis, Design, Research	5 Modern Tool Usage	6 Society & Culture	7 Environment & Sustainability	8 Ethics	9 Individual & Team Work	10 Communication	11 Project Mgt. & Finance	12 Life Long Learning	13 PSO - 1	14 PSO - 2	15 PSO - 3
CLO-1 :	*Understand the fundamentals of robot technology, sensors, drives and systems*	2	90	85	H	-	H	L	M	-	-	-	-	-	H	-	H	-	H
CLO-2 :	*Recognize the ideas about robot cell design, work cell control*	2	90	85	H	-	H	L	M	-	-	-	-	-	H	-	H	-	H
CLO-3 :	*Have knowledge about various applications of robots in material handling*	1	90	85	M	-	M	L	M	-	-	-	-	-	L	-	H	-	H
CLO-4 :	*Understand the concepts of automated material handling and its types*	2	90	85	L	-	L	L	M	-	-	-	-	-	M	-	H	-	H
CLO-5 :	*Identify the application of automated guided vehicles in material handling*	1	90	85	M	-	H	L	M	-	-	-	-	-	M	-	H	-	H
CLO-6 :	*Recognize about vehicle guidance and routing in material handling*	2	90	85	H	-	H	L	M	-	-	-	-	-	M	-	H	-	H

Duration (hour)		9	9	9	9	9
S-1	SLO-1	*Automation and Robotics*	*Robot cell layouts- Robot centered cell*	*General consideration in Robot Material Handling*	*Automated material handling*	*Automated Guided Vehicle Systems - Introduction*
	SLO-2	*History of Robots*	*In line Robot cell*	*Material Transfer Application*	*Hand trucks, Powered trucks*	*Introduction to Drones*
S-2	SLO-1	*Robot Anatomy*	*Mobile robot cell*	*Pick and place operations*	*Cranes monorails and Hoists*	*Driverless Trains*
	SLO-2	*Robot configurations*	*Multiple robots and machine Interface*	*Palletizing and related operations*	*Conveyors systems*	*AGVs Pallet Trucks*
S-3	SLO-1	*Robot motions, Joint Notation Scheme*	*MR- MI Example*	*Machine loading and unloading*	*Selection of material handling equipment*	*AGVs Unit load carriers*
	SLO-2	*Work volume*	*Other considerations in work cell design*	*Die casting, plastic molding*	*Principles of material handling*	*Driverless train operation*
S-4	SLO-1	*Polar, Cylindrical, Cartesian*	*Work cell control*	*Forging, Machining operations*	*Roller, stake wheel conveyor*	*Storage/ Distribution system*
	SLO-2	*Robot drive systems*	*Sequence control*	*Stamping press operations*	*Belt, chain conveyors*	*Assembly line operation*
S-5	SLO-1	*Speed of motion*	*operation interface*	*Robots in spot welding*	*Overhead trolley conveyor*	*Miscellaneous operation*
	SLO-2	*Load carrying capacity*	*Safety monitoring*	*Robots in arc welding*	*slat conveyors*	*Functions of AGV*
S-6	SLO-1	*4 types of robot control system*	*Interlocks*	*Problems for Robots in arc welding*	*In floor towline conveyor*	*Vehicle guidance and routing*
	SLO-2	*Precision of movement*	*Error detection and recovery*	*Features of the welding robot*	*Cart on track conveyor*	*Operation of on board sensor system*
S-7	SLO-1	*End effectors- types of grippers*	*Work cell controller*	*Sensors in arc welding robot*	*Other handling equipment, Dial Indexing tables*	*Frequency select, path switch select method*

	SLO-2	*Gripper selection and design*	*Robot controller*	*Vision based systems, Benefits*	*Elevators, Pipelines*	*Traffic control and safety*
S-8	SLO-1	*Transducers and sensors*	*Electro mechanical Relays, Programmable controllers*	*Robots in Spray coating*	*Containers, Highway Tractor trailers*	*On board vehicle sensing, zone blocking*
	SLO-2	*Tactile sensors*	*A computer as the work cell controller*	*Immersion and flow coating, Spray coating methods*	*Railway trains, Cargo aircraft, Ship, barges.*	*System management, On board control panel*
S-9	SLO-1	*Proximity and Range sensors*	*Robot cycle time analysis*	*Benefits of robot spray coating*	*Types of AS / RS*	*Remote call stations, Central computer control*
	SLO-2	*Uses of sensors in robotics*	*Elements in RTM*	*Other Processing operations using robots*	*Advanced ware housing robots, Applications.*	*Automotive Intelligent vehicles*

Learning Resources	1. *Mikell P Groover, Mitchell Weiss, Rogen N Nagel, Nicholas G Odrey, Ashish Dutta, Industrial Robotics Technology,Programmming, and Applications, Tata McGraw Hill Special Indian Edition, 2012.* 2. *K.Lalit Narayan, K.Mallikarjuna Rao, Computer Aided Design and Manufacturing, Prentice Hall of India, 2008.* 3. *Mikell P Groover, Mitchell Weiss, Roger N Nagel, Industrial Robotics Technology, Programming, and Applications, Tata McGraw Hill Publishers, 2008.*	4. *S.R.Deb, S.Deb, Robotics Technology & Flexible Automation, Tata McGraw-Hill Education, 2012.* 5. *James A Rehg, Introduction to Robotics in CIM system, Prentice Hall, 2002.* 6. *S.K.Saha, Introduction to Robotics, Tata McGraw Hill Publishing Company Limited, 2014.*

Learning Assessment

	Bloom's Level of Thinking	Continuous Learning Assessment (50% Weightage)								Final Examination (50% Weightage)	
		CLA – 1 (10%)		CLA – 2 (15%)		CLA – 3 (15%)		CLA – 4 (10%)#			
		Theory	Practice	Theory	Practice	Theory	Practice	Theory	Practice	Theory	Practice
Level 1	Remember Understand	40%	-	30%	-	30%	-	30%	-	30%	-
Level 2	Apply Analyze	40%	-	40%	-	40%	-	40%	-	40%	-
Level 3	Evaluate Create	20%	-	30%	-	30%	-	30%	-	30%	-
	Total	100%		100%		100%		100%		100%	

CLA – 4 can be from any combination of these: Assignments, Seminars, Tech Talks, Mini-Projects, Case-Studies, Self-Study, MOOCs, Certifications, Conf. Paper etc.,

Course Designers

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3. Dr. A. Velayutham, DRDO, Avadi, velayutham.a@cvrde.drdo.in		

Course Code	18MEE808T	Course Name	SUSTAINABLE GREEN MANUFACTURING	Course Category	E	Professional Elective	L	T	P	C
							3	0	0	3

Pre-requisite Course	Nil	Co-requisite Course	Nil	Progressive Courses	Nil
Course Offering Department	Mechanical Engineering	Data Book/Codes/Standards	Nil		

Course Learning Rationale (CLR):	The purpose of learning this course is to:
CLR-1 :	*Learn about Sustainable and Green Manufacturing Techniques*
CLR-2 :	*Aspects of Green supply chain and clean energy in manufacturing*
CLR-3 :	*Understanding the principle of green manufacturing*
CLR-4 :	*Learn about green in Manufacturing Processes*
CLR-5 :	*Introduce the concept of life cycle analysis (LCA)*
CLR-6 :	*Sustainability aspects in modern manufacturing enterprises*

Course Learning Outcomes (CLO):	At the end of this course, learners will be able to:	Learning 1: Level of Thinking (Bloom)	2: Expected Proficiency (%)	3: Expected Attainment (%)	PLO 1: Engineering Knowledge	2: Problem Analysis	3: Design & Development	4: Analysis, Design, Research	5: Modern Tool Usage	6: Society & Culture	7: Environment & Sustainability	8: Ethics	9: Individual & Team Work	10: Communication	11: Project Mgt. & Finance	12: Life Long Learning	13: PSO - 1	14: PSO - 2	15: PSO - 3
CLO-1 :	*Understand the need for green and sustainable manufacturing*	2	90	90	H	H	-	-	-	H	H	-	-	-	-	H	-	-	H
CLO-2 :	*Identification of clean energy and green supply chain in manufacturing*	2	85	80	H	-	H	H	-	H	H	-	-	-	-	H	-	-	H
CLO-3 :	*Apply the concepts green principles and industrial ecology tools*	2	85	80	H	-	M	L	-	H	H	-	-	-	-	-	-	-	H
CLO-4 :	*Identification the strategies for green manufacturing*	2	85	85	M	L	-	-	-	H	H	-	-	-		H	-	-	M
CLO-5 :	*Analyze the technologies enabling green manufacturing*	2	90	85	M	L	H	H	M	H	H	-	H	-	-	H	-	-	M
CLO-6 :	*Apply the concepts of sustainability in modern manufacturing enterprises*	2	85	70	H	H	H	H	M	H	H	-	H	-	-	H	-	-	M

Duration (hour)		9	9	9	9	9
S-1	SLO-1	*Concept of Sustainability*	*Introduction to thermodynamics analysis in manufacturing processes*	*Principle of Green Manufacturing*	*Functions and types of cutting fluids*	*Introduction to Green supply chain*
	SLO-2	*Introduction to green Manufacturing*	*Thermodynamic framework of manufacturing processes*	*Cleaner Production , Dematerialization*	*Problems related to cutting fluids*	*Green Supply Chain*
S-2	SLO-1	*Motivations for sustainable development*	*Estimation of minimum work for materials transformations*	*Closed Loop Production systems Economic and Ecological Benefits of Closed-Loop Systems*	*Dry machining*	*Issues in Green supply Chain Techniques*
	SLO-2	*Motivations for sustainable Manufacturing*	*Estimation of minimum work for materials transformations*	*Design for Disassembly, Industrial Metabolism*	*Advantages and Limitations*	*Green packaging*
S-3	SLO-1	*Productivity and sustainability*	*Estimation of minimum work for materials transformations*	*Adoption of low carbon technologies*	*Near dry machining*	*The Packaging supply chain*
	SLO-2	*Metrics for green manufacturing*	*Temperature and Pressure Changes for Open Materials-Processing Systems*	*Need to reduce the carbon footprint of manufacturing operations*	*Advantages, Disadvantages*	*Future of Green Supply Chain*
S-4	SLO-1	*Societal metrics*	*Energy use for elastic – plastic deformation*	*Life Cycle assessment*	*Minimum Quantity Lubrication systems*	*Lean Production*
	SLO-2	*Economic Metrics*	*Electric energy used in manufacturing processes*	*Life cycle assessment elements*	*Economics of Environmentally Friendly Machining*	*Types of wastes*
S-5	SLO-1	*Environmental metrics*	*Resource accounting*	*Life cycle assessment procedure*	*Development of Environmentally Friendly cutting fluids, cutting tools and machine tools*	*Lean Manufacturing Techniques*
	SLO-2	*Barriers to Green Manufacturing*	*Introduction to Clean Energy Technologies*	*Life Cycle Assessment (LCA) of Machine tools*	*Enabling Technologies for Green Manufacturing*	*Agile Manufacturing*

S-6	SLO-1	*Advantages and Limitations of Green manufacturing*	*Solar Photovoltaic*	*Design for Environment*	*Sustainable solutions*	*Components of the agile manufacturing system/enterprise*
	SLO-2	*Environmental Impact of Manufacturing*	*Wind Energy*	*Product life extension and the service economy*	*Adoptrontics in Machine tools*	*Comparison between agile and traditional manufacturing enterprises*
S-7	SLO-1	*Standards for green manufacturing*	*Fuel cells*	*Eco Labelling, Industrial Ecology tools*	*Reconfigurable Machine tools*	*Analysis of Manufacturing Firms for Agility*
	SLO-2	*ISO 14000*	*Comparison of lean Energy Technologies*	*Case studies in Industrial Ecology*	*Process Monitoring System*	*Remanufacturing*
S-8	SLO-1	*OHSAS 18000*	*Application Potentials of clean energy supply in green manufacturing*	*Case studies in Industrial Ecology*	*Smart building blocks*	*Recycling*
	SLO-2	*Sustainability rating schemes*	*Cost benefit of environmental emission mitigation through clean energy supply*	*How is Industrial Ecology Viewed by Industry*	*Add-ons for machine tool upgrade*	*Materials for sustainability and recycling*
S-9	SLO-1	*Strategies for Green Manufacturing*	*Technological Performance of clean Energy Supply.*	*Awareness of Industrial Ecology and its components*	*Applying Sensor Flows in Decision Making (Automated Manufacturing) Manufacturing Complexity*	*Sustainability Assessments of Competitive Manufacturing Strategies*
	SLO-2	*Strategies for Green Manufacturing*	*Energy efficient manufacturing processes*	*Case studies of product improvement and redesign*	*Environmental implications of nano manufacturing and Semiconductor manufacturing*	*Sustainability Assessment for Industrial Estates*

Learning Resources	1. *Dornfeld, David A., ed. Green manufacturing: fundamentals and applications. Springer Science & Business Media, 2012.* 2. *Gouge, Michael, and Pan Michaleris, eds. Thermo-mechanical modeling of additive manufacturing. Butterworth-Heinemann, 2017.* 3. *Davim, J. Paulo, ed. Sustainable Manufacturing. John Wiley & Sons, 2013.* 4. *Dixit, Uday S., D. K. Sarma, and J. Paulo Davim. Environmentally friendly machining. Springer Science & Business Media, 2012.* 5. *Stark, Rainer, GüntherSeliger, and JérémyBonvoisin. Sustainable Manufacturing. Springer, 2017.*	6. *Garbie, Ibrahim. Sustainability in manufacturing enterprises: Concepts, analyses and assessments for industry 4.0. Springer, 2016.* 7. *Madu, Christian N., ed. Handbook of environmentally conscious manufacturing. Springer Science & Business Media, 2012.* 8. *Fiksel, Joseph. Design for environment: a guide to sustainable product development: eco-efficient product development. McGraw Hill Professional, Boston, 2009.*

Learning Assessment											
	Bloom's Level of Thinking	Continuous Learning Assessment (50% Weightage)								Final Examination (50% Weightage)	
		CLA – 1 (10%)		CLA – 2 (15%)		CLA – 3 (15%)		CLA – 4 (10%)			
		Theory	Practice	Theory	Practice	Theory	Practice	Theory	Practice	Theory	Practice
Level 1	Remember Understand	40%	-	30%	-	30%	-	30%	-	30%	-
Level 2	Apply Analyze	40%	-	40%	-	40%	-	40%	-	40%	-
Level 3	Evaluate Create	20%	-	30%	-	30%	-	30%	-	30%	-
	Total	100%		100%		100%		100%		100%	

CLA – 4 can be from any combination of these: Assignments, Seminars, Tech Talks, Mini-Projects, Case-Studies, Self-Study, MOOCs, Certifications, Conf. Paper etc.,

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3. Dr. A. Velayutham, DRDO, Avadi, velayutham.a@cvrde.drdo.in		

Course Code	18MEE809J	Course Name	DATABASE MANAGEMENT SYSTEM	Course Category	E	Professional Elective	L	T	P	C
							2	0	2	3

Pre-requisite Course	Nil	Co-requisite Course	Nil	Progressive Courses	Nil
Course Offering Department	Mechanical Engineering	Data Book/Codes/ Standards	Nil		

Course Learning Rationale (CLR):	*The purpose of learning this course is to:*
CLR-1 :	*To impart an introduction to the theory and practice of database systems*
CLR-2 :	*To learn various database models and query language.*
CLR-3 :	*To understand effective manipulation of memory space for database files.*
CLR-4 :	*To understand the normalization in building effective database table*
CLR-5 :	*To protect the data and database from foreign access*

Course Learning Outcomes (CLO):	*At the end of this course, learners will be able to:*	Learning 1: Level of Thinking (Bloom)	2: Expected Proficiency (%)	3: Expected Attainment (%)	PLO 1: Engineering Knowledge	2: Problem Analysis	3: Design & Development	4: Analysis, Design, Research	5: Modern Tool Usage	6: Society & Culture	7: Environment & Sustainability	8: Ethics	9: Individual & Team Work	10: Communication	11: Project Mgt. & Finance	12: Life Long Learning	13: PSO - 1	14: PSO - 2	15: PSO - 3
CLO-1 :	*Develop the terminology and features in database*	2	90	85	H	M	-	M	-	-	-	-	M	H	-	M	-	-	-
CLO-2 :	*Analyze the information of storage details*	2	90	85	H	L	-	-	-	-	-	-	-	H	-	L	-	-	-
CLO-3 :	*Transform an information into relational database*	2	90	85	H	M	M	M	-	-	-	-	M	H	-	H	-	-	-
CLO-4 :	*Ability to work in data manipulation*	2	90	85	H	L	-	-	-	-	-	-	M	L	-	L	-	-	-
CLO-5 :	*Analyze the Client/Server and Internet Database Environment*	2	90	85	H	M	-	L	-	-	-	-	-	H	-	M	-	-	-
CLO-6 :	*Write queries for design and manipulation of database table using MySQL or Oracle*	2	90	85	H	H	M	M	M	-	-	-	M	H	-	H	-	-	-

Duration (hour)		12	12	12	12	12
S-1	SLO-1	*Introduction to database Systems*	*Entity types*	*Relational Model*	*Structured Query Language (SQL)*	*Introduction to parallel database*
	SLO-2	*History of DBMS applications*	*Entity sets*	*Structural of database*	*SQL Data definition*	*I/O Parallelism*
S-2	SLO-1	*File System versus a DBMS*	*Attributes and Keys*	*Structure of relational Databases*	*Queries on Single Relation*	*Lab 13: Simple PL/SQL Programs, Use of Exceptions, Cursor, Procedure, Function, Trigger, Sequence*
	SLO-2	*Database Language*	*Basic building blocks*	*Keys, Schema Diagram*	*Queries on multiple Relations*	
S-3	SLO-1	*Lab 1: Creating database table*	*Levels of data abstraction*	*Relational Algebra*	*Overview of SQL*	*Security :Database security – Granting,Removing*
	SLO-2		*Physical Schemas and Conceptual Schemas*	*Relational Algebra - Set Operation, Renaming,*	*Basic structure of SQL Queries*	*Type of Security*
S-4	SLO-1	*Lab 2: DDL Commands*	*Overview ofEntity-Relationship (E-R) Model*	*Relational Algebra - Joins*	*Lab 9:Simple queries*	*Control measures*
	SLO-2		*Relationship set, Entity set*	*Relational Algebra - Division*		*Database Recovery*
S-5	SLO-1	*Database Interface*	*Database design and Entity-Relationship(ER) Model, Design alternatives*	*Lab 7: Joining tables*	*Lab 10: Nested queries*	*Storage, Data access*
	SLO-2	*Form based Interface, Graphical based Interface*	*Constraints, Entity-Relationship (ER)-Diagrams, Roles and Structural Constraints*			*Buffer Management*
S-6	SLO-1	*Database Environment*	*Lab 4: Basic SELECT statements*	*Relational Algebra - Division*	*Data definition commands, DML Commands, Set operations*	*Database – Backup*
	SLO-2	*Database Component Modules*		*Extended Relational Algebra Operations*	*Aggregate functions*	*Recovery Algorithm*
S-7	SLO-1	*Database System utilities*	*Lab 5: Advanced SELECT statements*	*Views*	*Lab 11:Creation, Insertion, Updating, Deletion ofViews operation*	*Lab 14: DBMS for CAD software design*
	SLO-2	*Database System Architecture*		*Functional Dependency*		

S-8	SLO-1	*Lab 3: Data Manipulation Commands*	*Entity-Relationship(ER) Design Issues*	*Various process in designing a Database*	*Aggregate functions - Basic aggregation*	*Emerging Database technology - Mobile database*
	SLO-2		*E-R Model and Enhanced entity-relationship (EER) Model*	*Lab 8: Basic SQL functions*	*Aggregate functions- Aggregation with Grouping*	*Emerging Database technology - Multimedia database*
S-9	SLO-1	*Data Independence*	*Enhanced entity-relationship (EER) Model*		*Lab 12: Basics of PL/SQL*	*Access controls*
	SLO-2	*Data Mappings*	*Enhanced entity-relationship(EER)-Specialization*	*Normalization using functional dependencies*		*Security for internet applications*
S-10	SLO-1	*Structure of DBMS*	*Enhanced entity-relationship(EER)-Generalization*	*Decomposition*	*Null values, Joins, Nested queries*	*Web Technology in Smart Manufacturing*
	SLO-2	*Security and Authorization,*	*Enhanced entity-relationship(EER)-Attribute Inheritance*	*Boyce-Codd Normal Form*	*Client/Server Database Environment*	*Web Technology in Smart Manufacturing*
S-11	SLO-1	*Database Turning*	*Constrain on Generalization*	*DBMS application in Computer Integrated manufacturing*	*Basics of Ontology Language and its applications.*	*DBMS for computer integrated manufacturing*
	SLO-2	*Data Models*	*Aggregation*	*3NF, Correctness of the 3NF Algorithm*	*Design Challenges in SPARQL,*	*Material Handling System Design*
S12	SLO-1	*Types of DBMS*	*Lab 6: Constraints in Tables*	*Comparison of BCNF and 3NF*	*SPARQL Query Forms,*	*Lab 15:Report Generation for Material Handling System Design*
	SLO-2	*Objective data model and Hierarchical data model*		*Normalization using multivalued dependencies*	*SPARQL Graph Patterns*	

Learning Resources	1. *RamezElmasri, Shanmkant B., Fundamentals of Database System, 5th Edition, Pearson, 2011.* 2. *Silberschatz, Abraham, Henry F. Korth, and ShashankSudarshan. Database system concepts. Vol. 4. New York: McGraw-Hill, 1997.* 3. *Ramakrishnan, Raghu, and Johannes Gehrke. Database management systems. McGraw Hill, 2000.* 4. *Hansen, Gary W., and James V. Hansen. Database management and design. 1996.*	5. *Peter rob, Carlos Coronel, Database Systems – Design, Implementation, and Management , 9th Edition, 2009, Thomson Learning System* *Software Needed: Oracle 8, MySQL*

Learning Assessment											
	Bloom's Level of Thinking	Continuous Learning Assessment (50% Weightage)								Final Examination (50% Weightage)	
		CLA – 1 (10%)		CLA – 2 (15%)		CLA – 3 (15%)		CLA – 4 (10%)			
		Theory	Practice	Theory	Practice	Theory	Practice	Theory	Practice	Theory	Practice
Level 1	Remember Understand	40%	-	30%	-	30%	-	30%	-	30%	-
Level 2	Apply Analyze	40%	-	40%	-	40%	-	40%	-	40%	-
Level 3	Evaluate Create	20%	-	30%	-	30%	-	30%	-	30%	-
	Total	100%		100%		100%		100%		100%	

CLA – 4 can be from any combination of these: Assignments, Seminars, Tech Talks, Mini-Projects, Case-Studies, Self-Study, MOOCs, Certifications, Conf. Paper etc.,

Course Designers		
Experts from Industry	Experts from Higher Technical Institutions	Internal Experts
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3. Dr. A. Velayutham, DRDO, Avadi, velayutham.a@cvrde.drdo.in		

ACADEMIC CURRICULA

Professional Elective Courses

MECHATRONICS ENGINEERING

Regulations - 2018

SRM INSTITUTE OF SCIENCE AND TECHNOLOGY

(Deemed to be University u/s 3 of UGC Act, 1956)

Kattankulathur, Kancheepuram, Tamil Nadu, India

Course Code	18MHE401T	Course Name	ELEMENTS OF MECHATRONICS SYSTEMS	Course Category	E	Professional Elective	L	T	P	C
							3	0	0	3

Pre-requisite Courses	Nil	Co-requisite Courses	Nil	Progressive Courses	Nil
Course Offering Department	Mechatronics Engineering	Data Book / Codes/Standards			Nil

Course Learning Rationale (CLR):	*The purpose of learning this course is to:*
CLR-1 :	*Identify the key elements of mechatronics system and the design issues*
CLR-2 :	*Identify the different types of sensors used in mechatronics system*
CLR-3 :	*Identify the different types of actuators used in mechatronics system*
CLR-4 :	*Identify the different types of controllers used in mechatronics system*
CLR-5 :	*Identify the mechatronics system applied for different applications*
CLR-6 :	*Utilize the elements of mechatronics systemsfor different applications*

Course Learning Outcomes (CLO):	*At the end of this course, learners will be able to:*	Learning			Program Learning Outcomes (PLO)														
		1	2	3	1	2	3	4	5	6	7	8	9	10	11	12	13	14	15
		Level of Thinking (Bloom)	Expected Proficiency (%)	Expected Attainment (%)	Engineering Knowledge	Problem Analysis	Design & Development	Analysis, Design, Research	Modern Tool Usage	Society & Culture	Environment & Sustainability	Ethics	Individual & Team Work	Communication	Project Mgt. & Finance	Life Long Learning	PSO - 1	PSO - 2	PSO - 3
CLO-1 :	*Analyze the various elements of mechatronics system*	1	85	80	H	L	-	H	M	-	L	L	M	-	-	-	M	-	-
CLO-2 :	*Analyze the different types of sensor for developing a mechatronics system*	2	85	80	H	H	-	H	M	-	L	L	M	-	-	-	-	-	-
CLO-3 :	*Analyze the different types of actuators for developing a mechatronics system*	2	85	80	H	H	-	H	M	-	L	L	M	-	-	-	-	-	-
CLO-4 :	*Analyze the different types of controllers for developing a mechatronics system*	2	85	80	H	H	-	H	M	-	L	L	M	-	-	-	-	-	-
CLO-5 :	*Apply the mechatronics elements in to various applications*	2	85	80	H	H	-	H	M	-	L	L	M	-	-	-	-	-	-
CLO-6 :	*Apply the sensors and actuators for developing a mechatronics system*	2	85	80	H	H	-	H	M	-	L	L	M	-	-	-	-	-	-

		Introduction to Mechatronics Systems	Sensors	Actuation System	Controllers	Applications of Mechatronics Systems
Duration (hour)		9	9	9	9	9
S-1	SLO-1	*Introduction to mechatronics system*	*Sensor characteristics*	*Introduction to electrical ,mechanical, hydraulic and pneumatic actuation system*	*Proportional, Integral controller*	*Car park barriers using PLC.*
	SLO-2	*Definition of mechatronics: Concurrent and sequential integration*	*Signal conditioning system*	*Solid state switches*	*Derivative and PID controller*	*Bar code reader*
S-2	SLO-1	*The Design process*	*Resistive sensors*	*Construction and operation of solenoids*	*Example: Boiler control using PID*	*Coin counting machine*
	SLO-2	*Mechatronics design elements*	*Types and working principle*	*Relay Construction, working principle, Types and applications.*	*Introduction to Micro controller*	*Conveyor based material handling system*
S-3	SLO-1	*Measurement system*	*Capacitive sensors*	*DC motor: Construction and principle of operation*	*Architecture of M68HC11 microcontroller*	*Computer controlled CNC drilling machine*
	SLO-2	*Actuation system*	*Types and working principle*	*AC motor: construction and principle of operation*	*Architecture of ATMEGA328 microcontroller*	*Computer controlled CNC drilling machine*
S-4	SLO-1	*Control system*	*Inductive transducers*	*Stepper motors: Construction and principle of operation*	*Signal processing, Multiplexer and Demultiplexer*	*Electronic car engine management system*
	SLO-2	*Control system*	*Types and working principle*	*Types of stepper motor*	*Dataacquisition system*	*Solenoid operated fuel injector: construction and operation*
S-5	SLO-1	*Introduction to microprocessor based controllers*	*Temperature sensors*	*Servo motors: Construction, principle of operation*	*Types: A/D converters*	*Electronic control of steering system*
	SLO-2	*Intelligent control*	*Types and working principle*	*Types of servo motor*	*Types: D/A converters*	*Autonomous guided vehicle (AGV)*
S-6	SLO-1	*System integration*	*Pressure sensors*	*Construction and operation of Synchronous motor*	*Basic structure, Programming units and Memory ofProgrammable logic controller*	*Automatic vehicle transmission system*

	SLO-2	*Integrated design issues in mechatronics*	*Types and working principle*	*Construction and operation of BLDC motor*	*Input and Output Modules, Mnemonics for programming*	*Wind screen wiper using stepper motor control*
S-7	SLO-1	*Hardware in loop simulation*	*Nano sensor Parameters and characteristics. Necessity of Nano scale measurements*	*Construction and operation of PMDC motor*	*Timers*	*Pneumatic controlled three axis Pick and place robot*
	SLO-2	*Shaft speed control*	*Magneto resistance Nano sensor, Hall effect Nano sensor*	*Pressure control valve*	*Counters and Shift Registers*	*Obstacle avoidance robot*
S-8	SLO-1	*Water level controller*	*NEMS accelerometer*	*Rotary actuators and cylinders*	*Latching and Internal relays*	*Self-balancing robot*
	SLO-2	*Open loop and closed loop temperature control system*	*Silicon nanowire accelerometer*	*Hydraulic and pneumatic systems with example*	*Master relay and Jump Controls*	*Actuation of robotic gripper using SMA wire*
S-9	SLO-1	*Washing machine control*	*Optical displacement Nano sensor, Magneto motive displacement Nano sensor*	*Mechanical actuation system :Types of motion*	*Programming the PLC using Ladder diagram for Simpleapplications*	*Nano mechanical cantilever based manipulation for sensing and imaging.*
	SLO-2	*Digital camera control*	*Piezoresistive and Piezoelectric displacement Nano sensor*	*Kinematic chains, Cams actuation with example, Gear trains with example*	*Programming the PLC using Ladder diagram for Simpleapplications*	*Swam of self-organized nano Robots.*

Learning Resources	1. *Bolton, W., "Mechatronics", Addison Wesley, 2nd edition, New Delhi, 1999.* 2. *Vinod Kumar Khanna., "Nanosensors: Physical, Chemical and Biological", CRC press, 2012* 3. *Gabor L. Hornyak., John J. Moore., H.F. Tibbals, JoydeepDutta., "Fundamentals of Nanotechnology", CRC Press, 2009.*	4. *ConstantinosMavroidis, Antoine Ferreira., "Nanorobotics: Current Approaches and Techniques", Springer 2013.* 5. *Bradley.D.A, Dawson.DBurdN.C.and Loader A.J, "Mechatronics", Chapman and Hall Publications,New York, 1993.* 6. *Rohner.P, "Automation with Programmable Logic Controllers", Macmillan / McGraw Hill, New York,1996.* 7. *Jacob Fraden, "Handbook of Modern Sensors Physics, Designs, and Applications", Third Edition,Springer-Verlag New York, 2004.*

Learning Assessment

	Bloom's Level of Thinking	Continuous Learning Assessment (50% weightage)								Final Examination (50% weightage)	
		CLA – 1 (10%)		CLA – 2 (15%)		CLA – 3 (15%)		CLA – 4 (10%)#			
		Theory	Practice	Theory	Practice	Theory	Practice	Theory	Practice	Theory	Practice
Level 1	Remember Understand	30 %	-	30 %	-	30 %	-	30 %	-	30%	-
Level 2	Apply Analyze	40 %	-	40 %	-	40 %	-	40 %	-	40%	-
Level 3	Evaluate Create	30 %	-	30 %	-	30 %	-	30 %	-	30%	-
	Total	100 %		100 %		100 %		100 %		100 %	

CLA – 4 can be from any combination of these: Assignments, Seminars, Tech Talks, Mini-Projects, Case-Studies, Self-Study, MOOCs, Certifications, Conf. Paper etc.,

Course Designers

Experts from Industry	Experts from Higher Technical Institutions	Internal Experts
1. Mr. C. Purushothaman, ABB India Ltd, Chennai, purushothaman.c@in.abb.com	*1. Dr.G.Sakthivel, VIT University, Chennai, sakthivel.g@vit.ac.in.*	*1. Mr.R.Gangadevi, SRMIST*
2. Mr.J. Srinivasan, KONE Elevator India Private Limited,Chennai, srinikone@gmail.com	*2. Dr.R.AmuthaKannan, National University, Muscat,amuthakkannan@nu.edu.om.*	*2. Mr.A. JosinHippolitous, SRMIST*

Course Code	18MHE402T	Course Name	FUNDAMENTALS OF ROBOTICS	Course Category	E	Professional Elective	L	T	P	C
							3	0	0	3

Pre-requisite Courses	Nil	Co-requisite Courses	Nil	Progressive Courses	Nil
Course Offering Department		Mechatronics Engineering	Data Book / Codes/Standards	Nil	

Course Learning Rationale (CLR):	The purpose of learning this course is to:
CLR-1 :	*Introduce the various architecture of industrial robot*
CLR-2 :	*Introduce the vector transformation applied to robotics*
CLR-3 :	*Introduce the forward and inverse kinematics applied to serial manipulator robot*
CLR-4 :	*Emphasize on the various actuators and transmission element used in robot. Also to define various control strategy used in manipulator robotics*
CLR-5 :	*Introduce the formulation of various trajectories*

Course Learning Outcomes (CLO):	At the end of this course, learners will be able to:	Learning 1 Level of Thinking (Bloom)	2 Expected Proficiency (%)	3 Expected Attainment (%)	PLO 1 Engineering Knowledge	2 Problem Analysis	3 Design & Development	4 Analysis, Design, Research	5 Modern Tool Usage	6 Society & Culture	7 Environment & Sustainability	8 Ethics	9 Individual & Team Work	10 Communication	11 Project Mgt. & Finance	12 Life Long Learning	13 PSO - 1	14 PSO - 2	15 PSO - 3
CLO-1 :	*Understand the architecture and basic technical terms used in robotics*	2	80	70	H	M	M	H	M	-	-	-	-	-	-	H	H	-	-
CLO-2 :	*Learn the application of vector transformation in robotics*	2	80	70	H	H	M	H	M	-	-	-	-	-	-	H	H	-	-
CLO-3 :	*Learn to compute the forward and inverse kinematics model for various configuration of serial manipulator*	2	80	70	H	H	M	H	M	-	-	-	H	-	-	H	H	-	-
CLO-4 :	*Understand the various actuators and transmission elements used in robot. Also will learn the various control and trajectory planning algorithm*	2	80	70	H	H	H	H	M	-	-	-	M	-	-	H	H	-	-
CLO-5 :	*Understand the trajectory planning techniques and various industrial workcell*	2	80	70	H	H	M	H	M	-	-	-	M	-	-	H	H	-	-

		Introduction to Robotics	Transformations	Manipulator Kinematics	Introduction to sensors and actuators in robotics	Trajectory planning and work cell
Duration (hour)		7	12	8	9	9
S-1	SLO-1	*Definition of Robot, Laws of Robotics,*	*Description of point in space*	*Introduction to Manipulator Kinematics*	*Basic actuators and transmission elements*	*Introduction-Trajectory Planning.*
	SLO-2	*Basic terminologies used in robotics*	*Description of body in space*	*Forward Kinematics*	*Mathematical model of DC motor*	*Approach and importance of trajectory planning*
S-2	SLO-1	*Classification based on application*	*Review of Vectors*	*Forward Kinematics of RR planar manipulator- geometric approach*	*Harmonic Drives*	*Joint space and Cartesian space planning*
	SLO-2	*Classification based on work volume*	*Vector representation of points and bodies*	*Numerical*	*Computation of reduction ratio of harmonic drive and its advantage*	*Difference with an example*
S-3	SLO-1	*Definition – precision, repeatability and accuracy*	*Translation- Numerical*	*DH formulation*	*Force sensor and its uses*	*Cubic Polynomial trajectory planning*
	SLO-2	*Co-ordinate systems used in robotics, Degree of freedom with examples*	*Rotation-Numerical*	*Difference between modified and standard DH convention with example of RR planar manipulator*	*Maltese cross configuration*	*Problem on Cubic Polynomial trajectory planning*
S-4	SLO-1	*Links and various joints in robotics*	*Representing Rotation- Rotation Matrix*	*Forward kinematics of 3R spatial articulated arm*	*Importance of force control using force sensor*	*Case study on trajectory planning for manipulator robot*
	SLO-2	*Anatomy of Robot*	*Properties of Rotation matrix*	*Derivation of final DH matrix for 3R spatial articulated arm*	*Case study – Application of force sensor*	*Case study on trajectory planning for manipulator robot*
S-5	SLO-1	*RPY wrist*	*Numerical on rotation matrix*	*Forward kinematics of RPY wrist*	*Tactile sensor*	*Robot work cell layout*
	SLO-2	*Configuration space and operational space*	*Numerical on rotation matrix*	*Derivation of final DH matrix for RPY wrist*	*Various Tactile sensors- principle and working*	*Classification of robot work cell*
S-6	SLO-1	*Robot data sheet interpretation*	*Representing Rotation- Euler angles*	*Forward kinematics of 4 DOF SCARA robot*	*Slip Sensor*	*Multiple robot*
	SLO-2	*Important terms and finding in datasheet of manufacturer*	*Numerical*	*Derivation of final DH matrix for 4 DOF SCARA robot*	*Slip Sensor*	*Work cell control*

S-7	SLO-1	*Robot End effector*	*Representing Rotation- Equivalent axis representation*	*Introduction to Inverse kinematics*	*Application of tactile and slip sensor*	*Safety monitoring*
	SLO-2	*Types of gripper*	*Numerical*	*Inverse Kinematics of RR planar manipulator- Geometric approach*	*Case Study*	*Error detection and recovery*
S-8	SLO-1		*Difference between Current axis and fixed axis representation*	*Issues in Inverse Kinematics*	*Vision system for robot*	*Robot Cycle time analysis*
	SLO-2		*Numerical*	*Issues in Inverse Kinematics*	*Vision architecture block diagram*	*Economic analysis of robot*
S-9	SLO-1		*Homogenous Transformation*		*Case study on Vision based control*	*Criteria for selection of robot work cell*
	SLO-2		*Numerical*		*Case study on Vision based control*	*Case Study- Selection of robot based on application*
S-10	SLO-1		*Operators and Mapping Concept*			
	SLO-2		*Case Study- Numerical*			
S-11	SLO-1		*Compound Transformation*			
	SLO-2		*Case Study*			
S-12	SLO-1		*Case study of transformations in robotics*			
	SLO-2		*Case study of transformations in robotics*			

Learning Resources	*1. Mikell P. Groover, "Industrial Robotics", McGraw Hill, 2nd edition, 2012.* *2. John J. Craig, "Introduction to Robotics", Addison Wesley, ISE 2008.* *3. Deb S.R., "Robotics Technology and Flexible Automation", Tata McGraw - Hill Publishing Company Limited, 2012...*	*4. ArthorCritchlow, "Introduction to Robotics", Macmillan, 2009.* *5. Mohsen Shahinpoor, "A Robot Engineering Text Book", Harper and Row, 2004* *6. Mittal R.K., and Nagrath I.J., "Robotics and Control", 1st edition, Tata McGraw Hill, 2007.*

Learning Assessment

	Bloom's Level of Thinking	Continuous Learning Assessment (50% weightage)								Final Examination (50% weightage)	
		CLA – 1 (10%)		CLA – 2 (15%)		CLA – 3 (15%)		CLA – 4 (10%)#			
		Theory	Practice	Theory	Practice	Theory	Practice	Theory	Practice	Theory	Practice
Level 1	Remember Understand	40 %	-	30 %	-	30 %	-	30 %	-	30%	-
Level 2	Apply Analyze	40 %	-	40 %	-	40 %	-	40 %	-	40%	-
Level 3	Evaluate Create	20 %	-	30 %	-	30 %	-	30 %	-	30%	-
	Total	100 %		100 %		100 %		100 %		100 %	

CLA – 4 can be from any combination of these: Assignments, Seminars, Tech Talks, Mini-Projects, Case-Studies, Self-Study, MOOCs, Certifications, Conf. Paper etc.,

Course Designers

Experts from Industry	Experts from Higher Technical Institutions	Internal Experts
1.Mr.Ganesh Ram, Intel Labs ,Bangalore, ganeshram.nandakumar.@intel.com	*1. Dr., R. Thiyagarajan, Visiting faculty, IIT Madras, thiyaguiitm@gmail.com*	*1. Dr. G. Murali, SRMIST*
2. Mr. Mohammed Sagheer ,Wabco Technology Center ,India, mohammedsagheer.musthafa@wabco-auto.com	*2. Dr., P Karthikeyan, MIT,Anna University, pkarthikeyan@annauniv.edu*	*2. Ranjith Pillai R, SRMIST*

Course Code	18MHE403T	Course Name	INDUSTRIAL INSTRUMENTATION AND CONTROL	Course Category	E	Professional Elective	L	T	P	C
							3	0	0	3

Pre-requisite Courses	Nil	Co-requisite Courses	Nil	Progressive Courses	Nil
Course Offering Department	Mechatronics Engineering	Data Book / Codes/Standards	Nil		

Course Learning Rationale (CLR):	*The purpose of learning this course is to:*
CLR-1 :	*Gain the knowledge of industrial automation*
CLR-2 :	*Identify the need for process control*
CLR-3 :	*Build the various concepts of PID tuning*
CLR-4 :	*Utilize the control algorithm for actuators*
CLR-5 :	*Gain knowledge of programmable logic controllers*
CLR-6 :	*Introduce the knowledge of distributed control systems*

Course Learning Outcomes (CLO):	*At the end of this course, learners will be able to:*	Learning			Program Learning Outcomes (PLO)														
		1	2	3	1	2	3	4	5	6	7	8	9	10	11	12	13	14	15
		Level of Thinking (Bloom)	Expected Proficiency (%)	Expected Attainment (%)	Engineering Knowledge	Problem Analysis	Design & Development	Analysis, Design, Research	Modern Tool Usage	Society & Culture	Environment & Sustainability	Ethics	Individual & Team Work	Communication	Project Mgt. & Finance	Life Long Learning	PSO - 1	PSO - 2	PSO - 3
CLO-1 :	*Knowledge of industrial automation*	2	75	70	H	H	M	H	M	-	-	-	-	-	-	H	H	H	H
CLO-2 :	*Knowledge of process control*	3	75	70	H	H	M	H	M	-	-	-	-	-	-	H	M	M	M
CLO-3 :	*Design of PID based control tuning methods*	3	75	70	H	H	M	H	M	-	-	-	-	-	-	H	M	M	M
CLO-4 :	*Application of control algorithm for actuators*	3	75	70	H	H	M	H	M	-	-	-	-	-	-	H	M	M	M
CLO-5 :	*knowledge of programmable logic controllers*	3	75	70	H	H	M	H	M	-	-	-	-	-	-	H	M	M	M
CLO-6 :	*Interpret the knowledge of distributed control systems*	3	75	70	H	H	M	H	H	-	-	-	-	-	-	H	H	H	H

		Industrial Automation	Process Control	Controlling of Actuators	Programmable Logic Controllers	Distributed Control Systems
Duration (hour)		9	9	9	9	9
S-1	SLO-1	*Evolution of instrumentation and control.*	*Introduction of Process control*	*Need of Machine tools control*	*Introduction of sequence Control*	*Introduction to Distributed Control Systems*
	SLO-2	*Need of instrumentation and control.*	*Need of Process control*	*Need of Machine tools control*	*Need of sequence Control*	*Need of Distributed Control Systems*
S-2	SLO-1	*Need of automation in industry*	*Basics of P I D control*	*Need of CNC Machines*	*Need of Programmable Logic Controllers*	*Concept of Distributed Control Systems*
	SLO-2	*Role of automation in industry*	*Implementation of PID controllers*	*Components of CNC Machines*	*Need of Programmable Logic Controllers*	*Components of Distributed Control Systems*
S-3	SLO-1	*Components of industrial automation systems*	*Need for controller tuning*	*Analysis of a control loop*	*Concepts of Relay Ladder Logic*	*Functions of DCS*
	SLO-2	*Architecture of industrial automation systems*	*Steps in controller tuning*	*Analysis of a control loop*	*Need of Relay Ladder Logic*	*Advantages and limitations of DCS*
S-4	SLO-1	*Need for sensors*	*Need of digital controllers*	*Adjustable field drives*	*Scan cycle*	*DCS as an automation tool*
	SLO-2	*Need for measurement systems*	*Significance of digital controllers*	*DC motor drive*	*RLL Syntax*	*Enterprise Resource Planning by DCS*
S-5	SLO-1	*Pressure measurement*	*Principles of predictive control*	*Need of variable frequency control*	*Analog control using PLC*	*Schematic block diagram of DCS*
	SLO-2	*Force measurement*	*Principles of predictive control*	*Variable frequency control of induction motor drive*	*Analog control using PLC*	*Schematic block diagram of DCS*
S-6	SLO-1	*Need of temperature measurement*	*Control of systems with inverse response*	*Need of closed loop control*	*Advanced RLL programming*	*Need of date acquisition*
	SLO-2	*Thermocouple and Thermistor*	*Control of systems with inverse response*	*Closed loop synchronous motor drive*	*Advanced RLL programming*	*Concepts of data acquisition*
S-7	SLO-1	*Displacement measurement*	*Special control structures*	*Need of proportional valve in fluid power systems*	*PLC interfacing to SCADA/DCS using Communications links*	*Specifications involved in DCS*
	SLO-2	*Speed measurement*	*Concepts of cascade control*	*Implementation of proportional valve in fluid power systems*	*PLC interfacing to SCADA/DCS using Communications links*	*Specifications involved in DCS*
S-8	SLO-1	*Measurement of level*	*Introduction of automation tools*	*Need of proportional valve in fluid power systems*	*Need for industrial Ethernet*	*Latest trends in DCS*

	SLO-2	*Measurement of humidity and pH*	*PLC and DCS*	*Implementation of proportional valve in fluid power systems*	*Implementation of industrial Ethernet*	*Latest developments in DCS*
S-9	SLO-1	*Need for Signal Conditioning*	*SCADA*	*PID based pneumatic controllers for positioning*	*Advanced applications of PLC*	*SCADA specifications for different real time applications*
	SLO-2	*Need for Signal processing*	*Hybrid DCS/PLC*	*PID based pneumatic controllers for positioning*	*Advanced applications of PLC*	*SCADA specifications for different real time applications*

Learning Resources	1. *William .C. Dunn., "Fundamentals of industrial instrumentation and process control", McGraw-Hill Publications, 2005.* 2. *Patranabis. D., "Principles of industrial instrumentation", Tata McGraw-Hill, 3rd edition, 2010.* 3. *Bolton. W., "Programmable logic controllers", Newnes Publications, 4th edition, 2006.*	4. *Groover. M.P., "Automation, production systems and computer integrated manufacturing", 3rd edition, Prentice Hall of India, 2007.* 5. *Stuart A Boyer., "SCADA supervisory control and data acquisition", International society of automation (ISA) Publications, 4th edition, 2010.*

Learning Assessment

	Bloom's Level of Thinking	Continuous Learning Assessment (50% weightage)								Final Examination (50% weightage)	
		CLA – 1 (10%)		CLA – 2 (15%)		CLA – 3 (15%)		CLA – 4 (10%)#			
		Theory	Practice	Theory	Practice	Theory	Practice	Theory	Practice	Theory	Practice
Level 1	Remember Understand	30 %	-	30 %	-	30 %	-	30 %	-	30%	-
Level 2	Apply Analyze	40 %	-	40 %	-	40 %	-	40 %	-	40%	-
Level 3	Evaluate Create	30 %	-	30 %	-	30 %	-	30 %	-	30%	-
	Total	100 %		100 %		100 %		100 %		100 %	

CLA – 4 can be from any combination of these: Assignments, Seminars, Tech Talks, Mini-Projects, Case-Studies, Self-Study, MOOCs, Certifications, Conf. Paper etc.,

Course Designers

Experts from Industry	Experts from Higher Technical Institutions	Internal Experts
1. Mr. K.P.Srinivasan, Visteon Automotive Electronics Limited, Chennai, psriniv1@visteon.com	*1. Dr. B. Mohan, Anna University, Chennai, mohan@mitindia.edu*	*1. Dr. T. Muthuramalingam, SRMIST*
2. Mr. S. EllanChezhiyan, Keyence Microscope Limited, Chennai, ellanchezhian@gmail.com	*2. Dr. D. Saravanakumar, Vellore Institute of Technology, Chennai, saravanakumar.d@vit.ac.in.*	*2. Dr. M. Mohamed Rabik, SRMIST*

Course Code	18MHE404T	Course Name	INDUSTRIAL AUTOMATION	Course Category	E	Professional Elective	L	T	P	C
							3	0	0	3

Pre-requisite Courses	Nil	Co-requisite Courses	Nil	Progressive Courses	Nil
Course Offering Department	Mechatronics Engineering	Data Book / Codes/Standards	Nil		

Course Learning Rationale (CLR):	*The purpose of learning this course is to:*
CLR-1 :	*Identify potential areas for automation and justify need for automation.*
CLR-2 :	*Select suitable major control components required to automate a process.*
CLR-3 :	*Translate and simulate a real time activity using modern tools*
CLR-4 :	*Discuss the benefits of automation.*
CLR-5 :	*Identify the suitable automation hardware for the given application.*
CLR-6 :	*Model and simulate tool for the given manufacturing operation.*

Course Learning Outcomes (CLO):	*At the end of this course, learners will be able to:*	Learning 1 Level of Thinking (Bloom)	2 Expected Proficiency (%)	3 Expected Attainment (%)	Program Learning Outcomes (PLO) 1 Engineering Knowledge	2 Problem Analysis	3 Design & Development	4 Analysis, Design, Research	5 Modern Tool Usage	6 Society & Culture	7 Environment & Sustainability	8 Ethics	9 Individual & Team Work	10 Communication	11 Project Mgt. & Finance	12 Life Long Learning	13 PSO - 1	14 PSO - 2	15 PSO - 3
CLO-1 :	*Identify potential areas for automation and justify need of it.*	2	75	70	H	M	M	H	M	L	M	L	M	M	-	H	H	H	H
CLO-2 :	*Analyze suitable major control components required to automate a process.*	3	75	70	H	M	M	H	M	L	M	-	M	M	L	H	H	H	H
CLO-3 :	*Able to Translate and simulate a real time activity using modern tools*	3	75	70	H	M	M	M	L	L	M	L	M	M	L	H	-	-	-
CLO-4 :	*Analyze discuss the benefits of automation.*	3	75	70	H	M	M	-	L	L	M	L	-	M	L	H	H	H	H
CLO-5 :	*Analyze suitable automation hardware for the given application.*	3	75	70	H	M	M	H	L	-	M	L	M	M	L	H	-	-	-
CLO-6 :	*Apply Model and simulate tool for the given manufacturing operation.*	3	75	70	H	M	-	H	M	L	M	L	M	M	L	H	H	H	H

Duration (hour)		Automation in production system	Automated manufacturing systems	Industrial control systems.	Computer based industrial control	Modeling and simulation for plant automation:
		9	9	9	9	9
S-1	SLO-1	*Automation in production system,*	*Automated manufacturing systems:*	*Industrial control systems.*	*Computer based industrial control*	*Modeling and simulation for plant automation:*
	SLO-2	*principles and strategies of automation,*	*Components, classification and*	*Process industries*	*Need for the system*	*Introduction and process.*
S-2	SLO-1	*Basic elements of an automated system.*	*overview of manufacturing systems,*	*Discrete manufacturing industries.*	*Automatic process control.*	*Need for system modeling.*
	SLO-2	*Functions of automation*	*Manufacturing cells.*	*Process industries versus discrete manufacturing industries.*	*Building blocks of automation systems:*	*Building model of a plant.*
S-3	SLO-1	*levels of automations*	*Group technology*	*Control systems*	*LAN*	*Cement plant*
	SLO-2	*Advanced automation*	*Cellular manufacturing.*	*Basic elements of control system*	*Interface.*	*Thermal plant*
S-4	SLO-1	*flow lines*	*Flexible manufacturing system*	*Continuous control*	*Computer Networks*	*water treatment plant*
	SLO-2	*transfer mechanisms*	*planning for FMS*	*Discrete control.*	*Topology.*	*Steel plant*
S-5	SLO-1	*fundamentals of transfer lines*	*Implementation of FMS*	*Continuous versus discrete control.*	*Analog I/O Modules,*	*Modern tools*
	SLO-2	*Material handling systems: Introduction*	*Quality control systems,*	*Regulatory control*	*Digital I/O Modules,*	*Future perspective.*
S-6	SLO-1	*principles and design considerations*	*traditional and modern quality control methods*	*Feed forward control.*	*SCADA systems*	*Industrial control applications: Cement plant*
	SLO-2	*Material transport systems – out bound*	*SPC tools.*	*Automated control*	*Real-time user interface.*	*Design and implementation*
S-7	SLO-1	*Introduction, conveyors.*	*inspection principles*	*Adaptive control*	*Distributed control system,*	*thermal plant*
	SLO-2	*Industrial robots*	*practices*	*Definition, Types*	*Functional requirements.*	*Design and implementation*
S-8	SLO-1	*Automated guided vehicles.*	*Inspection technologies.*	*Comparisons*	*Elements of DCS*	*Industrial control applications: Water treatment plant*
	SLO-2	*Storage systems:*	*overview of automatic identification methods*	*online strategies*	*Configurations of DCS.*	*Design and implementation*
S-9	SLO-1	*Automatic storage and retrieval systems.*	*Barcode readers*	*Computer process*	*Popular distributed control systems.*	*Industrial control applications: steel plant*
	SLO-2	*Realtime Application*	*Machine vision systems.*	*Forms of computer process*	*Realtime Application*	*Design and implementation*

Learning Resources	1. P.Groover, "Automation, Production Systems and Computer Integrated Manufacturing", Pearson Education, 5th edition, 2009. 2. Krishna Kant, "Computer Based Process Control", Prentice Hall of India, 2nd edition, 2010. 3. Tiess Chiu Chang and Richard A. Wysk, "An Introduction to Automated Process Planning Systems", Prentice Hall of India, 1985.	4. Viswanandham, "Performance Modeling of Automated Manufacturing Systems", Prentice Hall of India, 1st edition, 2009. 5. S.K.Singh, "Computer Aided Process Control", Prentice Hall of India, 1st edition, 2004.

Learning Assessment

	Bloom's Level of Thinking	Continuous Learning Assessment (50% weightage)								Final Examination (50% weightage)	
		CLA – 1 (10%)		CLA – 2 (15%)		CLA – 3 (15%)		CLA – 4 (10%)#			
		Theory	Practice	Theory	Practice	Theory	Practice	Theory	Practice	Theory	Practice
Level 1	Remember Understand	30 %	-	30 %	-	30 %	-	30 %	-	30%	-
Level 2	Apply Analyze	40 %	-	40 %	-	40 %	-	40 %	-	40%	-
Level 3	Evaluate Create	30 %	-	30 %	-	30 %	-	30 %	-	30%	-
	Total	100 %		100 %		100 %		100 %		100 %	

CLA – 4 can be from any combination of these: Assignments, Seminars, Tech Talks, Mini-Projects, Case-Studies, Self-Study, MOOCs, Certifications, Conf. Paper etc.,

Course Designers		
Experts from Industry	Experts from Higher Technical Institutions	Internal Experts
1. Dr. A. Velayutham, DRDO, Avadi, velayudham.a@cvrde.drdo.in	*Dr.R.Sivaramakrishnan, MIT, Anna University, Chennai*	*1. Dr. B K Vinayagam, SRMIST*
2. Mr. ElayarajSivaraj, Tesla,California, elayaraj@hotmail.com	*Dr. R.ArockiaRajan, IIT-Madras, Chennai*	*2. Mr. S,Vigneshwaran, SRMIST*

Course Code	18MHE405T	Course Name	MANUFACTURING INFORMATION SYSTEMS	Course Category	P	Professional Elective	L	T	P	C
							3	0	0	3

Pre-requisite Courses	Nil	Co-requisite Courses	Nil	Progressive Courses	Nil
Course Offering Department	Mechatronics Engineering	Data Book / Codes/Standards	Nil		

Course Learning Rationale (CLR):	*The purpose of learning this course is to:*
CLR-1 :	*Understand the Concepts of information*
CLR-2 :	*Identify the information generated in manufacturing industry*
CLR-3 :	*Understandthe concepts of database systems in manufacturing industry*
CLR-4 :	*Understand the database design and architecture*
CLR-5 :	*Comprehend the computerized manufacturing information systems*
CLR-6 :	*Understand computerized production planning and scheduling systems*

Course Learning Outcomes (CLO):	*At the end of this course, learners will be able to:*	Learning 1	2	3	Program Learning Outcomes (PLO) 1	2	3	4	5	6	7	8	9	10	11	12	13	14	15
		Level of Thinking (Bloom)	Expected Proficiency (%)	Expected Attainment (%)	Engineering Knowledge	Problem Analysis	Design & Development	Analysis, Design, Research	Modern Tool Usage	Society & Culture	Environment & Sustainability	Ethics	Individual & Team Work	Communication	Project Mgt. & Finance	Life Long Learning	PSO - 1	PSO - 2	PSO - 3
CLO-1 :	*Identify the various concepts of information with respect to products and processes in manufacturing industry*	2	90	85	H	L	-	M	-	-	-	-	L	-	-	-	-	L	L
CLO-2 :	*Identify the orderly arrangement of information flow in the manufacturing processes*	2	90	85	H	H	-	M	-	-	-	-	L	-	-	-	-	L	L
CLO-3 :	*Compare the different types of database systems and utilize the most appropriate one for a given manufacturing industry*	2	90	85	H	M	-	H	-	-	-	-	L	-	-	-	-	L	L
CLO-4 :	*Identify the suitable database design and architecture for a given manufacturing industry*	2	90	85	H	M	-	H	-	-	-	-	L	-	-	-	-	L	L
CLO-5 :	*Select the rational computerized manufacturing system for the products*	2	90	85	H	H	-	H	-	-	-	-	L	-	-	-	-	L	L
CLO-6 :	*Chose the rational computer based production management system for production data control, customer order servicing and plant control*	2	90	85	H	H	-	H	-	-	-	-	L	-	-	-	-	L	L

Duration (hour)		INTRODUCTION	DATA PROCESSING	DATA HANDLING	DATA FORM	NEED OF COMPUTER IN MANUFACTURING
		9	9	9	9	9
S-1	SLO-1	*Need for manufacturing*	*Introduction to data base system*	*Introduction to relational database.*	*Basic QBE and multiple relations*	*Parts oriented production information system concept*
	SLO-2	*Need for manufacturing*	*Need for database system*	*Introduction to relational database.*	*Basic QBE and multiple relations*	*Parts oriented production information system concept*
S-2	SLO-1	*Macroscopic view of manufacturing organization*	*Need for database system*	*Integrity constraints over relations*	*Aggregates, condition box, data base design: Schema refinement*	*Parts oriented production information system structure*
	SLO-2	*Macroscopic view of manufacturing organization*	*Benefits of database approach*	*Integrity constraints over relations*	*Aggregates, condition box, data base design: Schema refinement*	*Parts oriented production information system structure*
S-3	SLO-1	*Principal properties of manufacturing information: MRP I*	*Data and data models*	*Enforcing integrity constraint*	*Functional dependencies and reasoning*	*Computerized production scheduling*
	SLO-2	*Principal properties of manufacturing information: MRP II*	*Data and data models*	*Enforcing integrity constraint*	*Functional dependencies and reasoning*	*Computerized production scheduling*
S-4	SLO-1	*Principal properties of manufacturing information: SFC*	*Entity and relationship diagram*	*Querying relational data*	*Trivial and non-trivial dependencies.*	*Online production control system*
	SLO-2	*Principal properties of manufacturing information: MPS*	*Diagram, database design with E/R model*	*Logical database design.*	*Trivial and non-trivial dependencies.*	*Online production control system*
S-5	SLO-1	*Information principles of manufacturing*	*Data independence and stored fields*	*Translating ER model to relational model.*	*Closure of a set of dependencies and attributes.*	*Computer based production management system: Engineering and production data control*
	SLO-2	*Information principles of manufacturing*	*Records and files.*	*Translating ER model to relational model*	*Closure of a set of dependencies and attributes.*	*Computer based production management system: Engineering and production data control*
S-6	SLO-1	*Measurement of manufacturing information*	*Three levels of architecture: External*	*Relational algebra and queries*	*Normal forms and normalization: First form*	*Computer based production management system: Customer order servicing*

	SLO-2	*Information physics, Communication approach*	*Three levels of architecture: Internal and conceptual.*	*Syntax and semantics*	*Normal forms and normalization: Second form*	*Computer based production management system: Customer order servicing*
S-7	SLO-1	*Synthesis of manufacturing information*	*Mappings*	*Form of basic SQL query*	*Normal forms and normalization: Third form*	*Computer based production management system: Forecasting*
	SLO-2	*Information intensity and value matrices*	*DBMS functions and components*	*Form of basic SQL query*	*Normal forms and normalization: Third normal form*	*Computer based production management system: Plant maintenance and control*
S-8	SLO-1	*Dual nature of manufacturing information*	*Data Communication*	*Union, intersect and except*	*Multi valued dependency and fourth normal form*	*Computerized manufacturing information system, case study*
	SLO-2	*Performance maximization rules*	*Data Communication*	*Nested queries*	*Multi valued dependency and fourth normal form*	*Computerized manufacturing information system, case study*
S-9	SLO-1	*Materialization of manufacturing information*	*Distributed processing*	*Aggregate queries and null values*	*Join dependencies and fifth normal form*	*Computerized manufacturing information system, case study*
	SLO-2	*Materialization of manufacturing information*	*Distributed processing*	*Triggers and active databases*	*Join dependencies and fifth normal form*	*Computerized manufacturing information system, case study*

Learning Resources	1. *Date.C.J., "An Introduction to Database Systems", Addison Wesley, 8th edition 2003.* 2. *Raghu Ramakrishnan and Johannes Gehrke, "Data Base Management Systems", McGraw- Hill Higher Education, 3rd edition 2002.* 3. *Luca G.Sartori, "Manufacturing Information Systems", Addison-Wesley Publishing Company, 1988. Reference Books/Other Reading Materials*	4. *FranjoCecelja, "Manufacturing Information and Data systems – Analysis, Design and Practice", ISBN: 978-1-85718-031-2, Elsevier, 2002.* 5. *John A. Schey, Introduction to manufacturing processes, 3rd ed., McGraw-Hill, 2000* 6. *Zude Zhou, Shane (Shengquan) XieDejun Chen, "Fundamentals of Digital Manufacturing Science", ISBN 978-0-85729-563-7, Springer-Verlag London Limited, 2012.*

Learning Assessment											
	Bloom's Level of Thinking	Continuous Learning Assessment (50% weightage)								Final Examination (50% weightage)	
		CLA – 1 (10%)		CLA – 2 (15%)		CLA – 3 (15%)		CLA – 4 (10%)#			
		Theory	Practice	Theory	Practice	Theory	Practice	Theory	Practice	Theory	Practice
Level 1	Remember Understand	40 %	-	30 %	-	30 %	-	30 %	-	30%	-
Level 2	Apply Analyze	40 %	-	40 %	-	40 %	-	40 %	-	40%	-
Level 3	Evaluate Create	20 %	-	30 %	-	30 %	-	30 %	-	30%	-
	Total	100 %		100 %		100 %		100 %		100 %	

\# CLA – 4 can be from any combination of these: Assignments, Seminars, Tech Talks, Mini-Projects, Case-Studies, Self-Study, MOOCs, Certifications, Conf. Paper etc.,

Course Designers		
Experts from Industry	Experts from Higher Technical Institutions	Internal Experts
1. Dr. A. Velayutham, DRDO, Avadi, velayudham.a@cvrde.drdo.in	*Dr.R.Sivaramakrishnan, MIT, Anna University, Chennai*	*1. Dr. B K Vinayagam, SRMIST*
2. Mr. ElayarajSivaraj, Tesla,California, elayaraj@hotmail.com	*Dr. R.ArockiaRajan, IIT-Madras, Chennai*	*2. Mr. J.Arivarasan, SRMIST*

Course Code	18MHE406T	Course Name	INDUSTRIAL ELECTRONICS	Course Category	E	Professional Elective	L	T	P	C
							3	0	0	3

Pre-requisite Courses	18MHC103T, 18MHC204T	Co-requisite Courses	NIL	Progressive Courses	NIL
Course Offering Department	Mechatronics Engineering	Data Book / Codes/Standards	NIL		

Course Learning Rationale (CLR):	The purpose of learning this course is to:
CLR-1 :	*Identify different Regulators and utilize them in different Regulated Power supply circuits*
CLR-2 :	*Recognizes the concept of heating and welding.*
CLR-3 :	*Identify working principle of different speed control methods for DC and AC motor.*
CLR-4 :	*Apply Power semiconductor switching devices concept in industrial applications.*
CLR-5 :	*Identify the principle of chopper to drive servo motors*
CLR-6 :	*Gain knowledge on regulators for regulated power supplies, Power Semiconductor devices for industrial applications, operate DC and AC drives using converters.*

Course Learning Outcomes (CLO):	At the end of this course, learners will be able to:	Learning 1 Level of Thinking (Bloom)	2 Expected Proficiency (%)	3 Expected Attainment (%)	PLO 1 Engineering Knowledge	2 Problem Analysis	3 Design & Development	4 Analysis, Design, Research	5 Modern Tool Usage	6 Society & Culture	7 Environment & Sustainability	8 Ethics	9 Individual & Team Work	10 Communication	11 Project Mgt. & Finance	12 Life Long Learning	13 PSO - 1	14 PSO - 2	15 PSO - 3
CLO-1 :	*Analyze various regulators used in Power supplies*	3	75	70	H	L	M	H	M	-	L	L	M	M	-	H	-	-	-
CLO-2 :	*Interpret the working principle of heating and welding in order to apply the advanced controls to improve their knowledge in understanding the concept of heating and welding.*	3	75	70	H	M	M	H	H	-	M	L	H	M	-	H	-	-	-
CLO-3 :	*Explore themselves familiar with functions of several industrial motor controls.*	3	75	70	H	L	M	H	M	-	L	L	M	M	-	H	-	-	-
CLO-4 :	*Operate various industrial appliances using Power semiconductor switching devices*	3	75	70	H	-	L	H	M	-	H	L	M	M	-	H	-	-	-
CLO-5 :	*Operate UPS and servo motors using Choppers*	3	75	70	H	-	L	H	M	-	M	L	M	M	-	H	-	-	-
CLO-6 :	*Identify power semiconductor devices, regulators, choppers, heating and welding, speed control methods for operating electric drives.*	3	75	70	H	L	M	H	M	-	L	L	M	M	-	H	-	-	-

		Introduction to Regulators and Power Supplies	Heating and Welding Control	Industrial Motor Control	Industrial Application of Power Switching Devices	AC Power Conditioner
Duration (hour)		9	9	9	9	9
S-1	SLO-1	*Concept of regulation, block diagram of a regulated power supply*	*Electronic control of heating: Introduction, Types*	*Method of controlling speed of DC motor*	*Principle of operation of automatic battery charger using SCR*	*Power supply noise*
	SLO-2	*Significance of regulated power supply.*	*Electronic control of heating: Resistance heating principle, Induction heating*	*Basic control circuit: DC motor control*	*Working of automatic battery charger using SCR*	*Different forms of noise.*
S-2	SLO-1	*Performance parameters: Major specifications of a regulated power supply, line and load regulation, output ripple and transients.*	*Induction heating: Principle of operation*	*Speed control of DC motors: Types*	*Principle of operation of emergency light using SCR.*	*Servo system: Fundamentals of Servo motor*
	SLO-2	*Concepts of fold back limiting, short circuit and overload protection.*	*Electronic control of heating: effects of supply frequency and source voltage, choice of frequency,*	*Speed control of small DC motors-operating principle*	*Working of emergency light using SCR.*	*Servo system: Principle of Servo motor*
S-3	SLO-1	*Principle of series regulators*	*Electronic control of heating: advantages and applications*	*Solid state motor control: Speed control of DC shunt motor using thyristor technology.*	*Principle of operation of Time delay relay circuit*	*Principle of buck-boost control of a servo controlled voltage stabilizer*
	SLO-2	*Types of Series regulators*	*High frequency induction heating: Fundamentals, Operation*	*Speed control of DC shunt motor using thyristor technology.*	*Working of Time delay relay circuit*	*Working of buck-boost control of a servo controlled voltage stabilizer*
S-4	SLO-1	*Principles of shunt regulators: Types*	*High frequency induction heating: Types*	*PLL control of a DC motor control*	*Automatic temperature control circuit.*	*Servo-controlled voltage stabilizer, Constructional features*
	SLO-2	*Types of shunt regulators*	*Electronic heaters employed for induction heating.*	*Over-voltage and Over load protection of DC motors.*	*Automatic temperature control circuit: types.*	*Servo-controlled voltage stabilizer: Principle of operation*
S-5	SLO-1	*Three terminal voltage regulator ICs: Positive, negative and variable applications.*	*Operation of Electronic heaters employed for induction heating.*	*AC motor control: Methods*	*Battery operated inverter circuit using power transistor*	*Ferro-resonant AC regulator- Synchro: Constructional features*
	SLO-2	*Three terminal voltage regulator ICs: negative and variable applications.*	*Thyristorised supplies used in induction furnaces*	*Speed control of three phase induction motor*	*Illumination control using SCR*	*Ferro-resonant AC regulator- Synchro: Principle of operation*

S-6	SLO-1	*Switched Mode Power Supply: Basic working principles*	*Dielectric heating: Working principle*	*Speed control of single phase induction motor.*	*Illumination control using DIAC.*	*UPS- Introduction, Types*
	SLO-2	*Switched Mode Power Supply: applications, advantages and disadvantages.*	*Dielectric heating: Advantages and disadvantages, Applications*	*Speed control of single phase induction motor.*	*Illumination control using TRIAC.*	*UPS - Principle of operation Online UPS*
S-7	SLO-1	*Concept of floating and grounded power supplies*	*Electronic control of welding, electric welding*	*TRIAC as a starter for single phase induction motors and universal series motor.*	*Electronic timers: Introduction*	*UPS - Principle of operation Offline UPS*
	SLO-2	*Concept of floating and grounded power supplies: interconnections to obtain multiple output supplies.*	*Classification of resistance welding.*	*Operation of TRIAC as a starter for single phase induction motors and universal series motor.*	*Advantages of Electronic timers*	*Advantages and Applications of UPS, Comparison of different types of UPS*
S-8	SLO-1	*Switch Mode Power Supply: Fly back converter.*	*Control circuit for resistance welding*	*Applications of AC line voltage controllers circuit.*	*Electronic timers: Sequential timer.*	*Principle of operation of choppers: Types*
	SLO-2	*Switch Mode Power Supply: forward/buck converter*	*Operation of Control circuit for resistance welding*	*Zero voltage switching circuit.*	*Digital timer*	*Principle of operation of step up chopper.*
S-9	SLO-1	*Switch Mode Power Supply: Boost converter and buck-boost converter*	*AC resistance heating.*	*Synchronous tap changer circuit.*	*Electronic time delay circuits.*	*Principle of operation of step down chopper.*
	SLO-2	*Switch Mode Power Supply: cuk converter.*	*Operation and circuit of AC resistance heating*	*AC power control of a lamp dimmer circuit.*	*Electronic time delay circuits: Advantages, Applications.*	*Principle of operation of reversible chopper.*

Learning Resources	1. *S. Bhattacharya, S. Chatterjee, "Industrial Electronics And Control", Tata McGraw Hill, 2006.* 2. *Dubey, G.K., Doradia. S.R., Joshi.A. andSingh.R.M., "Thyristorised Power Controllers", Wiley Eastern Limited, 2008.* 3. *Biswanath Paul, "Industrial Electronics and Control", Prentice Hall India publisher , 2004.*	4. *Chitode .J.S, "Industrial Electronics", Technical Publications, 2009.* 5. *G. K. Mithal, "Industrial and Power Electronics", Khanna Publishers, Delhi, 2000.* 6. *M. H. Rashid, "Power Electronics Circuits, Devices and Application", Prentice Hall of India, 3rd edition, 2004.* 7. *Terry Baltelt, "Industrial electronics, devices, systems and applications", Delmar publishers, 2006.* 8. *Stephan L.Herman, Walter N.Alerich, "Industrial Motor Control", 4th edition, Delmar publishers, 2010.*

Learning Assessment											
	Bloom's Level of Thinking	Continuous Learning Assessment (50% weightage)								Final Examination (50% weightage)	
		CLA – 1 (10%)		CLA – 2 (15%)		CLA – 3 (15%)		CLA – 4 (10%)#			
		Theory	Practice	Theory	Practice	Theory	Practice	Theory	Practice	Theory	Practice
Level 1	Remember Understand	30 %	-	30 %	-	30 %	-	30 %	-	30%	-
Level 2	Apply Analyze	40 %	-	40 %	-	40 %	-	40 %	-	40%	-
Level 3	Evaluate Create	30 %	-	30 %	-	30 %	-	30 %	-	30%	-
	Total	100 %		100 %		100 %		100 %		100 %	

CLA – 4 can be from any combination of these: Assignments, Seminars, Tech Talks, Mini-Projects, Case-Studies, Self-Study, MOOCs, Certifications, Conf. Paper etc.,

Course Designers		
Experts from Industry	Experts from Higher Technical Institutions	Internal Experts
1.Mr.S.AnandaKumar, Deputy Chief Engineer, Control & Instrumentation, NLC India Ltd.,sith.anandkumar@gmail.com	*1. Dr.M.Jagadeeshkumar,SriSaiRam Institute of Technology, jagadeeshkumar.eee@sairamit.edu.in*	*1.Dr.M.SanthoshRani,SRMIST*
2. Mrs.T.Priya,Sr.Design Engineer, Electrical & Instrumentation, KavinEngg and Services Pvt. Ltd, priya@kavinengg.com	*2. Dr.S.S. Dash,Government College of Engineering Kednhhar,Odisha, munu_dash_2k@yahoo.com*	*2. Mrs.V.Krithika, SRMIST*

Course Code	18MHE407T	Course Name	GEOMETRIC MODELLING	Course Category	C	Professional Core	L	T	P	C
							3	0	0	3

Pre-requisite Courses	Nil	Co-requisite Courses	Nil	Progressive Courses	Nil
Course Offering Department	Mechatronics Engineering	Data Book / Codes/Standards	Nil		

Course Learning Rationale (CLR):	The purpose of learning this course is to:
CLR-1 :	Gain the knowledge in fundamentals of Graphics and transformations.
CLR-2 :	Impart the Knowledge in modeling of CAD system.
CLR-3 :	Learn the various algorithm used in geometric modelling
CLR-4 :	Understand the mathematical concept of Model assembly for a machine elements
CLR-5 :	Distinguish data exchange standards and common file types in CAD

Course Learning Outcomes (CLO):	At the end of this course, learners will be able to:	Learning 1 Level of Thinking (Bloom)	2 Expected Proficiency (%)	3 Expected Attainment (%)	PLO 1 Engineering Knowledge	2 Problem Analysis	3 Design & Development	4 Analysis, Design, Research	5 Modern Tool Usage	6 Society & Culture	7 Environment & Sustainability	8 Ethics	9 Individual & Team Work	10 Communication	11 Project Mgt. & Finance	12 Life Long Learning	13 PSO - 1	14 PSO - 2	15 PSO - 3
CLO-1 :	Gain knowledge in fundamentals of Graphics and transformations.	1	85	80	H	H	-	H	-	-									
CLO-2 :	Impart Knowledge in modelling of CAD system.	1	85	80	H	H	H	-	H	-									
CLO-3 :	Learn the various algorithm used in geometric modelling	1	85	80	H	H	H	H	H										
CLO-4 :	Understand the mathematical concept of Model assembly for a machine elements	2	85	80	H	H	H	H	H										
CLO-5 :	Distinguish data exchange standards and common file types in CAD	2	85	80	H			H		H									

Duration (hour)		Fundamentals of Computer Graphics	Geometric Modelling	Visual Realism	Assembly and Tolerance	Graphics Standards
		10	10	08	09	08
S-1	SLO-1	Design as a process, sequential and concurrent engineering.	Introduction to geometric modelling	Hidden line removal: Visibility of object views	Assembly modelling: Introduction, Part modelling.	Computer graphics: Introduction
	SLO-2	Computer Aided Design (CAD) and its architecture.	Wire frame modelling: Introduction	Visibility of object techniques	Assembly modeling: Representation Hierarchical relationship & Mating Condition.	Computer graphics: software and Database CAD Graphics
S-2	SLO-1	Computer graphics, co-ordinate system	Model, entities of wire frame modelling.	Visibility of object techniques: Sorting & Coherence	Assembly modeling: Types of Approach	Translator: Types
	SLO-2	Transformation types: Two and three dimensional.	Representation of synthetic curves: Hermite curve	Visibility of object technique: Priority and area orientation	Interferences of positions	Software standards: Graphical Kernel System (GKS)
S-3	SLO-1	Transformation in 2D and 3D: Translational, scaling.	Bezier curve.	Hidden surface removal: Back face, Scan line Algorithm	Tolerance: Introduction, need& concept of conventional.	Exchange Database : IGES
	SLO-2	Problems in translational scaling.	Problems on Bezier Curve	Hidden surface removal: Z-buffer Algorithm	Fits and Limits: MMC , LMC	Exchange Database :STEP
S-4	SLO-1	Transformation in 2D and 3D: Rotation, reflection	B-spline curves	Warnock's algorithm	Tolerance: Modelling Accumulation, Drafting and Manufacturing	Drawing Exchange Format & ACIS
	SLO-2	Problems in Rotation, reflection	Problems on B – Spline curve	Hidden solid removal: Ray-tracing algorithm.	Geometric tolerance: Representation and Types	Graphics Functions: Output Primitives
S-5	SLO-1	Two dimensional transformations: Problems on rotation,	rational curves	Shading: Model, surface	Tolerance analysis: Worst- case arithmetic method	Line attributes: types width , color
	SLO-2	2D Problems on scaling	Surface modelling: Introduction, model.	Shading: Enhancement, solid.	Tolerance analysis: Worst- case statistical method	Curve attributes :Color , table & Grayscale levels
S-6	SLO-1	2D Problems on translation,	Parametric representation of analytic surface.	Shading: solid	Tolerance analysis: Worst- case arithmetic method problems	Area Fill Attributes : Style, pattern, soft
	SLO-2	2D Problems on, reflection.	Plane surface	Coloring: Models	Tolerance analysis: Worst- case statistical method problems	Character Attributes: Text ,Marker

S-7	SLO-1	*Three dimensional transformations: Problems on rotation,*	*ruled surface*	*Coloring: Types*	*Monte Carlo simulation method*	*Processors : Design and Implementation*
	SLO-2	*3D Problems on scaling,*	*Parametric representation of synthetic surface: Coons and*	*Animation: Conventional, Computer & Engineering*	*Mass property calculations: First and second Moment of inertia*	*Processors :Error handling , testing and verification,*
S-8	SLO-1	*3D problems on translation*	*Parametric representation of Synthetic curve : Bicubic*	*Animation Types and Techniques*	*Mass property calculations: second Moment of inertia*	*Open Graphics Library (OpenGL): Introduction*
	SLO-2	*3D problems on reflection*	*Parametric representation of Bezier curve*	*Morphing: Types and model*	*Geometrical property: Curve Length, Surface Area*	*Open Graphics Library (OpenGL) : Types*
S-9	SLO-1	*Homogeneous co-ordinates.*	*Parametric representation of B Spline curve*		*Geometrical property: Volume: & Cross section Area*	*Communication standards for CAD systems*
	SLO-2	*Algorithms: Line, circle*	*Solid modelling: Introduction, models, entities*		*Properties of composites, mass property calculation by using CAD systems*	
S-10	SLO-1	*Clipping algorithm.*	*Solid modelling representation: Boundary representation.*			
	SLO-2	*Windowing and viewing.*	*constructive solid geometry.*			

Learning Resources	*1. Ibrahim Zeid, "Mastering CAD CAM", Tata McGraw-Hill Publishing Co, 2007.* *2. Chris McMahon and Jimmie Browne, "CAD/CAM Principles", Practice and Manufacturing Management 2nd edition, Pearson Education, 1999.*	*4. William M Neumann and Robert F.Sproul, "Principles of Computer Graphics", McGraw-Hill Book Co.Singapore, 1989.* *5. Donald Hearn and M. Pauline Baker, "Computer Graphics", Prentice Hall, Inc, 1992.* *6. Foley, Wan Dam, Feiner and Hughes, "Computer Graphics Principles and Practice", Pearson Education, 2003.*

Learning Assessment

	Bloom's Level of Thinking	Continuous Learning Assessment (50% weightage)								Final Examination (50% weightage)	
		CLA – 1 (10%)		CLA – 2 (15%)		CLA – 3 (15%)		CLA – 4 (10%) #			
		Theory	Practice	Theory	Practice	Theory	Practice	Theory	Practice	Theory	Practice
Level 1	Remember Understand	40 %	-	30 %	-	30 %	-	30 %	-	30%	-
Level 2	Apply Analyze	40 %	-	40 %	-	40 %	-	40 %	-	40%	-
Level 3	Evaluate Create	20 %	-	30 %	-	30 %	-	30 %	-	30%	-
	Total	100 %		100 %		100 %		100 %		100 %	

CLA – 4 can be from any combination of these: Assignments, Seminars, Tech Talks, Mini-Projects, Case-Studies, Self-Study, MOOCs, Certifications, Conf. Paper etc.

Course Designers

Experts from Industry	Experts from Higher Technical Institutions	Internal Experts
1. Mrs.A.Priya ,Principal Engg, TechnipFMC,apriya@technipfmc.com,Chennai	*1. Dr.S.NeelavathyPari, Asst. Professor (Senior Grade), MIT,neela@annauniv.edu, Chennai.*	*1. D.Gayathiri, SRMIST*
2. Mr. Ak. Lakshminaraimhan, Senior Principal Engineer,Technip FMCAK lakshminaraimhan@technipfmc.com, Chennai	*2. Dr. R.sarala,AlagappaChettiar college of Engineering and Technology, r.sarala@accetedu.in, karaikudi.*	*2. Mr.J.Arivarasan, SRMIST*

Course Code	18MHE408T	Course Name	MICRO ELECTRO MECHANICAL SYSTEMS	Course Category	E	Professional Elective	L	T	P	C
							3	0	0	3

Pre-requisite Courses	Nil	Co-requisite Courses	Nil	Progressive Courses	Nil
Course Offering Department	Mechatronics Engineering	Data Book / Codes/Standards	Nil		

Course Learning Rationale (CLR):	The purpose of learning this course is to:
CLR-1 :	*Provide necessary fundamental knowledge in manufacturing and packaging of micro systems*
CLR-2 :	*Impart knowledge of behavior of mechanical and electrical elements at micro level*
CLR-3 :	*Emphasis on electrical and Thermal actuation in microsystems*
CLR-4 :	*Emphasis on Piezoelectric and Magnetic actuation in microsystems*
CLR-5 :	*Expose on MEMS applications in Automotive sector and Space exploration*
CLR-6 :	*Introduce computer aided simulation of microsystems*

Course Learning Outcomes (CLO):	At the end of this course, learners will be able to:	Learning 1 Level of Thinking (Bloom)	2 Expected Proficiency (%)	3 Expected Attainment (%)	Program Learning Outcomes (PLO) 1 Engineering Knowledge	2 Problem Analysis	3 Design & Development	4 Analysis, Design, Research	5 Modern Tool Usage	6 Society & Culture	7 Environment & Sustainability	8 Ethics	9 Individual & Team Work	10 Communication	11 Project Mgt. & Finance	12 Life Long Learning	13 PSO - 1	14 PSO - 2	15 PSO - 3
CLO-1 :	*Understand the operation and manufacturing of microsystems*	1	85	80	H	L	-	L	L	M		L	M	-	-	-	M	-	-
CLO-2 :	*Analyze the behavior of MEMS systems*	2	85	80	H	H	-	H	L	-		L	M	-	-	-	-	-	-
CLO-3 :	*Design micro sensors and actuators actuated by electrical and Thermal actuation*	2	85	80	H	H	H	H	L	-	H	L	M	-	-	-	-	-	-
CLO-4 :	*Design micro sensors and actuators actuated by Piezoelectric and Magnetic actuation*	2	85	80	H	H	H	H	L	-	H	L	M	-	-	-	-	-	-
CLO-5 :	*Gain knowledge on different applications of MEMS devices*	2	85	80	H	H	-	L	L	M		L	M	-	-	-	-	-	-
CLO-6 :	*Simulate simple Microsystems*	2	85	80	H	H	-	L	H	-		L	M	-	-	-	-	-	-

		Introduction to MEMS & Microsystem Fabrication Processes	Mechanical and Electrical Conceptions	Sensing and Actuation-I (Electrical and Thermal)	Sensing and Actuation-II (Piezoelectric and Magnetic)	Mems Case studies
Duration (hour)		9	9	9	9	9
S-1	SLO-1	*Overview of MEMS,*	*Review of Semiconductor*	*Electrostatic sensors and actuators*	*Piezoresistivity gauge factor*	*MEMS inertial sensor in automobile airbag deployment*
	SLO-2	*Elements of MEMS, Applications*	*Carrier concentration in Silicon semiconductors*	*Parallel plate capacitors*	*Piezoresistive materials*	*MEMS vibratory gyroscope*
S-2	SLO-1	*Intrinsic characteristics of MEMS, Multidisciplinary nature of microsystem design and Manufacture*	*Calculation of Conductivity and resistivity of semiconductor Electron mobility in Silicon*	*Equilibrium position of parallel plate actuators*	*Applications of piezoresistive sensor*	*Optical MEMS*
	SLO-2	*Scaling Law of Miniaturization*	*Sheet resistivity Numerical Problems*	*Pull-in effect of parallel plate actuators*	*Inertia sensors, pressure sensors based on piezoresistivity*	*Digital Micro Mirror Devices*
S-3	SLO-1	*Simple problems related to miniaturization*	*Crystal planes and Orientations, General scalar relationship between stress and strain*	*Applications of Parallel plate capacitors, Inertia sensor*	*Tactile sensor*	*MEMS devices in Biotechnology*
	SLO-2	*Materials for MEMS: Silicon, Silicon Compounds and Polymers*	*Study of Flexural beams bending under simple loading conditions*	*Pressure sensors*	*Flow sensor*	*Scanning Tunnelling Microscope*
S-4	SLO-1	*Microsystem Fabrication Processes: Photolithography*	*Mechanical deformation of cantilever beam spring*	*Flow sensors*	*Piezoelectric sensing and actuation*	*Polymerase Chain reaction*
	SLO-2	*Ion Implantation*	*Deformation of torsional bars*	*Tactile sensors, Parallel plate actuators*	*Piezoelectric materials*	*Microsystems for DNA amplification*
S-5	SLO-1	*Diffusion*	*Discussing the Simple problems related to force constant*	*Interdigitated Finger capacitors*	*Piezoelectric Accelerometer*	*Fluidic MEMS, Micro channels*
	SLO-2	*Oxidation*	*Origin of intrinsic stress, Methods for characterization*	*Comb drive accelerometer*	*Acoustic sensors*	*Polymer MEMS, Liquid crystal Polymer, PDMS,PMMA*

S-6	SLO-1	*Chemical Vapor Deposition (CVD)*		*Thermal Sensing and Actuation*	*Tactile sensors*	*MEMS devices in space exploration*
	SLO-2	*Physical Vapor Deposition (PVD)*		*Thermal resistance*	*Flow sensors*	*Micro power sources, micro turbines*
S-7	SLO-1	*Surface micromachining*	*Control and compensation of bending*	*Thermal bimorph principle*	*Magnetic actuation*	*Introduction to NEMS*
	SLO-2	*LIGA Process*	*Analysis of essential elements of MEMS system dynamics*	*Thermal bimorph actuator*	*Essential concepts and principles*	*Nano fabrication*
S-8	SLO-1	*Bulk micromachining; Dry etching, Wet etching*	*Discussion*	*Accelerometer based on thermal transfer principle*	*Deposition of Magnetic materials*	*Nano devices*
	SLO-2	*Plasma etching, DRIE*	*Damping & Quality factor, Resonant Frequency*	*Thermal accelerometer with no moving mass*	*Fabrication of Magnetic coil*	*Nano manipulation*
S-9	SLO-1	*MEMS process integration strategies*		*Flow sensors based on thermal transfer principle*	*Magnetic motors*	*Computer aided simulation and design of MEMS devices Background to Finite element method*
	SLO-2	*Microsystem Packaging*	*Active Tuning of spring constant and resonant frequency*	*Infrared sensor*	*Magnetic beam actuation*	*Exposure to commercial software packages*

Learning Resources	*1. Tai- Ran Hsu, "MEMS and Microsystem Design and Manufacture" McGraw Hill Education (India) Private Limited, New Delhi, 2002.* *2. Chang Liu , " Foundations of MEMS" 2nd edition, Dorling Kindersley India Pvt Ltd, 2012.* *3. Rai-Choudhury.P., " MEMS and MOEMS Technology and Applications" Prentice Hall of Indian Indian Learning Private Limited, 2009.*	*4. NadimMaluf, " An Introduction to Microelectromechanical Systems Engineering" 2nd Edition, Artech House, 2004.* *5. Reza Ghodssi, Pinyen, " MEMS Materials and Processes Handbook", Springer Science Business Media, 2011.* *6. Sergey Edward Lyshevski, "MEMS and NEMS: Systems, Devices and Structures" CRC Press, 2002.*

Learning Assessment

	Bloom's Level of Thinking	Continuous Learning Assessment (50% weightage)								Final Examination (50% weightage)	
		CLA – 1 (10%)		CLA – 2 (15%)		CLA – 3 (15%)		CLA – 4 (10%)#			
		Theory	Practice	Theory	Practice	Theory	Practice	Theory	Practice	Theory	Practice
Level 1	Remember Understand	30 %	-	30 %	-	30 %	-	30 %	-	30%	-
Level 2	Apply Analyze	40 %	-	40 %	-	40 %	-	40 %	-	40%	-
Level 3	Evaluate Create	30 %	-	30 %	-	30 %	-	30 %	-	30%	-
	Total	100 %		100 %		100 %		100 %		100 %	

CLA – 4 can be from any combination of these: Assignments, Seminars, Tech Talks, Mini-Projects, Case-Studies, Self-Study, MOOCs, Certifications, Conf. Paper etc.,

Course Designers

Experts from Industry	Experts from Higher Technical Institutions	Internal Experts
1. Mr. C. Purushothaman, ABB India Ltd, Chennai, purushothaman.c@in.abb.com	*1. Dr.G.Sakthivel, VIT University, Chennai, sakthivel.g@vit.ac.in.*	*1. Dr.G.Murali, SRMIST*
2. Mr.J. Srinivasan, KONE Elevator India Private Limited,Chennai, srinikone@gmail.com	*2. Dr.R.AmuthaKannan, National University, Muscat,amuthakkannan@nu.edu.om.*	*2. Mr.N.Pradeep, SRMIST*

Course Code	18MHE409T	Course Name	AUTOMATION AND INTELLIGENT SYSTEMS	Course Category	C	Professional Core	L	T	P	C
							3	0	0	3

Pre-requisite Courses	Nil	Co-requisite Courses	Nil	Progressive Courses	Nil
Course Offering Department	Mechatronics Engineering	Data Book / Codes/Standards	Nil		

Course Learning Rationale (CLR):	*To impart the basics of automation and intelligent systems.*
CLR-1 :	*Explain the fundamentals of automated systems.*
CLR-2 :	*Identify the elements of CIM and its construction.*
CLR-3 :	*Discuss about the knowledge based systems.*
CLR-4 :	*Apply the artificial intelligent and expert systems in manufacturing.*
CLR-5 :	*Develop the Artificial neural network system for manufacturing*

Course Learning Outcomes (CLO):	*At the end of this course, learners will be able to:*	Learning 1: Level of Thinking (Bloom)	2: Expected Proficiency (%)	3: Expected Attainment (%)	PLO 1: Engineering Knowledge	2: Problem Analysis	3: Design & Development	4: Analysis, Design, Research	5: Modern Tool Usage	6: Society & Culture	7: Environment & Sustainability	8: Ethics	9: Individual & Team Work	10: Communication	11: Project Mgt. & Finance	12: Life Long Learning	13: PSO - 1	14: PSO - 2	15: PSO - 3
CLO-1 :	*Understand the basics of automation system and designing of simple automated system*	2	75	75	H	L	H	L	M	H	L	L	M	M	H	H	L	M	-
CLO-2 :	*Explain the modeling tools of Petri Nets and Quenching model*	2	75	80	H	L	M	-	H	M	-	-	-	-	L	L	-	-	L
CLO-3 :	*Analysis the Intelligent manufacturing system components and IMS architecture*	3	80	85	H	-	M	L	H	L	-	M	L	M	M	M	-	-	-
CLO-4 :	*Prescribe the structure of knowledge based systems and approaches in KBS*	2	80	75	H	L	L	M	-	-	-	-	L	-	L	L	L	-	-
CLO-5 :	*Learn the organizational platform in Janus system to implement the Holon control for Manufacturing.*	3	85	80	H	-	L	M	H	M	L	L	-	L	L	L	-	-	H
CLO-6:	*Understand the concept of Artificial Intelligence and Neural Network systems in Manufacturing*	3	85	80	H	L	H	-	L	L	-	-	L	-	-	H	-	-	L

Duration (hour)		Automation Systems	Modelling of Automation Systems	Computer Integrated Manufacturing Systems	Knowledge Based Systems	Machine Learning, Artificial Intelligence and Expert Systems
		09	09	09	09	09
S-1	SLO-1	*Introduction: Automation systems*	*Introduction of Modeling tools-Markov chain models*	*Introduction of CIMS Systems, CIM Definitions*	*Introduction of basic Knowledge Based Systems (KBS).*	*Introduction of Machine Learning*
	SLO-2	*Basic elements of automation system*	*Configuration of Markov model, Assumptions, application*	*Basic four plan Concept, Components, Benefits of CIMS*	*Basic components of Knowledge Based Systems (KBS).*	*Objectives of Machine Learning*
S-2	SLO-1	*Advantages, evolution of automation systems*	*Introduction of Quenching models, types of Quenching models*	*Structural and functional areas of CIMS Systems*	*Designing of Knowledge Based System(KBS)*	*Concepts of Machine Learning*
	SLO-2	*applications of automation systems*	*Various techniques of quenching models and applications*	*Features of CIM Wheel, CIM Evolution*	*Advantages and disadvantages of Knowledge Based System(KBS)*	*Types of Machine Learning and its algorithm with examples*
S-3	SLO-1	*Automation systems in Services*	*Introduction of Petri Nets models, classes of PN Models for manufacturing systems,*	*Introduction of Manufacturing Communication Systems*	*Application and limitation of Knowledge Based System(KBS)*	*Uses of Machine Learning*
	SLO-2	*Packaging and storage services*	*Basics of Petri Nets ,Examples*	*Types, layout of Manufacturing Communication Systems, Applications.*	*Introduction to Knowledge representation structure*	*Merits and Demerits of Machine Learning*
S-4	SLO-1	*Office automation systems*	*Types of Petri Nets models ,Properties of PN models,*	*Definition of Data redundancy, types , advantages of Data redundancy*	*Approaches in KBS.*	*Fundamental of Artificial Intelligence*
	SLO-2	*Stages of Growth, Basic activities , advantages and disadvantages of office Automation*	*Basics architecture of PN Models*	*Basic Definition of top-down and bottom-up approach volume of information,*	*Introduction to Engineering design for knowledge based reasoning*	*Concept and objective of Artificial Intelligence*
S-5	SLO-1	*Types of functions integrated by OAS*	*Structural properties of Petri Nets models, applications*	*Objectives, comparison of top- down and bottom up approaches*	*Engineering design knowledge based reasoning in manufacturing*	*Architecture of Artificial Intelligence*
	SLO-2	*Documentation and Communication*	*Discussion*	*Important roles of top- down and bottom up approaches*	*Introduction to Multi- agent manufacturing system*	*Various types of design pattern in Artificial Intelligence*
S-6	SLO-1	*Designing of simple automation systems*	*Various modeling of Petri Nets,*	*Introduction of intelligent manufacturing system, basic definition*	*Designing of Multi- agent manufacturing system*	*Application and advantages of Artificial Intelligence*

	SLO-2	*Components of simple automated design*	*Analysis methods of PN models*	*Basic concept of IMS, Components of IMS,.*	*Advantages and disadvantages of Multi- agent manufacturing system*	*Conceptual learning Expert Systems*
S-7	SLO-1	*Interlocking between feed and opening of the door*	*Differences between simple Petri Nets and high level Petri Nets.*	*Basic Principles of IMS, IMS overview, tools used for IMS*	*Application and limitation of Multi-agent manufacturing system*	*Basics Function of learning Expert Systems*
	SLO-2	*Various design steps and implementation of simple Automation*	*Types of simple Petri Nets, functions, examples*	*IMS architecture, applications of IMS*	*Introduction to Holonic manufacturing systems*	*Fundamental of Neural Networks*
S-8	SLO-1	*Designing of multi level automation systems*	*Types of high level Petri nets ,*	*Introduction of IMS data flow, definitions*	*Designing Holonic manufacturing systems*	*Types of Neural Networks*
	SLO-2	*Design steps and process of Multi level automation*	*Functions of High level Petri Nets , examples*	*Process modeling of data flow diagram, Identify the object of DFD(Data Flow Diagram)*	*Control of Holonic manufacturing systems*	*Application and limitation of Neural Networks in manufacturing*
S-9	SLO-1	*Monitoring the temperature on the basis of supply of fuels,*	*Introduction of PRQN – ESP models, types of PRQN – ESP models*	*Fundamental of IMS Operation,*	*Advantages and disadvantages of Holonic manufacturing systems*	*Introduction of Artificial Neural Networks and Fuzzy Logics*
	SLO-2	*pressure, velocity and calorific value*	*Integrated PRQN – ESP models*	*Tutorial*	*Application and limitation of Holonic manufacturing systems*	*Introduction and Concepts of Fuzzy set , Biological neuron , Artificial neuron*

Learning Resources	*1. Mikel P. Groover , "Automation, Production Systems and Computer Integrated Manufacturing", Prentice Hall of India, 2014.Text / Audio / Video* *2. T YagnaNarayana, "Artificial Neural Networks", Prentice Hall of India, 2009ext / Audio / Video* *3. Andre Kusaic, "Intelligent Manufacturing Systems", Prentice Hall of India, 1989.*	*4. Hamid R. Parsaei and Mohammad Jamshidi, "Design and Implementation of Intelligent Manufacturing Systems", Prentice Hall of India, 2009.* *5. Z. Zhou, Zude, Xie, Shane Shengquam, Chen, Dejun "Fundamentals of Digital Manufacturing Science", Springer Series in Advanced Manufacturing, Springer Verlag London Limited, 2012.*

Learning Assessment

	Bloom's Level of Thinking	Continuous Learning Assessment (50% weightage)								Final Examination (50% weightage)	
		CLA – 1 (10%)		CLA – 2 (15%)		CLA – 3 (15%)		CLA – 4 (10%) #			
		Theory	Practice	Theory	Practice	Theory	Practice	Theory	Practice	Theory	Practice
Level 1	Remember Understand	40 %	-	30 %	-	30 %	-	30 %	-	30%	-
Level 2	Apply Analyze	40 %	-	40 %	-	40 %	-	40 %	-	40%	-
Level 3	Evaluate Create	20 %	-	30 %	-	30 %	-	30 %	-	30%	-
	Total	100 %		100 %		100 %		100 %		100 %	

CLA – 4 can be from any combination of these: Assignments, Seminars, Tech Talks, Mini-Projects, Case-Studies, Self-Study, MOOCs, Certifications, Conf. Paper etc.

Course Designers

Experts from Industry	Experts from Higher Technical Institutions	Internal Experts
1. Mrs..A.Priya ,Principal Engg, Technip FMC,apriya@technipfmc.com	*1. Dr. B.Mohan, Professor,CEG,bmohan@annauniv.edu, Chennai*	*1. Ms.D.Gayathiri, SRMIST*
2.2.Mr. Ak. Lakshminaraimhan, Senior Principal Engineer,Technip FMCAK Lakshminaraimhan@technipfmc.com	*2. Dr. Dr.S.NeelavathyPari, Asst. Professor (Senior Grade), MIT,neela@annauniv.edu, Chennai.*	*2. Mr. K.Saravanan, SRMIST*

Course Code	18MHE410T	Course Name	VIRTUAL INSTRUMENTATION	Course Category	E	Professional Elective	L	T	P	C
							3	0	0	3

Pre-requisite Courses	Nil	Co-requisite Courses	Nil	Progressive Courses	Nil
Course Offering Department	Mechatronics Engineering	Data Book / Codes/Standards	Nil		

Course Learning Rationale (CLR):	*The purpose of learning this course is to:*
CLR-1 :	*Introduce the importance of virtual instrumentation and its benefit*
CLR-2 :	*Discuss about the various data acquisition devices and techniques*
CLR-3 :	*Discuss about the various interfacing techniques*
CLR-4 :	*Introduce the concepts of programming and VI*
CLR-5 :	*Learn simulation of various process using virtual instrumentation*

Course Learning Outcomes (CLO):	*At the end of this course, learners will be able to:*	Learning 1: Level of Thinking (Bloom)	2: Expected Proficiency (%)	3: Expected Attainment (%)	PLO 1: Engineering Knowledge	2: Problem Analysis	3: Design & Development	4: Analysis, Design, Research	5: Modern Tool Usage	6: Society & Culture	7: Environment & Sustainability	8: Ethics	9: Individual & Team Work	10: Communication	11: Project Mgt. & Finance	12: Life Long Learning	13: PSO - 1	14: PSO - 2	15: PSO - 3
CLO-1 :	*Understand the importance and benefits of virtual instrumentation and its application*	2	80	70	H	L	H	H	L	L	-	-	M	-	-	L	M	-	-
CLO-2 :	*Understand various data acquisition methods*	2	80	70	H	H	H	H	H	L	-	-	L	-	-	L	M	-	-
CLO-3 :	*Understand standard interfaces to connect external device to PC*	2	80	70	H	H	H	H	H	L	-	-	L	-	-	L	M	-	-
CLO-4 :	*Program and develop VI for various system*	2	80	70	H	H	H	H	H	L	-	-	M	-	-	L	M	-	-
CLO-5 :	*Understand the application of virtual instrumentation in the industry process*	3	80	70	H	H	H	H	H	L	-	-	M	-	-	L	M	-	-

		Introduction to virtual Instrumentation	Data Acquisition Techniques	Interfaces	Concept of Programming	Case Study
Duration (hour)		8	10	9	13	5
S-1	SLO-1	*Concept of virtual instrumentation*	*Introduction to Data Acquisition methods*	*Introduction to various Interfaces*	*Concept of programming*	*Simulation of system using virtual instrumentation- Introduction*
	SLO-2	*Example*	*PC based data Acquisition*	*Interfacing External instrument to a PC*	*Various tools and software available*	*Simple temperature indicator*
S-2	SLO-1	*Historical perspective of virtual instrumentation*	*Board DAQ card*	*RS 232 Interface*	*Concept of VI and Sub VI*	*ON/OFF control*
	SLO-2	*Development of virtual instrumentation*	*Resolution and sampling Frequency*	*RS422,RS485 Interfaces*	*Example*	*Case study-Any industrial process*
S-3	SLO-1	*Block diagram of basic virtual instrumentation*	*I/O techniques and buses,*	*USB standard*	*Display Types*	*PID control*
	SLO-2	*Architecture of virtual instrumentation*	*Analog to digital converter, digital to analog converter*	*Example*	*Digital ,Analog*	*Case study-Any industrial process*
S-4	SLO-1	*Advantages over other conventional programming*	*Multiplexing of Analog Input*	*IEEE 488 standard*	*Display Types*	*CRO Emulation*
	SLO-2	*Example for comparison*	*Single ended and differential ended*	*Example*	*Chart , Oscilloscope type*	*Case study*
S-5	SLO-1	*Application of VI in mechatronics engineering*	*Case Study- Data acquisition using DAQ card*	*Serial Bus*	*Programming constructs: Loops.*	*Simulation of simple second order system*
	SLO-2	*Case Study*	*Concept of sampling, resolution, single and differential ended*	*Example*	*Programming constructs: Charts.*	*Case Study*
S-6	SLO-1	*Review of Digital Instrumentation*	*Strategies for sampling multichannel analog input*	*Introduction to Bus protocol*	*Programming constructs: Arrays.*	
	SLO-2	*Representing Analog Signal in digital domain*	*Example*	*Various Example*	*Example*	
S-7	SLO-1	*Quantization*	*Concept of Universal DAQ card*	*MOD Bus*	*Programming constructs: Clusters*	
	SLO-2	*Sample and hold*	*Example*	*Example*	*Example*	
S-8	SLO-1	*Sampling Theorem*	*Use of Timers*	*CAN Bus*	*Programming constructs: graphs.*	
	SLO-2	*ADC and DAC*	*Example*	*Example*	*Example*	

S-9	SLO-1		*Use of Counter*	*Case Study (Communication protocols I2C,SPI,Serial)*	*Programming constructs: Case structure*	
	SLO-2		*Example*	*Interfacing sensor to the controller*	*Example*	
S-10	SLO-1		*Case Study*		*Programming constructs: sequence*	
	SLO-2		*Real time data acquisition process*		*Example*	
S-11	SLO-1				*Formula nodes*	
	SLO-2				*Local and global variables*	
S-12	SLO-1				*State machine*	
	SLO-2				*State machine*	
S-13	SLO-1				*Rtring and file input/output*	
	SLO-2				*Review of programming*	

Learning Resources	*1.Wells Lisa K and Travis Jeffrey, "LabVIEW for everyone", Prentice Hall, 1997.* *2. Gary Johnson,"LabVIEW Graphical Programming", 4th edition, McGraw Hill, Newyork, 1997.*	*3. Mahesh L Chgani and Abhay R. Samant, " Labview Signal Processing", Prentice Hall of India, 1998.* *4. James K, "PC Interfacing and Data Acquisition", Elsevier, 2002.6. Robert H. Bishop, "Learning with Labview", Prentice Hall of India, 2003.*

Learning Assessment											
	Bloom's Level of Thinking	Continuous Learning Assessment (50% weightage)								Final Examination (50% weightage)	
		CLA – 1 (10%)		CLA – 2 (15%)		CLA – 3 (15%)		CLA – 4 (10%)#			
		Theory	Practice	Theory	Practice	Theory	Practice	Theory	Practice	Theory	Practice
Level 1	Remember Understand	40 %	-	30 %	-	30 %	-	30 %	-	30%	-
Level 2	Apply Analyze	40 %	-	40 %	-	40 %	-	40 %	-	40%	-
Level 3	Evaluate Create	20 %	-	30 %	-	30 %	-	30 %	-	30%	-
	Total	100 %		100 %		100 %		100 %		100 %	

CLA – 4 can be from any combination of these: Assignments, Seminars, Tech Talks, Mini-Projects, Case-Studies, Self-Study, MOOCs, Certifications, Conf. Paper etc.,

Course Designers		
Experts from Industry	Experts from Higher Technical Institutions	Internal Experts
1.Mr.Ganesh Ram, Intel Labs ,Bangalore, ganeshram.nandakumar@intel.com	*1. Dr., R. Thiyagarajan, Visiting faculty, IIT Madras, thiyaguiitm@gmail.com*	*1. R Ranjith Pillai , SRMIST*
2. Mr. Mohammed Sagheer ,Wabco Technology Center ,India, mohammedsagheer.musthafa@wabco-auto.com	*2. Dr., P Karthikeyan, MIT,Anna University, pkarthikeyan@annauniv.edu*	*2. G. Madhumitha ,SRMIST*

Course Code	18MHE411T	Course Name	MACHINE VISION AND IMAGE PROCESSING	Course Category	E	Professional Elective	L	T	P	C
							3	0	0	3

Pre-requisite Courses	Nil	Co-requisite Courses	Nil	Progressive Courses	Nil
Course Offering Department	Mechatronics Engineering	Data Book / Codes / Standards	Nil		

Course Learning Rationale (CLR):	*The purpose of learning this course is to:*
CLR-1 :	*Impart knowledge on the machine vision technology as a tool for industrial automation.*
CLR-2 :	*Understand specifications of vision hardware*
CLR-3 :	*Understand the fundamental algorithms and implement them.*
CLR-4 :	*Enable reading of current image processing research literature.*
CLR-5 :	*Gain the experience in applying image processing algorithms to industrial problems.*
CLR-6 :	*Get an introductory information related to 3-D vision and deep learning techniques*

Course Learning Outcomes (CLO):	*At the end of this course, learners will be able to:*	Learning 1 Level of Thinking (Bloom)	2 Expected Proficiency (%)	3 Expected Attainment (%)	PLO 1 Engineering Knowledge	2 Problem Analysis	3 Design & Development	4 Analysis, Design, Research	5 Modern Tool Usage	6 Society & Culture	7 Environment &Sustainability	8 Ethics	9 Individual & Team Work	10 Communication	11 Project Mgt. & Finance	12 Life Long Learning	13 PSO - 1	14 PSO - 2	15 PSO - 3
CLO-1 :	*Abstract the physics of light which defines the possibilities and limitations of a vision system.*	2	80	80	L	H	-	H	L	-	-	-	L	L	-	L	H	M	-
CLO-2 :	*Interpret the various specifications of a imaging system and select the right hardware based on understanding of scene constraints*	3	85	75	M	H	L	M	L	-	-	-	M	L	-	L	H	M	-
CLO-3 :	*Develop the algorithms to enhance images.*	3	75	70	M	H	M	H	H	-	-	-	M	L	-	L	H	M	-
CLO-4 :	*Develop the algorithms that extract various types of attributes from digital images.*	3	85	80	M	H	M	H	H	-	-	-	M	L	-	L	H	M	-
CLO-5 :	*Appreciate the relevance of machine vision to mechatronics systems*	3	85	75	H	H	M	H	H	-	-	-	M	L	-	L	H	M	-
CLO-6 :	*Apply the concepts of machine vision and image processing in various industrial applications*	3	80	70	H	H	M	H	L	-	-	-	L	L	-	L	H	M	-

		Introductory concepts	Image acquisition	Image processing	Image analysis	3-d vision & deep learning
Duration (hour)		7	10	10	8	10
S-1	SLO-1	*Introduction to course*	*Scene constraints*	*Introduction to machine vision software*	*Feature Extraction*	*Classification of 3-D Vision Techniques*
	SLO-2	*Related fields and Industries using vision*	*Performance requirement*	*Software selection criteria*	*Region Features*	*Active Vision - LIDAR*
S-2	SLO-1	*Physics of light*	*Fundamentals of lighting*	*Basics of digital image*	*Template Matching*	*Computational Stereo Vision*
	SLO-2	*Imaging modalities with light*	*Why Lighting is important?*	*Sampling and quantization effects*	*Issues to be addressed*	*Steps in stereo vision*
S-3	SLO-1	*Interactions of light*	*Light sources*	*Gray scale histogram*	*Methods of Template Matching*	*Introduction to Neural Neteorks*
	SLO-2	*Reflection and Refraction*	*Light sources - types and selection*	*Image processing*	*Linear Classification*	*Types of nueral networks*
S-4	SLO-1	*Introduction to machine vision system building*	*lighting techniques*	*Thresholding*	*Corner Detection*	*Back propogation learning*
	SLO-2	*Task Specification*	*lighting techniques - types and selection*	*Contrast stretching*	*Harris Corner Detector*	*Numerical problem*
S-5	SLO-1	*Design of the system*	*Machine vision lenses*	*Image smoothing in spatial domain*	*Keypoint matching*	*Concepts in machine learning learning*
	SLO-2	*Cost calculation*	*Filters*	*Image sharpening in spatial domain*	*Matching methods*	*The Deep Learning Idea*
S-6	SLO-1	*Development, Testing and commissioning*	*Image sensor specifications*	*Edge detection in spatial domain*	*Texture Analysis*	*Application of deep learning in computer vision*
	SLO-2	*Human visual system*	*Terminologies*	*Derivative operators*	*Approaches and methods*	*Concepts in deep learning*
S-7	SLO-1	*Structure of human eye*	*Sensor types based on sensing element*	*Two dimensional discrete Fourier transform*	*Co-occurrence Matrix*	*Convolutional layer of neural network*
	SLO-2	*Comparison with a machine vision system*	*Selection criteria*	*Frequency domain processing for image smoothing*	*Properties of Co-occurrence Matrix*	*Numerical problem*
S-8	SLO-1		*Camera computer interfaces*	*Frequency domain processing for image sharpening*	*Decision making considerations*	*Convolutional neural network (CNN) for image classification*
	SLO-2		*Types and selection*	*Low and high pass filters*	*For various machine vision applications*	*Architecture details*
S-9	SLO-1		*Camera parameters governing geometrical image formation*	*Binary morphology*		*Object detection using CNN*
	SLO-2		*Camera modeling*	*Basic Morphological operations*		*Single shot learning for object detection*

S-10	SLO-1		*Camera calibration*	*Non Linear filters*		*Improving deep learning algorithms*
	SLO-2		*Distortions*	*Color image processing*		*Optimizers*

Learning Resources	1. *Rafael C. Gonzales, Richard.E.Woods, "Digital Image Processing", 2008 Edition, Pearson Education* 2. *Eugene Hecht, A.R. Ganesan "Optics", 2001 Edition, Pearson India.* 3. *Alexander Hornberg, "Handbook of Machine Vision", 2006 Edition, Wiley .*	4. *EmanueleTrucco, Alessandro Verri, "Introductory Techniques For 3D Computer Vision", 1998 Edition, Prentice Hall.* 5. *Ian Goodfellow, YoshuoBengio and Aaron Courvile, "Deep Learning", 2015 Edition, MIT Press.*

Learning Assessment

	Bloom's Level of Thinking	Continuous Learning Assessment (50% weightage)								Final Examination (50% weightage)	
		CLA – 1 (10%)		CLA – 2 (15%)		CLA – 3 (15%)		CLA – 4 (10%)#			
		Theory	Practice	Theory	Practice	Theory	Practice	Theory	Practice	Theory	Practice
Level 1	Remember Understand	40 %	-	30 %	-	30 %	-	20 %	-	40%	-
Level 2	Apply Analyze	30 %	-	40 %	-	40 %	-	40 %	-	30%	-
Level 3	Evaluate Create	30 %	-	30 %	-	30 %	-	40 %	-	30%	-
	Total	100 %		100 %		100 %		100 %		100 %	

CLA – 4 can be from any combination of these: Assignments, Seminars, Tech Talks, Mini-Projects, Case-Studies, Self-Study, MOOCs, Certifications, Conf. Paper etc.,

Course Designers

Experts from Industry	Experts from Higher Technical Institutions	Internal Experts
1. Mr. N. Ganesh Ram, Intel Labs ganeshram.nandakumar@intel.com	*1. Dr. R. Thiyagarajan, IIT Madras, thiyaguiitm@gmail.com*	*1. Dr. R. Senthilnathan, SRMIST*
2. Mr. Mohammed Sagheer ,Wabco Technology Center, mohammedsagheer.musthafa@wabco-auto.com	*2. Dr. P. Karthikeyan, MIT Campus, Anna University, pkarthikeyan@annauniv.edu*	*2. Ms. M. Nandhini, SRMIST*

Course Code	18MHE412T	Course Name	ADVANCED CONTROL SYSTEMS	Course Category	P	Professional Elective	L	T	P	C
							3	0	0	3

Pre-requisite Courses	18MHC201J	Co-requisite Courses	NIL	Progressive Courses	NIL
Course Offering Department	Mechatronics Engineering	Data Book / Codes/Standards	NIL		

Course Learning Rationale (CLR):	The purpose of learning this course is to:	Learning			Program Learning Outcomes (PLO)														
		1	2	3	1	2	3	4	5	6	7	8	9	10	11	12	13	14	15
CLR-1 :	*Gain understanding of nonlinear dynamics*																		
CLR-2 :	*Utilize the concepts pertaining to optimal and robust control systems*																		
CLR-3 :	*Develop an understanding of model based predictive control.*																		
CLR-4 :	*Gain knowledge on the implementation of optimal state estimators.*																		
CLR-5 :	*Gain knowledge on the implementation of adaptive control schemes for systems*																		
CLR-6 :	*Impart knowledge of design and implementation of advanced control systems*																		
Course Learning Outcomes (CLO):	*At the end of this course, learners will be able to:*	Level of Thinking (Bloom)	Expected Proficiency (%)	Expected Attainment (%)	Engineering Knowledge	Problem Analysis	Design & Development	Analysis, Design, Research	Modern Tool Usage	Society & Culture	Environment & Sustainability	Ethics	Individual & Team Work	Communication	Project Mgt. & Finance	Life Long Learning	PSO - 1	PSO - 2	PSO - 3
CLO-1 :	*Demonstrate an understanding of nonlinear dynamics*	*1*	*85*	*80*	*H*	*H*	*H*	*H*	*M*	*H*	*M*	*-*	*M*	*M*	*H*	*M*	*M*	*H*	*M*
CLO-2 :	*Identify the concepts pertaining to optimal and robust control systems*	*1*	*85*	*80*	*H*	*H*	*H*	*H*	*M*	*H*	*M*	*-*	*M*	*M*	*H*	*M*	*M*	*H*	*M*
CLO-3 :	*Demonstrate an understanding of model based predictive control.*	*1*	*85*	*80*	*H*	*H*	*H*	*H*	*M*	*H*	*M*	*-*	*M*	*M*	*H*	*M*	*M*	*H*	*M*
CLO-4 :	*Familiarize on the implementation of optimal state estimators.*	*2*	*85*	*80*	*H*	*H*	*H*	*H*	*M*	*H*	*M*	*-*	*M*	*M*	*H*	*M*	*M*	*H*	*M*
CLO-5 :	*Familiarize on the implementation of adaptive control schemes for systems*	*2*	*85*	*80*	*H*	*H*	*H*	*H*	*M*	*H*	*M*	*-*	*M*	*M*	*H*	*M*	*M*	*H*	*M*
CLO-6 :	*Demonstrate an understanding on the implementation of the design of advanced control systems*	*2*	*85*	*80*	*H*	*H*	*H*	*H*	*M*	*H*	*M*	*-*	*M*	*M*	*H*	*M*	*M*	*H*	*M*

		Non-linear systems	Robust control	Optimal control	Optimal estimation	Adaptive control
Duration (hour)		9	9	9	9	9
S-1	SLO-1	*Nonlinear Dynamics*	*Robustness*	*Principle Of Optimality*	*Overview Of Stochastic Processes*	*Need For Adaptive Control*
	SLO-2	*Common Physical Nonlinearities.*	*Sensitivity*	*Dynamic Programming*	*Probability And Random Variables*	*Adaptive Control Schemes*
S-2	SLO-1	*Concept Of Phase Plane Analysis*	*Analysis Of Robustness In System Parameters*	*Hamilton-Jacobi-Bellman Equation.*	*Spectral Analysis Of Stochastic Process,*	*Gain Scheduling*
	SLO-2	*Phase Portraits*	*Analysis Of Uncertainty In System Parameters*	*Hamilton-Jacobi-Bellman Equation.*	*Special Cases: Multivariate Normal Distribution.*	*Gain Scheduling*
S-3	SLO-1	*Singular Points*	*Robust Control Systems.*	*Calculus Of Variations*	*Linear Quadratic Regulator*	*Principle And Design*
	SLO-2	*Symmetry In Phase Plane Portraits*	*Design Of Robust Control Systems.*	*Pontryagin's Minimum Principle*	*Continuous And Discrete Form*	*Principle And Design*
S-4	SLO-1	*Non Linear Systems*	*PID Controlled Systems*	*Bang-Bang Control*	*Kalman Filters*	*Model Reference Adaptive Systems*
	SLO-2	*Equilibrium Points*	*Robust PID Controlled Systems.*	*Bang-Bang Control*	*Variants Of Kalman Filter*	*Principle And Approaches*
S-5	SLO-1	*Stability Analysis*	*Design Of Robust PID Controlled Systems.*	*Nonlinear Programming Methods*	*Extended Kalman Filter*	*The MIT Rule*
	SLO-2	*Lyapunov's Stability Criterion For Linear Systems.*	*Design Of Robust PID Controlled Systems*	*Direct Method*	*Unscented Kalman Filter*	*Determination Of Adaptation Gain.*
S-6	SLO-1	*Stability Analysis*	*Internal Model Control System.*	*Linear Quadratic Regulator Design*	*Kalman Filters : Continuous Time Versions.*	*Model Reference Adaptive Systems*
	SLO-2	*Lyapunov's Stability Criterion For Non-Linear Systems.*	*The Robust Internal Model Control System.*	*Continuous Riccati Equation Forms.*	*Kalman Filters : Continuous Time Versions.*	*Design Of MRAS Using Lyapunov Theory.*
S-7	SLO-1	*Phase Plane Trajectories*	*Pseudo-Quantitative Feedback Systems.*	*Discrete Riccati Equation Forms.*	*Kalman Filters : Discrete Time Versions*	*Self-Tuning Regulators*
	SLO-2	*Construction Of Phase Plane Trajectories.*	*Design Of Pseudo-Quantitative Feedback Systems.*	*Linear Quadratic Regulator Design*	*Kalman Filters : Discrete Time Versions*	*Pole Placement Design.*

S-8	SLO-1	*Describing Function Fundamentals*	*Overview Of Model Predictive Control Key Elements Of MPC.*	*H_2 And H-Infinity Optimal Control.*	*Linear–Quadratic–Gaussian*	*Direct Self-Tuning Regulators.*
	SLO-2	*Describing Function Of Common Nonlinearities*	*Overview Of Model Predictive Control Key Elements Of MPC.*	*H_2 And H-Infinity Optimal Control.*	*Linear–Quadratic–Gaussian (LQG) Control Problem*	*Direct Self-Tuning Regulators.*
S-9	SLO-1	*Describing Function Analysis Of Nonlinear Systems*	*Optimal Control*	*Basics Of Convex Optimization*	*LQG Controller Design And Implementation.*	*Indirect Self-Tuning Regulators.*
	SLO-2	*Stability Analysis By Describing Function Method.*	*Overview Of Methods In Optimal Control.*	*Receding Horizon Principle.*	*LQG Controller Design And Implementation.*	*Indirect Self-Tuning Regulators.*

Learning Resources	1. *Richard C Dorf and Robert H Bishop, "Modern Control Systems", 13th edition, Pearson Education, 2016* 2. *I J Nagrath, M Gopal, "Control Systems Engineering", 6th edition, New Age International, 2018.* 3. *DesineniSubbaram Naidu, "Optimal Control Systems", 1st edition, CRC Press, 2003.*	4. *Karl J Åström, BjörnWittenmark, "Adaptive Control", 2nd edition, Dover Publication, 2008.* 5. *Roland S Burns, "Advanced Control Engineering", Butterworth Heinemann, 2005.* 6. *Jean-Jacques E Slotine, Weiping Li, "Applied Nonlinear Control", Prentice Hall of India-New Jersey, 1991.*

Learning Assessment

	Bloom's Level of Thinking	Continuous Learning Assessment (50% weightage)				Final Examination (50% weightage)
		CLA – 1 (20%)	CLA – 2 (30%)	CLA – 3 (30%)	CLA – 4 (20%)#	
		Theory	Theory	Theory	Theory	Theory
Level 1	Remember / Understand	40 %	30 %	30 %	20 %	30 %
Level 2	Apply / Analyze	40 %	40 %	40 %	40 %	40 %
Level 3	Evaluate / Create	20 %	30 %	30 %	40 %	30 %
	Total	100 %	100 %	100 %	100 %	-

CLA – 4 can be from any combination of these: Assignments, Seminars, Tech Talks, Mini-Projects, Case-Studies, Self-Study, MOOCs, Certifications, Conf. Paper etc.,

Course Designers

Experts from Industry	Experts from Higher Technical Institutions	Internal Experts
1. Mr.JeganAmrithalingam, Asst Manager, RNTBCI,ecejegan@gmail.com	*1. Dr.K.Rahimunnisa, EashwariEngineering College, Chennai, krahimunnisa@gmail.com*	*1. Mrs.T.S.Rajalakshmi, SRMIST*
2. Mr. Reuben Fernandes, ATOM 360, India, wenisch@atom360.io	*2. Dr.SrideviSathyaPriya, KarunyaInstituteofTechology and Science,s.d.s.priya@gmail.com*	*2. Mrs.G.Madhumitha, SRMIST*

Course Code	18MHE413T	Course Name	INDUSTRIAL PROGRAMMABLE CONTROLLERS	Course Category	E	Professional Elective	L	T	P	C
							3	0	0	3

Pre-requisite Courses	Nil	Co-requisite Courses	Nil	Progressive Courses	Nil
Course Offering Department	Mechatronics Engineering	Data Book / Codes/Standards	Nil		

Course Learning Rationale (CLR):	*The purpose of learning this course is to:*	Learning			Program Learning Outcomes (PLO)														
CLR-1 :	*Understand the architecture, parts and operation of PLC, Industrial PC and PAC*	1	2	3	1	2	3	4	5	6	7	8	9	10	11	12	13	14	15
CLR-2 :	*Equip with the knowledge of various controllers specifications*	Level of Thinking (Bloom)	Expected Proficiency (%)	Expected Attainment (%)	Engineering Knowledge	Problem Analysis	Design & Development	Analysis, Design, Research	Modern Tool Usage	Society & Culture	Environment & Sustainability	Ethics	Individual & Team Work	Communication	Project Mgt. & Finance	Life Long Learning	PSO - 1	PSO - 2	PSO - 3
CLR-3 :	*Familiarize with the Ladder Programming/other programming constructs*																		
CLR-4 :	*Analyze and select the appropriate controller for given applications*																		
CLR-5 :	*Apply the knowledge of PLC, IPC and PAC for solving typical industrial automation problems*																		
Course Learning Outcomes (CLO):	*At the end of this course, learners will be able to:*																		
CLO-1 :	*Describe the architecture, parts and operation of PLC, Industrial PC and PAC*	2	75	70	H	H	M	H	M	-	-	-	-	-	-	H	H	H	H
CLO-2 :	*Recognize various controllers specifications*	3	75	70	H	H	M	H	M	-	-	-	-	-	-	H	M	M	M
CLO-3 :	*Develop the Ladder Programming/other programming for given applications*	3	75	70	H	H	M	H	M	-	-	-	-	-	-	H	M	M	M
CLO-4 :	*Analyze and select the appropriate controller for given applications*	3	75	70	H	H	M	H	M	-	-	-	-	-	-	H	M	M	M
CLO-5 :	*Apply the knowledge of PLC, IPC and PAC for solving typical industrial automation problems*	3	75	70	H	H	M	H	H	-	-	-	-	-	-	H	M	M	M

		Programmable Logic Controllers (PLC)	Programming of PLC	Application of PLC-Case studies	Industrial PC	Programmable Automation Controllers (PAC)
Duration (hour)		9	9	9	9	9
S-1	SLO-1	*Introduction to Industrial automation,-Overview of syllabus*	*Hardwired Logic vs Programmable Logic*	*Filling/Draining Control*	*Industrial PC-Introduction and evolution*	*Introduction to PACs*
	SLO-2	*Evolution of PLC , Features*	*Hardwired Logic vs Programmable Logic*	*Filling/Draining Control*	*Industrial PC-Introduction and evolution*	*FPGA based PACs*
S-2	SLO-1	*A short history of Industrial robots*	*Ladder programming*	*Car Park Control*	*Architecture of Generic Industrial PC*	*Compact RIO architecture*
	SLO-2	*Architecture/parts of PLC*	*Logic functions*	*Car Park Control*	*Architecture of Generic Industrial PC*	*Compact RIO architecture*
S-3	SLO-1	*Principles of operation*	*Latching*	*Interlocks, Priority determinism and example*	*Features of IPC*	*RT Processor*
	SLO-2	*Modifying the operation*	*Internal relay*	*Interlocks, Priority determinism and example*	*Types of industrial PCs*	*Reconfigurable I/O FPGA*
S-4	SLO-1	*Comparison with PC*	*Timers: On-delay - Off-delay - retentive timers*	*Part sorting*	*Types of industrial PCs*	*I/O modules-system configuration*
	SLO-2	*PLC selection criteria*	*Timers: On-delay - Off-delay - retentive timers*	*Part sorting*	*Comparison of Various types*	*I/O modules-system configuration*
S-5	SLO-1	*The I/O section-Discrete I/O modules-Analog I/O modules*	*Counters: Up-counter - down-counter -cascading counters and timers*	*Automatic control of warehouse door*	*Industrial control networks-Introduction*	*Software architecture-Programming modes*
	SLO-2	*Special I/O modules- specifications*	*Counters: Up-counter - down-counter -cascading counters and timers*	*Automatic control of warehouse door*	*Industrial control networks-Introduction*	*Scan interface and FPGA Interface modes*
S-6	SLO-1	*The CPU of PLC*	*Shift registers*	*Air-conditioning system*	*Architecture of Industrial control networks*	*Key considerations for using PAC*
	SLO-2	*Memory design*	*Shift registers*	*Air-conditioning system*	*Architecture of Industrial control networks*	*Key considerations for using PAC*
S-7	SLO-1	*Programming terminal device*	*Handling analog inputs*	*Applications in Fluid power automation*	*Requirements of Industrial control networks*	*Motion control with PAC-case study*
	SLO-2	*Programming terminal device*	*Handling analog inputs*	*Applications in Fluid power automation*	*Industrial Field bus and Industrial Ethernet*	*Motion control with PAC-case study*
S-8	SLO-1	*Recording and retrieving data*	*Introduction to IL&SFC*	*PID Control in PLC*	*Industrial Field bus and Industrial Ethernet*	*Vision based system using PAC- Case study*

	SLO-2	*Recording and retrieving data*	*Introduction to IL & SFC*	*PID Control in PLC*	*Security issues and threats in industrial networks*	*Vision based system using PAC- Case study*
S-9	SLO-1	*HMI*	*Introduction to FBD and ST*	*PLC based servo system*	*Practical modern SCADA Protocols*	*Comparison between PLC, IPC and PAC*
	SLO-2	*HMI*	*Introduction to FBD and ST*	*PLC based servo system*	*Practical modern SCADA Protocols*	*Concluding Remarks*

Learning Resources	1. *Frank D. Petruzella, "Programmable Logic Controllers", 4th Edition, McGraw-Hill, 2011.* 2. *William Bolton, "Programmable Logic Controllers", 6th Edition, Elsevier Ltd, 2015* 3. *Dong Seong Kim, Hoa Tran DangPetruzella, "Industrial sensors and Controls in Communication Networks", Springer, 2019.*	4. *www.pacontrol.com/download/OMRON-PLC-Programming.pdf* 5. *http://www.ni.com/pdf/products/us/fullcriodevguide.pdf*

Learning Assessment

	Bloom's Level of Thinking	Continuous Learning Assessment (50% weightage)								Final Examination (50% weightage)	
		CLA – 1 (10%)		CLA – 2 (15%)		CLA – 3 (15%)		CLA – 4 (10%)#			
		Theory	Practice	Theory	Practice	Theory	Practice	Theory	Practice	Theory	Practice
Level 1	Remember Understand	30 %	-	30 %	-	30 %	-	30 %	-	30%	-
Level 2	Apply Analyze	40 %	-	40 %	-	40 %	-	40 %	-	40%	-
Level 3	Evaluate Create	30 %	-	30 %	-	30 %	-	30 %	-	30%	-
	Total	100 %		100 %		100 %		100 %		100 %	

CLA – 4 can be from any combination of these: Assignments, Seminars, Tech Talks, Mini-Projects, Case-Studies, Self-Study, MOOCs, Certifications, Conf. Paper etc.,

Course Designers

Experts from Industry	Experts from Higher Technical Institutions	Internal Experts
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2. Mr. VisweswaranJagadeesan , National Instruments, Bangalore visweswaran.jagadeesan@ni.com	*2. Dr.D.Sathia Narayanan, National Institute of Ocean Technology, Chennai, sathianarayanan@niot.res.in.*	*2. Dr.R.Senthilnathan, SRMIST*

Course Code	18MHE414T	Course Name	SPECIAL ELECTRICAL MACHINES	Course Category	E	Professional Elective	L	T	P	C
							3	0	0	3

Pre-requisite Courses	18MHC102T	Co-requisite Courses	18MHC204T	Progressive Courses	Nil
Course Offering Department	Mechatronics Engineering	Data Book / Codes/Standards	Nil		

Course Learning Rationale (CLR):	*The purpose of learning this course is to:*
CLR-1 :	*Understand the construction and principle of operation of Synchronous Reluctance Motors*
CLR-2 :	*Analyse the Performance ofStepping Motors*
CLR-3 :	*Understand the controllers applied in the operation of Switched Reluctance Motors*
CLR-4 :	*Analyse the Magnetic circuit andcharacteristics of Permanent Magnet Brushless D.C. Motors*
CLR-5 :	*Analyse the Permanent Magnet Synchronous Motorsfor suitable applications*
CLR-6 :	*Apply the Control circuits for different applications*

Course Learning Outcomes (CLO):	*At the end of this course, learners will be able to:*	Learning 1 Level of Thinking (Bloom)	2 Expected Proficiency (%)	3 Expected Attainment (%)	Program Learning Outcomes (PLO) 1 Engineering Knowledge	2 Problem Analysis	3 Design & Development	4 Analysis, Design, Research	5 Modern Tool Usage	6 Society & Culture	7 Environment & Sustainability	8 Ethics	9 Individual & Team Work	10 Communication	11 Project Mgt. & Finance	12 Life Long Learning	13 PSO - 1	14 PSO - 2	15 PSO - 3
CLO-1 :	*Operate different types of Synchronous Reluctance Motors*	1	85	80	H	L	-	H	M	-	L	L	M	-	-	-	M	-	-
CLO-2 :	*Operate different types of Stepping Motors*	2	85	80	H	H	-	H	M	-	L	L	M	-	-	-	-	-	-
CLO-3 :	*Operate different types of Special machines*	2	85	80	H	H	-	H	M	-	L	L	M	-	-	-	-	-	-
CLO-4 :	*Analyze the control circuits for suitable actuation*	2	85	80	H	H	-	H	M	-	L	L	M	-	-	-	-	-	-
CLO-5 :	*Apply the different machines for suitable Application*	2	85	80	H	H	-	H	M	-	L	L	M	-	-	-	-	-	-
CLO-6 :	*Operate, Analyze and apply different machines and control circuits for suitable applications*	2	85	80	H	H	-	H	M	-	L	L	M	-	-	-	-	-	-

		Synchronous reluctance motors	Stepping motors	Switched reluctance motors	Permanent magnet brushless d.c. Motors	Permanent magnet synchronous motors
Duration (hour)		9	9	9	9	9
S-1	SLO-1	*Constructional features*	*Constructional features*	*Constructional features*	*Constructional features*	*Constructional features*
	SLO-2	*Constructional features*	*Constructional features*	*Constructional features*	*Constructional features*	*Constructional features*
S-2	SLO-1	*Types*	*Principle of operation*	*Principle of operation*	*Principle of operation*	*Principle of operation*
	SLO-2	*Types*	*Principle of operation*	*Principle of operation*	*Principle of operation*	*Principle of operation*
S-3	SLO-1	*Axial and radial air gap motors*	*Variable reluctance motor*	*Torque prediction*	*Types*	*EMF and torque equations*
	SLO-2	*Axial and radial air gap motors*	*Variable reluctance motor*	*Torque prediction*	*Types*	*EMF and torque equations*
S-4	SLO-1	*Operating principle*	*Hybrid motor*	*Power controllers*	*Magnetic circuit analysis*	*Reactance*
	SLO-2	*Operating principle*	*Hybrid motor*	*Power controllers*	*Magnetic circuit analysis*	*Reactance*
S-5	SLO-1	*Reluctance*	*Single and multi stack configurations*	*Non-linear analysis*	*EMF and torque equations*	*Phasor diagram*
	SLO-2	*Reluctance*	*Single and multi stack configurations*	*Non-linear analysis*	*EMF and torque equations*	*Phasor diagram*
S-6	SLO-1	*Phasor diagram*	*Theory of torque predictions*	*Microprocessor based control*	*Power controllers*	*Power controllers - Converters*
	SLO-2	*Phasor diagram*	*Theory of torque predictions*	*Microprocessor based control*	*Power controllers*	*Power controllers - Converters*
S-7	SLO-1	*Characteristics*	*Linear and non-linear analysis*	*Characteristics*	*Motor characteristics*	*Volt-ampere requirements*
	SLO-2	*Characteristics*	*Linear and non-linear analysis*	*Characteristics*	*Motor characteristics*	*Volt-ampere requirements*
S-8	SLO-1	*Vernier motor*	*Characteristics*	*Computer control*	*controllers*	*Torque speed characteristics*
	SLO-2	*Vernier motor*	*Characteristics*	*Computer control*	*controllers*	*Torque speed characteristics*
S-9	SLO-1	*Applications*	*Drive circuits*	*Applications*	*Applications*	*Microprocessor based control*
	SLO-2	*Applications*	*Drive circuits*	*Applications*	*Applications*	*Microprocessor based control*

Learning Resources	1. T.J.E. Miller, „Brushless Permanent Magnet and Reluctance Motor Drives‟, Clarendon Press, Oxford, 1989. 2. P.P. Aearnley, „Stepping Motors – A Guide to Motor Theory and P 3. ractice‟, Peter Perengrinus, London, 1982.	4. T. Kenjo, „Stepping Motors and Their Microprocessor Controls‟, Clarendon Press London, 1984. 5. T. Kenjo and S. Nagamori, „Permanent Magnet and Brushless DC Motors‟,Clarendon Press, London, 1988.

Learning Assessment											
	Bloom's Level of Thinking	Continuous Learning Assessment (50% weightage)								Final Examination (50% weightage)	
		CLA – 1 (10%)		CLA – 2 (15%)		CLA – 3 (15%)		CLA – 4 (10%)#			
		Theory	Practice	Theory	Practice	Theory	Practice	Theory	Practice	Theory	Practice
Level 1	Remember Understand	30 %	-	30 %	-	30 %	-	30 %	-	30%	-
Level 2	Apply Analyze	40 %	-	40 %	-	40 %	-	40 %	-	40%	-
Level 3	Evaluate Create	30 %	-	30 %	-	30 %	-	30 %	-	30%	-
	Total	100 %		100 %		100 %		100 %		100 %	

CLA – 4 can be from any combination of these: Assignments, Seminars, Tech Talks, Mini-Projects, Case-Studies, Self-Study, MOOCs, Certifications, Conf. Paper etc.,

Course Designers		
Experts from Industry	Experts from Higher Technical Institutions	Internal Experts
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2. Mrs.T.Priya,Sr.Design Engineer, Electrical & Instrumentation,KavinEngg& Services Pvt Ltd,priya@kavinengg.com	2. Dr.M.Jagadeeshkumar,SriSaiRam Institute of Technology, jagadeeshkumar.eee@sairamit.edu.in	2. Ms.R.Gangadevi,SRMIST

Course Code	18MHE415T	Course Name	DIGITAL MANUFACTURING	Course Category	C	Professional Core	L	T	P	C
							3	0	0	3

Pre-requisite Courses	Nil	Co-requisite Courses	Nil	Progressive Courses	Nil
Course Offering Department	Mechatronics Engineering	Data Book / Codes/Standards	Nil		

Course Learning Rationale (CLR):	The purpose of learning this course is to:
CLR-1 :	*To learn about CAE, PLM and numerical control machining integration technology.*
CLR-2 :	*To be familiar in interfacing and Communication with industrial machinery.*
CLR-3 :	*To know to formulate manufacturing computational model.*
CLR-4 :	*To gain knowledge about intelligent controls used in various machinery environment.*
CLR-5 :	*To know about future development in digital manufacturing.*

Course Learning Outcomes (CLO):	At the end of this course, learners will be able to:	Learning 1: Level of Thinking (Bloom)	2: Expected Proficiency (%)	3: Expected Attainment (%)	PLO 1: Engineering Knowledge	2: Problem Analysis	3: Design & Development	4: Analysis, Design, Research	5: Modern Tool Usage	6: Society & Culture	7: Environment & Sustainability	8: Ethics	9: Individual & Team Work	10: Communication	11: Project Mgt. & Finance	12: Life Long Learning	13: PSO - 1	14: PSO - 2	15: PSO - 3
CLO-1 :	*Gain knowledge in fundamentals of Digital Manufacturing*	1	85	80	H	H	-	H	-	-									
CLO-2 :	*Impart Knowledge in industrial machinery*	1	85	80	H	H	H	-	H	-									
CLO-3 :	*Learn the information characteristics of manufacturing*	1	85	80	H	H	H	H	H										
CLO-4 :	*Understand the concept ofintelligent control in digital manufacturing.*	2	85	80	H	H	H	H	H										
CLO-5 :	*To impart future development and application of digital manufacturing.*	2	85	80	H			H		H									

Duration (hour)		Introduction	Modeling	Manufacturing Information System	Intelligent control	Future developments
		9	9	9	9	9
S-1	SLO-1	*concepts of digital manufacturing*	*manufacturing computational model*	*information characteristics of manufacturing*	*Introduction to intelligent control in digital manufacturing*	*Future development and application of digital manufacturing*
	SLO-2	*Introduction to CIM and digital manufacturing.*	*Modeling theory of digital manufacturing,*	*Information activities*	*Intelligent multi information sensing.*	*Various digital technologies in product lifecycle*
S-2	SLO-1	*product life cycle management(PLM).*	*basic concepts of computing manufacturing methodology,*	*manufacturing informatics.*	*Concept of multi information sensing.*	*cax technology integration.*
	SLO-2	*Applications of PLM*	*Application of C space*	*Measurement of manufacturing information*	*Application of sensor in processing*	*Digital equipment*
S-3	SLO-1	*product data management (PDM).*	*Application of screw space.*	*Basic concept of measurement of Manufacturing information*	*Tool condition monitoring.*	*digital processing technology.*
	SLO-2	*Applications of PDM*	*Virtual Prototyping*	*synthesis of manufacturing information*	*Mechanism of tool condition monitoring*	*Introduction to MEMS*
S-4	SLO-1	*Virtual environment for digital manufacturing.*	*Basic theory of virtual prototyping*	*Mechanism of synthesizing manufacturing information.*	*Intelligent multi information fusing*	*Basic concept and application of MEMS in Digital manufacturing*
	SLO-2	*Application of virtual environment (DM)*	*Application of virtual prototyping*	*Materialization of manufacturing information*	*Elements of multi information fusing*	*Basic concept and application of NEMS in Digital manufacturing*
S-5	SLO-1	*Operation mode of digital manufacturing system.*	*Reverse Engineering*	*Basic layout of Materialization of manufacturing information*	*Multi sensor fusion in tool state monitoring.*	*micro nanoequipement*
	SLO-2	*Mechanism of operation mode*	*Basic theory and application of Reverse Engineering.*	*integration model for manufacturing information.*	*Self learning*	*Basic concepts of micro nanoequipement systems.*
S-6	SLO-1	*architecture of digital manufacturing system.*	*Discrete model of manufacturing computing.*	*Block diagram of integration model for manufacturing information.*	*Autonomy*	*Extremalization of digital manufacturing*
	SLO-2	*Introduction to CAE*	*Discrete model of controlled process in manufacturing*	*Mechanism of integration model*	*Compatibility*	*complex mechanical system modeling.*
S-7	SLO-1	*CAE:engineering products*	*information model of manufacturing computing.*	*introduction to sharing manufacturing resources.*	*Openness of sensor fusion in tool state monitoring.*	*complex electrical system modeling.*

	SLO-2	*Design representation*	*Geometric modeling*	*Principle of sharing manufacturing resources.*	*Tool condition monitoring based on fuzzy theory*	*Digital manufacturing Technology in Micro Nano Manufacturing*
S-8	SLO-1	*design process*	*theoretical foundation for geometric modeling*	*.mechanism of sharing manufacturing resources*	*Tool condition monitoring based on neural network.*	*Bionic Machinery*
	SLO-2	*role of cad.*	*geometric modeling forms.*	*Application of Sharing manufacturing resources.*	*Data mining applied to digital manufacturing*	*Application of bionic Machinery in digital manufacturing*
S-9	SLO-1	*Introduction to caX technology*	*Geometric reasoning in manufacturing computing.*	*Introduction to manufacturing information security*	*Application of data mining in digital manufacturing*	*Bio-Robot*
	SLO-2	*Basic concepts of caX technology*	*Application of geometric modelling in manufacturing computing*	*Basic theory of manufacturing information security.*	*knowledge based manufacturing system.*	*Application of bio robot in digital manufacturing*

Learning Resources	1. *Zudezhou, Shanexie, Dejunchen,"fundamentals of digital manufacturing science". Springer, 2012.* 2. *Lihui ,Wang ,Andrew ,Y C Nee, "Collaborative Design and Planning for Digital Manufacturing", springer, 2009.* 3. *Saaksvuori ,Antti, Anselmi, Immonen, 'Product Lifecycle Management', Springer New York , 2008.*	7. *Stark, J., "Product Lifecycle Management - 21st Century Paradigm for Product Realisation", Springer, 2005.* 8. *Vukicajovanovic ,Michealdebevee. "Applications of digital manufacturing in manufacturing process support" proceedings of IAJC/ ISAM, 2014.*

Learning Assessment											
	Bloom's Level of Thinking	Continuous Learning Assessment (50% weightage)								Final Examination (50% weightage)	
		CLA – 1 (10%)		CLA – 2 (15%)		CLA – 3 (15%)		CLA – 4 (10%) #			
		Theory	Practice	Theory	Practice	Theory	Practice	Theory	Practice	Theory	Practice
Level 1	Remember Understand	40 %	-	30 %	-	30 %	-	30 %	-	30%	-
Level 2	Apply Analyze	40 %	-	40 %	-	40 %	-	40 %	-	40%	-
Level 3	Evaluate Create	20 %	-	30 %	-	30 %	-	30 %	-	30%	-
	Total	100 %		100 %		100 %		100 %		100 %	

CLA – 4 can be from any combination of these: Assignments, Seminars, Tech Talks, Mini-Projects, Case-Studies, Self-Study, MOOCs, Certifications, Conf. Paper etc.

Course Designers		
Experts from Industry	Experts from Higher Technical Institutions	Internal Experts
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2.Mr.V.G. Balaji, Design Engineer, Rotork control, India private limited, balaji.govindan@rotork.com , Ambattur,	*2. Dr. R.sarala,AlagappaChettiar college of Engineering and Technology, Manufacturing department, r.sarala@accetedu.in, karaikudi.*	*2. Dr. B. K. Vinayagam, SRMIST*

Course Code	18MHE416T	Course Name	PROCESS CONTROL ENGINEERING	Course Category	E	Professional Elective	L	T	P	C
							3	0	0	3

Pre-requisite Courses	Nil	Co-requisite Courses	Nil	Progressive Courses	Nil
Course Offering Department	Mechatronics Engineering	Data Book / Codes/Standards	Nil		

Course Learning Rationale (CLR):	The purpose of learning this course is to:
CLR-1 :	*Identify the need for process control*
CLR-2 :	*Gain the knowledge on different controller modes*
CLR-3 :	*Build the various concepts of auto tuning*
CLR-4 :	*Utilize the control algorithm in pneumatic*
CLR-5 :	*Gain knowledge of multi loop control system*
CLR-6 :	*Introduce the knowledge of non-linear control algorithms*

Course Learning Outcomes (CLO):	At the end of this course, learners will be able to:	Learning 1: Level of Thinking (Bloom)	2: Expected Proficiency (%)	3: Expected Attainment (%)	PLO 1: Engineering Knowledge	2: Problem Analysis	3: Design & Development	4: Analysis, Design, Research	5: Modern Tool Usage	6: Society & Culture	7: Environment & Sustainability	8: Ethics	9: Individual & Team Work	10: Communication	11: Project Mgt. & Finance	12: Life Long Learning	13: PSO - 1	14: PSO - 2	15: PSO - 3
CLO-1 :	*Knowledge of process control*	2	75	70	H	M	M	H	M	-	-	-	M	M	-	H	H	H	H
CLO-2 :	*Knowledge about the different controller modes*	3	75	70	H	M	M	H	M	-	-	-	M	M	-	H	M	M	M
CLO-3 :	*Design various control tuning methods*	3	75	70	H	M	M	M	M	-	-	-	M	M	-	H	L	L	L
CLO-4 :	*Application of control algorithm in pneumatic*	3	75	70	H	M	M	-	M	-	-	-	-	M	-	H	M	M	M
CLO-5 :	*Evaluate about the multi loop control system*	3	75	70	H	M	M	H	M	-	-	-	M	M	-	H	L	L	L
CLO-6 :	*Interpret the knowledge of non-linear control algorithms*	3	75	70	H	M	-	H	H	-	-	-	M	M	-	H	H	H	H

		Introduction to Process Control	Controller Modes and Tuning	Final Control Elements	Multi Loop System	Nonlinear Systems and Intelligent Controllers
Duration (hour)		9	9	9	9	9
S-1	SLO-1	*Process control: Introduction,*	*First order system,*	*Basic of I/P converter.*	*Need, types of feed-forward controller*	*Non-linear elements in loop: Limiters*
	SLO-2	*Need for process control, terminologies.*	*second order system*	*Description about I/P converter.*	*Introduction to steady state and dynamic,*	*Non-linear elements in loop: dead zones*
S-2	SLO-1	*Characteristics of process.*	*Definition of Multi position action and floating action*	*Introduction of Pneumatic and electric actuators*	*Mathematical equation for steady state and dynamic feed-forward control*	*Non-linear elements in loop :backlash*
	SLO-2	*Liquid level control system Introduction*	*Need of Multi position action and floating.*	*Description about Pneumatic and electric actuators*	*Mathematical equation for dynamic feed-forward control*	*Non-linear elements in loop: dead band velocity.*
S-3	SLO-1	*Block diagram of Liquid level control system*	*Diagram of Multi position action and floating action:*	*Control algorithm for Servo motor*	*Definition of ratio control*	*Introduction of Limiter, negative resistance.*
	SLO-2	*Description of control elements used in liquid level control*	*Application of Multi position action, floating action:*	*Control algorithm for Stepper motor*	*Block diagram of ratio control, uses of ratio control.*	*Description of Limiter, negative resistance*
S-4	SLO-1	*Introduction of temperature control system*	*Introduction of PI, PD, PID controllers*	*Definition and need of Valve positioner control valves*	*Definition of cascade controller for heat exchanger*	*Introduction of optimal controller*
	SLO-2	*Block diagram of temperature control system*	*Block diagram and mathematical model of PI Controller*	*Types and configuration of valve position.*	*Advantages of cascade control*	*Definition of optimal controller*
S-5	SLO-1	*Description of control elements used in temperature control.*	*Block diagram and mathematical model of PD Controller*	*Introduction of control valves.*	*Adaptive control: Definition, objective, types, gain schedule adaptive controller.*	*Need for an optimal controller*
	SLO-2	*Explanation about temperature control*	*Block diagram and mathematical model of PID Controller*	*Characteristics of control valves.*	*Block diagram description of adaptive control*	*Structure of an optimal controller.*
S-6	SLO-1	*Introduction of process dynamics*	*Basic Selection criteria for controllers.*	*Inherent characteristics of control valves.*	*Inferential control: Need, inferential controller for distillated column*	*Introduction of Dynamic matrix controller (DMC)*

	SLO-2	*Elements of process dynamics*	*Description Selection criteria for controllers.*	*Installed characteristics of control valves.*	*block diagram description of Inferential control*	*Definition of Dynamic matrix controller*
S-7	SLO-1	*Interacting systems*	*Need of controller tuning,*	*Introduction of Mathematical modeling of pneumatic control valve.*	*Split-range control, objective of split range control*	*Structure of Dynamic matrix controller*
	SLO-2	*Non interacting systems*	*Criteria for good control.*	*Description of Mathematical modeling of pneumatic control valve.*	*Block diagram for split range control.*	*tuning parameters required to implement Dynamic matrix controller*
S-8	SLO-1	*Degrees of freedom: Definition*	*Tuning methods: Basic of Choen-Coon method.*	*Valve body*	*Introduction of Internal mode control*	*Introduction of self-tuning controller*
	SLO-2	*Determination of degrees of freedom.*	*Description of Choen-Coon method.*	*Commercial valve` bodies*	*Principle and structure of Internal mode control*	*Need for self-tuning controller*
S-9	SLO-1	*Introduction of Continuous and batch process.*	*Introduction of Process identification for controller tuning.*	*Control valve sizing*	*Principle of Model predictive control*	*Structure of self- tuning controller.*
	SLO-2	*Description about Continuous and batch process.*	*Description of Process identification for controller tuning.*	*Cavitation and flashing*	*Theory of model predictive control, applications.*	*Case study: Process control in chemical plant.*

Learning Resources	1. *David A Bell., "Electronic devices and circuits", Oxford Publication., 2008.* 2. *Robert Boylestad and Louis Nashelsky., "Electronic devices and circuit theory", Prentice Hall., 7th edition, 2005.*	3. *D.Roy Choudhury, ShailB.Jain., "Linear integrated circuits", New Age International publishers, 2010.* 4. *J.B. Gupta., "Electronic devices and Circuits", Sanjay Kumar Kattaria Publication, 2010.* 5. *Milman and Halkias.C., "Electronic devices and circuits", Tata McGraw Hill publications, 2001.*

Learning Assessment

	Bloom's Level of Thinking	Continuous Learning Assessment (50% weightage)								Final Examination (50% weightage)	
		CLA – 1 (10%)		CLA – 2 (15%)		CLA – 3 (15%)		CLA – 4 (10%)#			
		Theory	Practice	Theory	Practice	Theory	Practice	Theory	Practice	Theory	Practice
Level 1	Remember Understand	30 %	-	30 %	-	30 %	-	30 %	-	30%	-
Level 2	Apply Analyze	40 %	-	40 %	-	40 %	-	40 %	-	40%	-
Level 3	Evaluate Create	30 %	-	30 %	-	30 %	-	30 %	-	30%	-
	Total	100 %		100 %		100 %		100 %		100 %	

CLA – 4 can be from any combination of these: Assignments, Seminars, Tech Talks, Mini-Projects, Case-Studies, Self-Study, MOOCs, Certifications, Conf. Paper etc.,

Course Designers

Experts from Industry	Experts from Higher Technical Institutions	Internal Experts
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Course Code	18MHE417T	Course Name	APPLIED MECHATRONICS SYSTEMS	Course Category	E	Professional Elective	L	T	P	C
							3	0	0	3

Pre-requisite Courses	Nil	Co-requisite Courses	Nil	Progressive Courses	Nil
Course Offering Department	Mechatronics Engineering	Data Book / Codes/Standards		Nil	

Course Learning Rationale (CLR):	*The purpose of learning this course is to:*
CLR-1 :	*Understand the design process and integrated design issues in mechatronics system*
CLR-2 :	*Apply the concept of robots used in different applications*
CLR-3 :	*Apply the concept of mechatronics system in medical application.*
CLR-4 :	*Apply the concept of mechatronics system in automobile application.*
CLR-5 :	*Apply the concept of mechatronics system in various industrial applications.*
CLR-6 :	*Utilize the concept of mechatronics system design into robotics, automobile and other industrial applications.*

		Learning			Program Learning Outcomes (PLO)														
		1	2	3	1	2	3	4	5	6	7	8	9	10	11	12	13	14	15
Course Learning Outcomes (CLO):	*At the end of this course, learners will be able to:*	Level of Thinking (Bloom)	Expected Proficiency (%)	Expected Attainment (%)	Engineering Knowledge	Problem Analysis	Design & Development	Analysis, Design, Research	Modern Tool Usage	Society & Culture	Environment & Sustainability	Ethics	Individual & Team Work	Communication	Project Mgt. & Finance	Life Long Learning	PSO - 1	PSO - 2	PSO - 3
CLO-1 :	*Analyze the mechatronics system process into various applications.*	*1*	*85*	*80*	*H*	*L*	*-*	*H*	*M*	*-*	*L*	*L*	*M*	*-*	*-*	*-*	*M*	*-*	*-*
CLO-2 :	*Build parallel manipulator ,wall climbing, firefighting robot and obstacle avoidance robot*	*2*	*85*	*80*	*H*	*H*	*M*	*H*	*M*	*-*	*L*	*L*	*M*	*-*	*-*	*-*	*-*	*-*	*-*
CLO-3 :	*Build a robot for Neuro rehabilitation, mechatronic assistant for laparoscopic solo surgery, Exoskeleton and powered wheelchair*	*2*	*85*	*80*	*H*	*H*	*M*	*H*	*M*	*-*	*L*	*L*	*M*	*-*	*-*	*-*	*-*	*-*	*-*
CLO-4 :	*Build a system for cruise control, ABS, suspension, unmanned ground vehicle and measurement system in automobile applications.*	*2*	*85*	*80*	*H*	*H*	*M*	*H*	*M*	*-*	*L*	*L*	*M*	*-*	*-*	*-*	*-*	*-*	*-*
CLO-5 :	*Build a system for thermal cycle fatigue failure, PH level neutralization system and CNC controlled drilling machine in to industrial applications*	*2*	*85*	*80*	*H*	*H*	*M*	*H*	*M*	*-*	*L*	*L*	*M*	*-*	*-*	*-*	*-*	*-*	*-*
CLO-6 :	*Build the mechatronics system into various applications*	*2*	*85*	*80*	*H*	*H*	*M*	*H*	*M*	*-*	*L*	*L*	*M*	*-*	*-*	*-*	*-*	*-*	*-*

		Introduction	Robotic Applications	Medical Applications	Automobile Applications	Other applications
Duration (hour)		9	9	9	9	9
S-1	SLO-1	*Mechatronics design concept and framework.*	*Case study 1: Parallel manipulators: state of art and perspectives*	*Application of robotics and mechatronic systems to neuro rehabilitation: Overview.*	*Electronics car engine management system*	*Case study 1:Thermal cycle fatigue of a ceramic plate*
	SLO-2	*Overview of mechatronics key elements.*	*Theoretical aspects of parallel manipulators and Practical applications*	*Robotic systems for upper limbs rehabilitation.*	*Stepper motor and vacuum operated throttle actuator*	*Case study 2:Strain gauge weighing system*
S-2	SLO-1	*Definition of mechatronics: Sequential integration and concurrent integration.*	*Development of parallel manipulator*	*Robotic systems for lower limbs rehabilitation.*	*Adaptive cruise control system*	*Case study 3:pH control system*
	SLO-2	*Integrated design issues in mechatronics.*	*Direct and inverse kinematics*	*Material and methods of neurorehabilitation system.*	*Adaptive cruise control system*	*Case study 3:pH control system*
S-3	SLO-1	*Introduction to real time interfacing*	*Bio parallel mechanism of mastication robot*	*Mechatronic systems for the functional assessment and the movement analysis.*	*Antilock braking system*	*Case study 4: Skip control of a CD player*
	SLO-2	*Elements of Data acquisition and control system*	*Mandibular movement and its parallel mechanism*	*Open issues.*	*Antilock braking system*	*Case study 4: Skip control of a CD player*
S-4	SLO-1	*Transducer and signal conditioning*	*Case study 2: Overview of a bio-inspired small sized wall climbing caterpillar Robot.*	*Overview of postural mechatronic assistant for laparoscopic solo surgery.*	*Electronics suspension control system*	*Case study 5: Position control of permanent magnet dc gear motor*
	SLO-2	*Transducer and signal conditioning*	*System architecture and Control methods of a bio-inspired Robot.*	*Overview of postural mechatronic assistant for laparoscopic solo surgery.*	*Electronics suspension control system*	*Case study 5: Position control of permanent magnet dc gear motor*
S-5	SLO-1	*Devices for data conversion*	*Climbing mechanism of the caterpillars.*	*Exoskeleton development and control*	*Electronic steering control for 4WS configuration*	*Case study 6: Testing of transportation bridge surface materials.*
	SLO-2	*Data conversion process*	*Mechanical module design and inchworm configuration realization, control realization.*	*Human robot interface*	*Low tire pressure warning system*	*Case study 6: Testing of transportation bridge surface materials.*

S-6	SLO-1	*Linking HMI design and system design*	*Locomotion control.*	*Wearable exoskeletal rehabilitation robot for interactive therapy*	*Automatic car parking system*	*PC based computer numerically controlled (CNC) drilling machine*
	SLO-2	*Human machine interface design process.*	*Case study 3: Firefighting Robot, Multiple interfaces based firefighting Robot.*	*Robot controller and therapy modes*	*Fuel quantity, coolant temperature measurement system*	*PC based computer numerically controlled (CNC) drilling machine*
S-7	SLO-1	*HMI design method*	*Case study 4: Torque cancelling system for quick-motion robots*	*Force sensing in medical robotics*	*Oil pressure and vehicle speed measurement system*	*Auto control system for green house temperature*
	SLO-2	*Designing human-automation interaction*	*Case study 4: Torque cancelling system for quick-motion robots*	*Haptic feedback using robotics surgery*	*Onboard diagnosis system*	*Mechatronics design of coin counter*
S-8	SLO-1	*Human error, interaction and the development of safety -critical systems*	*Case study 5: Recognition of finger motions for bio electric prosthetic hand via surface EMG*	*Model based fault detection and isolation for a powered wheelchair*	*Series hybrid electric vehicle*	*Magnetic levitation system*
	SLO-2	*Human error, interaction and the development of safety -critical systems*	*Case study 5: Recognition of finger motions for bio electric prosthetic hand via surface EMG*	*Model based fault detection and isolation for a powered wheelchair*	*Parallel hybrid electric vehicle*	*Washing machine control.*
S-9	SLO-1	*Cognitive function analysis in the design of human and machine multi agent system*	*Case study 6: Swimming Mechanism for robotic fish*	*Accurate positioning for intervention on a beating heart using crawling robot*	*Mechatronics design of an unmanned ground vehicle for military applications: Historical perspective, Current military systems*	*Electronic control of a balancing robot.*
	SLO-2	*Cognitive function analysis in the design of human and machine multi agent system*	*Case study 6: Swimming Mechanism for robotic fish*	*Accurate positioning for intervention on a beating heart using crawling robot*	*Design considerations, hardware implementation of unmanned ground vehicle, Vehicle software architecture.*	*Pneumatic controlled car park barrier system.*

Learning Resources	1. *Robort H Bishop,"Mechatronics an introduction" ,Taylor and Francis, 2nd edition, 2003* 2. *Annalisa Melilla, Donato Di Paola and GraziaCicirelli, "Mechatronic Systems, Applications", InTech publisher, 2010* 3. *Bolton, "Mechatronics - Electronic Control Systems in Mechanical and Electrical Engineering", 2nd edition, Addison Wesly Longman Ltd., 2007.*	4. *Devdasshetty, Richard A. Kolkm, "Mechatronics System Design", PWS Publishing company, 2nd edition, 2010.* 5. *M. D. Singh, J. G. Joshi, "Mechatronics", Prentice Hall of India private limited, 2006.* 6. *William B. Ribbens, Norman P. Mansour",Understanding Automotive Electronics", 6th edition,Elsevier science,2013.*

Learning Assessment											
	Bloom's Level of Thinking	Continuous Learning Assessment (50% weightage)								Final Examination (50% weightage)	
		CLA – 1 (10%)		CLA – 2 (15%)		CLA – 3 (15%)		CLA – 4 (10%)#			
		Theory	Practice	Theory	Practice	Theory	Practice	Theory	Practice	Theory	Practice
Level 1	Remember Understand	30 %	-	30 %	-	30 %	-	30 %	-	30%	-
Level 2	Apply Analyze	40 %	-	40 %	-	40 %	-	40 %	-	40%	-
Level 3	Evaluate Create	30 %	-	30 %	-	30 %	-	30 %	-	30%	-
	Total	100 %		100 %		100 %		100 %		100 %	

CLA – 4 can be from any combination of these: Assignments, Seminars, Tech Talks, Mini-Projects, Case-Studies, Self-Study, MOOCs, Certifications, Conf. Paper etc.,

Course Designers		
Experts from Industry	Experts from Higher Technical Institutions	Internal Experts
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Course Code	15MHE418T	Course Name	REAL TIME EMBEDDED SYSTEMS	Course Category	C	Professional Core	L	T	P	C
							3	0	0	3

Pre-requisite Courses	18MHC205J	Co-requisite Courses	Nil	Progressive Courses	Nil
Course Offering Department	Mechatronics Engineering	Data Book / Codes/Standards	Nil		

Course Learning Rationale (CLR):	*The purpose of learning this course is to:*
CLR-1 :	*Learn the basics of Embedded System*
CLR-2 :	*Perceive the concept of interrupts,memory and I/O management*
CLR-3 :	*Study the functions and scheduling of real –time operating systems*
CLR-4 :	*Learn the concept of semaphore,Queue and pipes*
CLR-5 :	*Know the different approach of a Real Time characteristics*
CLR-6 :	*Implement the concept of interrupts with an interfacing applications*

Course Learning Outcomes (CLO):	*At the end of this course, learners will be able to:*	Learning 1: Level of Thinking (Bloom)	Learning 2: Expected Proficiency (%)	Learning 3: Expected Attainment (%)	PLO 1: Engineering Knowledge	PLO 2: Problem Analysis	PLO 3: Design & Development	PLO 4: Analysis, Design, Research	PLO 5: Modern Tool Usage	PLO 6: Society & Culture	PLO 7: Environment & Sustainability	PLO 8: Ethics	PLO 9: Individual & Team Work	PLO 10: Communication	PLO 11: Project Mgt. & Finance	PLO 12: Life Long Learning	PLO 13: PSO - 1	PLO 14: PSO - 2	PLO 15: PSO - 3
CLO-1 :	*Explain the fundamentals of embedded system design with real time system*	2	90	85	H	L	H	L	M	-	H	-	-	-	-	L	M	-	M
CLO-2 :	*Analyze the fundamental concepts and can control with OS*	2	90	80	H	L	M	L	M	L	M	-	-	H	-	H	M	M	L-
CLO-3 :	*Evaluate the feasible algorithm and interrupts with interface applications*	2	90	85	H	L	H	L	M	L	M	-	-	H	-	M	M	H	M
CLO-4 :	*Implement the concept of RTOS and interrupts with interface*	2	95	90	H	L	H	L	M	-	M	-	-	M	-	M	M	H	M
CLO-5 :	*Analyse real time systems with regard to keeping time and resource restrictions*	2	90	85	H	L	M	L	H	L	M	-	-	M	-	M	H	H	H
CLO-6 :	*Know the concepts of interfacing applications*	2	85	85	H	L	H	M	M	-	-	-	-	M	-	M	M	H	M

		Introduction to Embedded System	Interrupts in Embeddded Systems	Overview of RTOS	Real-Time Characteristics	Communication Interfacing
Duration (hour)		09	09	09	09	09
S-1	SLO-1	*Introduction to the course and Discussion*	*Terminologies of an Embedded System.*	*Introduction*	*Introduction to Real time Characteristics*	*Introduction to converters and its types*
	SLO-2	*Embedded computers,Characteristics of embedded computing,challenegs in embedded computing system design*	*Gates and timing diagram*	*Multiple task and Multiple processes:Task and Processess,Multirate Systems*	*Algorithm:Clock driven approach*	*Types od ADCs and its working principle*
S-2	SLO-1	*Embedded System Design process:Requirements,Specification*	*Memory and its types*	*Timing requirements on process,CPU metrics*	*Weighted round robin approach*	*Types of DACs and its working principle*
	SLO-2	*Architecture Design*	*Memory and its types*	*Process stateandscheduling,some scheduling policies*	*Weighted round robin approach*	*Types of DACs and its working principle*
S-3	SLO-1	*Designing of hardware components*	*Microprocessor buses*	*Running periodic process,RTOS task and task state*	*Priority Driven Approach:Introduction and Concepts*	*Introduction to programmable Interface with A/D and its working principle*
	SLO-2	*Designing of software components*	*Programming the Input and Output Devices*	*Preemptive Real Time Operating Systems,Multithread preemptive schedule*	*Priority Driven Approach:Introduction and Concepts*	*Introduction to programmable Interface with A/D and its working principle*
S-4	SLO-1	*System Integration*	*Direct Memory Access*	*Priority Based Scheduling:Introduction and its types*	*Example of Priority Driven Approach*	*Introduction to programmable Interface with D/A and its working principle and Digital Voltmete*
	SLO-2	*System Integration*	*Direct Memory Access*	*Rate-Monoitic Scheduling*	*Example of Priority Driven Approach*	*Introduction to programmable Interface with D/A and its working principle and Digital Voltmete*
S-5	SLO-1	*Formalism for System Design:Structural Description*	*Interrupts: Built interrupts*	*Earliest Deadline First scheduling.*	*Dynamic versus Static systems*	*Introduction and working principle of Control robot system*

	SLO-2	*Formalism for System Design:Structural Description*	*Interrupts basis:Supervisemode,Exceptions and Traps*	*Evaluation of operating systems performance*	*Dynamic versus Static systems*	*Introduction and working principle of Control robot system*
S-6	SLO-1	*Formalism for System Design:Behavioral Description*	*Shared Data problem*	*Design of Telephone Answering Machine*	*Effective release Times and deadline*	*Introduction and working principle of Pulse Width Modulation*
	SLO-2	*Formalism for System Design:Behavioral Description*	*Disadvantage and interrupt latency*	*Design of Telephone Answering Machine*	*Effective release Times and deadline*	*Introduction and working principle of Motor Speed Controller*
S-7	SLO-1	*Design Example: Data Compressor*	*Embedded System evolution trends*	*Process synchronizationand Message queues.*	*Optimality of the Earliest Deadline First(EDF) algorithm:Introduction*	*Serial Communication and parallel Communication*
	SLO-2	*Design Example: Data Compressor*	*Embedded System evolution trends*	*Mailboxes,Pipes,critical selection*	*Optimality of the Earliest Deadline First(EDF) algorithm:Introduction*	*Wireless Communication*
S-8	SLO-1	*Design Example: Data Compressor*	*Interrupt routines in an RTOS environment*	*Semaphores:Classical synchronization problem,deadlocks.*	*Real Time concepts of EDF*	*Serial Protocols:I²C,CAN and USB*
	SLO-2	*Design Example: Data Compressor*	*Interrupt routines in an RTOS environment*	*Semaphores:Classical synchronization problem,deadlocks.*	*Real Time concepts of EDF*	*Serial Protocols:I²C,CAN and USB*
S-9	SLO-1	*Design Example:Alarm Clock*	*Real time clock*	*Basic Design using a Real-Time Operating System:Principle*	*Challenges in validating timing constraints in priority driven systems*	*Parallel Protocols:PCI and ARM Bus*
	SLO-2	*Design Example:Alarm Clock*	*System Clock*	*Encapsulating semaphores and Queues,Hard Real –Time Scheduling Considerstions*	*Off-line versus online scheduling*	*Wireless Protocols:IrDA,Bluetoothand IEEE 802.11*

Learning Resources	1. *Wayne Wolf,"Computers as Components:Principles of Embedded Computing System Design", Morgan Kauffman Publishers,2011* 2. *Frank Vahid and Tony Givargis,"Embedded SystmeDesign:AUnifiefd Hardware/Software Introduction", John Wiley and Sons,2002.*	3. *David E.Simon, "An Embedded Software Primer",Pearson Education Asia,2001.* 4. *RajKamal, "Embedded Systems",Tata McGraw Hill,2009* 5. *NPTEL Engineering Mechanics Lectures by IIT Guwahati 'https://nptel.ac.in/courses/112103109/'*

Learning Assessment

	Bloom's Level of Thinking	Continuous Learning Assessment (50% weightage)								Final Examination (50% weightage)	
		CLA – 1 (10%)		CLA – 2 (15%)		CLA – 3 (15%)		CLA – 4 (10%)#			
		Theory	Practice	Theory	Practice	Theory	Practice	Theory	Practice	Theory	Practice
Level 1	Remember Understand	40 %	-	20 %	-	30 %	-	30 %	-	30%	-
Level 2	Apply Analyze	40 %	-	40 %	-	40 %	-	40 %	-	40%	-
Level 3	Evaluate Create	20 %	-	45 %	-	30 %	-	30 %	-	30%	-
	Total	100 %		100 %		100 %		100 %		100 %	

CLA – 4 can be from any combination of these: Assignments, Seminars, Tech Talks, Mini-Projects, Case-Studies, Self-Study, MOOCs, Certifications, Conf. Paper etc.,

Course Designers

Experts from Industry	Experts from Higher Technical Institutions	Internal Experts
1. Dr.K.Kathikeyan,R&DSpecialist,ABB India Ltd., Bangalore,India, sayalkarthik@yahoo.co.in	*1. Dr. K..Balasubdra,RMD Engineering College,Kavaraipettai,Thiruvallurdistrict,hodit@rmd.ac.in*	*1. Ms.D.Sasikala, SRMIST*
2.Mrs.A.Priya,Principal Engineer,TechnipFMC,Chennai,apriya@technipfmc.com	*2.Dr.Albert Rajan,Karunya Institute of Technology and Sciences,Coimbatore,albert@karunya.edu*	*2.Dr.M.Mohamed Rabik, SRMIST*

Course Code	18MHE419T	Course Name	INTELLIGENT CONTROL SYSTEMS	Course Category	P	Professional Elective	L	T	P	C
							3	0	0	3

Pre-requisite Courses	NIL	Co-requisite Courses	18MHE412T	Progressive Courses	NIL
Course Offering Department		Mechatronics Engineering	Data Book / Codes/Standards	NIL	

Course Learning Rationale (CLR):	The purpose of learning this course is to:
CLR-1 :	*Understand the basics of fuzzy logic*
CLR-2 :	*Impart knowledge on the learning in neural network systems*
CLR-3 :	*Gain knowledge on the Hybrid Intelligent Systems*
CLR-4 :	*Impart knowledge on controllers based on fuzzy logic.*
CLR-5 :	*Design control systems based on artificial neural networks.*
CLR-6 :	*Impart the knowledge of advanced control systems for implementation.*

Course Learning Outcomes (CLO):	At the end of this course, learners will be able to:	Learning 1 Level of Thinking (Bloom)	2 Expected Proficiency (%)	3 Expected Attainment (%)	PLO 1 Engineering Knowledge	2 Problem Analysis	3 Design & Development	4 Analysis, Design, Research	5 Modern Tool Usage	6 Society & Culture	7 Environment & Sustainability	8 Ethics	9 Individual & Team Work	10 Communication	11 Project Mgt. & Finance	12 Life Long Learning	13 PSO - 1	14 PSO - 2	15 PSO - 3
CLO-1 :	*Comprehend the basics of fuzzy logic*	1	85	80	H	H	M	M	M	L	M	L	L	L	L	M	H	H	H
CLO-2 :	*Understand the learning in neural network systems*	1	85	80	H	H	M	M	M	L	M	L	L	L	L	M	H	H	H
CLO-3 :	*Familiarize with the controllers based on fuzzy logic.*	1	85	80	H	H	M	M	M	L	M	L	L	L	L	M	H	H	H
CLO-4 :	*Demonstrate synthesis of controllers based on fuzzy logic.*	2	85	80	H	H	M	M	M	L	M	L	L	L	L	M	H	H	H
CLO-5 :	*Implement control systems based on artificial neural networks.*	2	85	80	H	H	M	M	M	L	M	L	L	L	L	M	H	H	H
CLO-6 :	*Implement control system based on fuzzy or neural network*	2	85	80	H	H	M	M	M	L	M	L	L	L	L	M	H	H	H

		Fuzzy logic	Artificial neural networks	Hybrid intelligent systems	Fuzzy control	Neural control
Duration (hour)		9	9	9	9	9
S-1	SLO-1	*Intelligent Systems*	*Artificial Neural Networks*	*Neuro-Fuzzy Systems*	*Knowledge-Based Fuzzy Control*	*Overview Of Supervisory Control.*
	SLO-2	*Intelligence In Machines*	*Operation Of A Single Artificial Neuron.*	*Fuzzy Basis Function Networks*	*Fuzzy PID Control*	*Direct Inverse Control*
S-2	SLO-1	*Intelligent Control System Structure*	*Network Architectures*	*Adaptive Neuro-Fuzzy Inference System - ANFIS*	*Knowledge-Based Fuzzy Control*	*Direct Learning Schemes.*
	SLO-2	*Soft Computing Techniques For Intelligent Control*	*Feed Forward Networks*	*Adaptive Neuro-Fuzzy Inference System - ANFIS*	*Model Reference Based Fuzzy Control*	*Indirect Learning Schemes.*
S-3	SLO-1	*Fuzzy Logic Systems*	*Radial Basis Function Networks*	*Training Algorithm -Supervised Algorithm*	*Fuzzy Control.*	*Model Reference Neural Adaptive Control - Direct Control*
	SLO-2	*Fuzzy Set Theory*	*Definition And Types Of RBF*	*Training Algorithm -Supervised Algorithm*	*Hybrid Fuzzy Control*	*Model Reference Neural Adaptive Control - Direct Control*
S-4	SLO-1	*Fuzzy Operations*	*Recurrent Networks*	*Training Algorithm -Unsupervised Algorithm.*	*Adaptive Fuzzy Control -Direct Adaptive Control.*	*Model Reference Neural Adaptive Control - Indirect Control*
	SLO-2	*Fuzzy Relations*	*Recurrent Network Architecture*	*Training Algorithm -Unsupervised Algorithm.*	*Adaptive Fuzzy Control -Direct Adaptive Control.*	*Model Reference Neural Adaptive Control - Direct Control*
S-5	SLO-1	*Fuzzy Implications*	*Learning In Neural Networks*	*Back Propagation Algorithm*	*Adaptive Fuzzy Control -Indirect Adaptive Control*	*Fundamentals Of Internal Model Control*
	SLO-2	*Theory Of Approximate Reasoning*	*Supervised Learning*	*Back Propagation Algorithm*	*Adaptive Fuzzy Control -Indirect Adaptive Control*	*Model Predictive Control*
S-6	SLO-1	*Fuzzy Inference System*	*Learning In Neural Networks*	*Dynamic Back Propagation*	*Self-Organizing Fuzzy Control*	*MPC With NN*
	SLO-2	*Fuzzifier*	*Unsupervised Learning*	*Dynamic Back Propagation*	*SOFC Based On The Direct Lyapunov Method.*	*MPC Vs Conventional Control*

S-7	SLO-1	*Fuzzy Rule Base*	*Activation Function, Adding A Bias*	*Orthogonal Least Squares Algorithm*	*SOFC Based Hurwitz Stability Criteria.*	*MPC Features*
	SLO-2	*Fuzzy Inference Engine*	*Perceptron Learning Rule*	*OLS Learning*	*SOFC Based On Sensitivity Functions*	*MPC Control Law And Convergence*
S-8	SLO-1	*Defuzzifier*	*Back Propagation Algorithm*	*Orthogonal Least Squares And Genetic Algorithm*	*Model Based Fuzzy Control*	*Pros And Cons Of MPC*
	SLO-2	*Defuzzification Methods*	*Back Propagation Algorithm*	*Orthogonal Least Squares And Genetic Algorithm*	*Fuzzy Inverse Control.*	*Feed Forward Control.*
S-9	SLO-1	*Fuzzy Logic Controllers*	*Neural Network Controller*	*Adaptive Least Squares Learning Using Genetic Algorithm.*	*Fuzzy Model Based Predictive Control.*	*FFC With NN*
	SLO-2	*General Case Study*	*Application Of Neural Networks In Modeling, Estimation And Control*	*Adaptive Least Squares Learning Using Genetic Algorithm.*	*Fuzzy Internal Model Control*	*FFC Vs Conventional Control*

Learning Resources	1. *Yung C. Shin and ChengyingXu, "Intelligent Systems: Modeling, Optimization and Control", CRC Press, 2009.* 2. *Roland S Burns, "Advanced Control Engineering", Butterworth Heinemann, 2005.* 3. *René Jager, "Fuzzy Logic in Control", TU Delft Institutional Repository, 1995.*	4. *George William Irwin, K Warwick, Kenneth J Hunt, "Neural Network Applications in Control", The Institution of Electrical Engineers, 1995.* 5. *Ali Zilouchian, Mo Jamshidi, "Intelligent Control Systems using Soft Computing Methodologies", CRC Press, 2001.* 6. *Hung T Nguyen, Nadipuram R Prasad, Carol L Walker, Elbert A Walker, "A First Course in Fuzzy and Neural Control", Chapman and Hall, CRC, 2003.*

Learning Assessment

	Bloom's Level of Thinking	Continuous Learning Assessment (50% weightage)				Final Examination (50% weightage)
		CLA – 1 (20%)	CLA – 2 (30%)	CLA – 3 (30%)	CLA – 4 (20%)#	
		Theory	Theory	Theory	Theory	Theory
Level 1	Remember Understand	40 %	30 %	30 %	20 %	30 %
Level 2	Apply Analyze	40 %	40 %	40 %	40 %	40 %
Level 3	Evaluate Create	20 %	30 %	30 %	40 %	30 %
	Total	100 %	100 %	100 %	100 %	-

CLA – 4 can be from any combination of these: Assignments, Seminars, Tech Talks, Mini-Projects, Case-Studies, Self-Study, MOOCs, Certifications, Conf. Paper etc.,

Course Designers

Experts from Industry	Experts from Higher Technical Institutions	Internal Experts
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Course Code	18MHE420T	Course Name	INTELLIGENT MECHATRONICS SYSTEM	Course Category	E	Professional Elective	L	T	P	C
							3	0	0	3

Pre-requisite Courses	Nil	Co-requisite Courses	Nil	Progressive Courses	Nil
Course Offering Department	Mechatronics Engineering	Data Book / Codes/Standards		Nil	

Course Learning Rationale (CLR):	*The purpose of learning this course is to:*
CLR-1 :	*Understand the different types intelligent mechatronics*
CLR-2 :	*Analyze the biological foundation used in intelligent systems*
CLR-3 :	*Identify the modeling technique of intelligent mechatronics system using bond graph*
CLR-4 :	*Identify the intelligent system applied into robots*
CLR-5 :	*Identify the intelligent system applied to automobiles*
CLR-6 :	*Utilize the knowledge of artificial intelligence, neural network, bond graph modeling into developing and controlling of mechatronics system.*

Course Learning Outcomes (CLO):	*At the end of this course, learners will be able to:*	Learning 1: Level of Thinking (Bloom)	2: Expected Proficiency (%)	3: Expected Attainment (%)	PLO 1: Engineering Knowledge	2: Problem Analysis	3: Design & Development	4: Analysis, Design, Research	5: Modern Tool Usage	6: Society & Culture	7: Environment & Sustainability	8: Ethics	9: Individual & Team Work	10: Communication	11: Project Mgt. & Finance	12: Life Long Learning	13: PSO - 1	14: PSO - 2	15: PSO - 3
CLO-1 :	*Identify the different types of intelligent mechatronics system*	1	85	80	H	L	-	H	M	-	L	L	M	-	-	-	M	-	-
CLO-2 :	*Apply the knowledge of artificial intelligent, neural network and genetic algorithm in to mechatronics system*	2	85	80	H	H	-	H	M	-	L	L	M	-	-	-	-	-	-
CLO-3 :	*Apply the bond graph modeling technique for intelligent mechatronics system*	2	85	80	H	H	-	H	M	-	L	L	M	-	-	-	-	-	-
CLO-4 :	*Apply the intelligent control into robotics application*	2	85	80	H	H	-	H	M	-	L	L	M	-	-	-	-	-	-
CLO-5 :	*Apply the intelligent control into automobile application*	2	85	80	H	H	-	H	M	-	L	L	M	-	-	-	-	-	-
CLO-6 :	*Apply the artificial intelligence, neural network, bond graph modeling into developing and controlling of mechatronics system.*	2	85	80	H	H	-	H	M	-	L	L	M	-	-	-	-	-	-

		Introduction to Intelligent Mechatronics Systems	Biological Foundations to Intelligent Systems	Bond graph modeling of Mechatronics	Case Studies - I	Case Studies - II
Duration (hour)		9	9	9	9	9
S-1	SLO-1	*Design of a mechatronics system*	*Artificial Neural Networks: Introduction*	*Bond graph for modeling, control and diagnostic*	*Introduction: Automatically evaluating the training of the laparoscopic surgeon*	*Introduction: Rail bound mechatronics systems.*
	SLO-2	*Autonomous supervisory control*	*AI programming vs conventional programming*	*Power variable, energy variable*	*Development of three-dimensional registration system, user interface*	*Hybrid planning for self-optimization*
S-2	SLO-1	*Intelligent mechatronics device*	*Knowledge acquisition and knowledge representation*	*Pseudo bond graph, analogy of energy variable*	*Calibration of the mechatronics evaluation system*	*Active suspension system*
	SLO-2	*Hierarchical architecture*	*Back - propagation networks*	*Bond graph elements: passive, active and junctions, two port elements*	*Automatic evaluation of laparoscopic training, discussion.*	*Air Gap Adjustment System (AGAS)*
S-3	SLO-1	*System structure of intelligent mechatronics*	*Radial basis function networks*	*Causality: sequential causality assignment procedure(SCAP), Bicasual bond graph*	*Artificial intelligence for an automatic robotic excavator*	*Overview of the hybrid planning architecture.*
	SLO-2	*Introduction to Network intelligent mechatronics*	*Implementation of neural network*	*Casual path: Types*	*Development of low cost electromyographyhy(EMG)prosthetic hand: background*	*Modeling and optimization of the suspension system*
S-4	SLO-1	*Structure of Network intelligent mechatronics*	*Fuzzy logic: Fuzzy set and membership functions.*	*State space equation, state equation, properties of sate variable*	*Mechanical design and modeling*	*Modeling for air gap adjustment and prediction.*
	SLO-2	*Introduction to Cognitive intelligent mechatronics*	*Knowledge representation and inference mechanism.*	*State space equation of an electrical system*	*Electronic design ,control and actuators*	*Modeling for air gap adjustment and prediction.*
S-5	SLO-1	*Structure of Cognitive intelligent mechatronics.*	*Fuzzy reasoning and control*	*Bond graph for electrical system*	*Robust monitoring of an omnidirectional mobile robot: introduction*	*Automatic transmission system*
	SLO-2	*Introduction to Communicative intelligent mechatronics*	*Developing a fuzzy system*	*Bond graph for mechanical system*	*Bond graph modeling, fault detection and isolation using bond graph*	*Concept of Hybrid electric vehicles*

S-6	SLO-1	*Structure and operation of Communicative intelligent mechatronics*	*Fuzzy neural systems: Feed forward network*	*Bond graph for milti energy domain system*	*Residual evaluation, application and conclusion*	*Concept of High speed tilting trains*
	SLO-2	*Introduction to Biological intelligent mechatronics*	*Feedback neural networks*	*Multi-port field element: RS element*	*Dynamic modeling and control of an hexapod robot: Introduction*	*Concept of Path planning robot*
S-7	SLO-1	*Structure and operation of Biological intelligent mechatronics.*	*Genetic algorithm and traditional search methods*	*C field, I field, IC field*	*Geometric modeling, hexapod dynamic model, force distribution problem*	*Introduction to Intelligent autonomous vehicle ,definition and problem formulation*
	SLO-2	*Introduction to Human assistive intelligent mechatronics*	*Genetic algorithm: Data analysis and prediction*	*R field and vector junction*	*Quadratic problem formulation and solution*	*Model based fault detection and isolation for electric vehicle*
S-8	SLO-1	*Structure and operation of Human assistive intelligent mechatronics.*	*Implementation of genetic algorithm*	*Vector bond graph for rigid body dynamics*	*Computed torque control and conclusion*	*Results of the co-simulations and conclusion*
	SLO-2	*Fault ,failure, safety and fault tolerance*	*Implementation of genetic algorithm*	*Bond graph modeling of uncertain systems*	*Control of free and constrained motion of a C5 parallel robot, adaptive position and force controller design*	*Vehicle braking ,brake system model*
S-9	SLO-1	*Signal conditioning and interfacing*	*Hybrid genetic algorithm: Lamarckian evaluation, memetic algorithm*	*Bond graph for modeling, control and diagnostic*	*Mode control for unmanned aerial vehicle*	*Regenerative braking,4 wheel vehicle model and conclusion*
	SLO-2	*Signal conditioning and interfacing*	*Hybrid genetic algorithm: Lamarckian evaluation, memetic algorithm*	*Power variable, energy variable*	*Mode control for unmanned aerial vehicle*	*Regenerative braking,4 wheel vehicle model and conclusion*

Learning Resources	1. *BodganWilamowski, J. David Irwin, "Control and Mechatronics", 2nd edition, CRC press, 2008.* 2. *Stanislaw H. Zak, "Systems and Control", Oxford University Press, 2003* 3. *Ganesh Naik, "Intelligent Mechatronics", Intech publication, 2016*	4. *Kevin M. Passino and Stephen Yurkovich, "Fuzzy Control", Addison Wesley Longman publication, 2001* 5. *Timothy J.Ross, "Fuzzy Logic with Engineering Applications", 2nd edition, John Wiley and sons, 2008* 6. *RochdiMerzouki" Mechatronic & Innovative Applications"Bentham books,2004*

Learning Assessment

	Bloom's Level of Thinking	Continuous Learning Assessment (50% weightage)								Final Examination (50% weightage)	
		CLA – 1 (10%)		CLA – 2 (15%)		CLA – 3 (15%)		CLA – 4 (10%)#			
		Theory	Practice	Theory	Practice	Theory	Practice	Theory	Practice	Theory	Practice
Level 1	Remember Understand	30 %	-	30 %	-	30 %	-	30 %	-	30%	-
Level 2	Apply Analyze	40 %	-	40 %	-	40 %	-	40 %	-	40%	-
Level 3	Evaluate Create	30 %	-	30 %	-	30 %	-	30 %	-	30%	-
	Total	100 %		100 %		100 %		100 %		100 %	

CLA – 4 can be from any combination of these: Assignments, Seminars, Tech Talks, Mini-Projects, Case-Studies, Self-Study, MOOCs, Certifications, Conf. Paper etc.,

Course Designers

Experts from Industry	Experts from Higher Technical Institutions	Internal Experts
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2. Mr.J. Srinivasan, KONE Elevator India Private Limited,Chennai.srinikone@gmail.com	*2. Dr.R.AmuthaKannan, National University, Muscat,amuthakkannan@nu.edu.om.*	*2. Mr.A. JosinHippolittous, SRMIST*

Course Code	18MHE421T	Course Name	AUTONOMOUS MOBILE ROBOTICS	Course Category	E	Professional Elective	L	T	P	C
							3	0	0	3

Pre-requisite Courses	Nil	Co-requisite Courses	Nil	Progressive Courses	Nil
Course Offering Department	Mechatronics Engineering	Data Book / Codes/Standards	Nil		

Course Learning Rationale (CLR):	The purpose of learning this course is to:
CLR-1 :	*Formulate the challenges in developing autonomous mobile robots*
CLR-2 :	*Abstract kinematic control of wheeled mobile robots*
CLR-3 :	*Understand the challenges involved in sensory perception for mobile robots*
CLR-4 :	*Understand the localization and path planning algorithms*
CLR-5 :	*Comprehend the challenges and configurations of aerial and underwater mobile robots*
CLR-6 :	*Build the foundations of mobile robots in various modalities*

Course Learning Outcomes (CLO):	At the end of this course, learners will be able to:	Learning 1: Level of Thinking (Bloom)	Learning 2: Expected Proficiency (%)	Learning 3: Expected Attainment (%)	PLO 1: Engineering Knowledge	PLO 2: Problem Analysis	PLO 3: Design & Development	PLO 4: Analysis, Design, Research	PLO 5: Modern Tool Usage	PLO 6: Society & Culture	PLO 7: Environment & Sustainability	PLO 8: Ethics	PLO 9: Individual & Team Work	PLO 10: Communication	PLO 11: Project Mgt. & Finance	PLO 12: Life Long Learning	PLO 13: PSO - 1	PLO 14: PSO - 2	PLO 15: PSO - 3
CLO-1 :	*Formulate the challenges in developing autonomous mobile robots*	3	80	75	H	H	M	L	L	-	-	-	L	L	-	L	H	M	-
CLO-2 :	*Abstract kinematic control of wheeled mobile robots*	3	85	80	H	H	M	M	L	-	-	-	M	L	-	L	H	M	-
CLO-3 :	*Understand the challenges involved in sensory perception for mobile robots*	2	70	65	H	M	L	M	L	-	-	-	M	L	-	L	H	M	-
CLO-4 :	*Develop localization and path planning algorithm for mobile robot navigation*	2	75	70	H	M	M	M	M	-	-	-	M	L	-	L	H	M	-
CLO-5 :	*Comprehend the challenges and configurations of legged, aerial and underwater mobile robots.*	2	85	80	H	M	M	M	M	-	-	-	M	L	-	L	H	M	-
CLO-6 :	*Build the required foundation for developing autonomous mobile robots.*	2	80	75	H	M-	M	M	M	-	-	-	L	L	-	L	H	M	-

		Introduction	Kinematics and Control of Mobile Robots	Sensors for Mobile Robots	Localization and Path Planning	Aerial and Underwater Robots
Duration (hour)		6	10	9	10	10
S-1	SLO-1	*Mobile Robots vs. Manipulators*	*Kinematic constraints of a fixed standard wheel*	*Sensors for mobile robots*	*Introduction to localization*	*Non-ground modality*
	SLO-2	*Introduction to autonomous mobile robots*	*Derivation*	*Definitions, classification*	*Localization challenges*	*Case studies*
S-2	SLO-1	*Locomotion aspects of mobile robots*	*Kinematic constraints of a omni-directional wheel*	*Characteristics applicable to mobile robots*	*Belief representations*	*Aerial robots*
	SLO-2	*Locomotion aspects of mobile robots*	*Derivation*	*Relating the characteristics to performance attributes of mobile robot*	*Considerations in Belief representations*	*Types and comparison*
S-3	SLO-1	*Introduction to wheeled mobile robots*	*Forward kinematic models of three wheeled differential drive robot*	*Physical and computational attributes of sensors applicable to mobile robots*	*Map representations*	*Multi-rotor aerial robot*
	SLO-2	*wheel types*	*Derivation*	*sensor noise and sensor aliasing*	*Types*	*Types and applications*
S-4	SLO-1	*Wheeled Configurations*	*Forward kinematics of a three wheeled omni-directional robot*	*GPS and heading sensors*	*Probabilistic localization*	*Quadrotor aerial robot*
	SLO-2	*Various wheeled configurations*	*Derivation*	*Principles, challenges and interpretation*	*Markov localization*	*Modelling of dynamics*
S-5	SLO-1	*Maneuverability, controllability*	*Degree of freedom, differential degrees of freedom*	*Light and sound based ranging*	*Introduction to Kalman filtering*	*Modelling of flight controller*
	SLO-2	*stability of mobile robots*	*Degree of Maneuverability*	*Principles, challenges and interpretation*	*Derivation of Kalman gain*	*Derivation*
S-6	SLO-1	*Wheeled Locomotion*	*Mobility analysis of various wheeled configurations*	*Wheel Odometry*	*Kalman filter for localization*	*Commercial flight controllers*
	SLO-2	*Case studies*	*Two, three, four, five and six wheeled configurations*	*Implementation algorithm for wheel odomoetry*	*Example case study and derivation*	*Specifications and selection criteria*
S-7	SLO-1		*Workspace and trajectory considerations*	*Wheel Odometry Critical Analysis*	*Sensor fusion using Kalman filter*	*Underwater vehicles*
	SLO-2		*Comparison of manuerability and controllability*	*Wheel Odometry error reduction*	*Derivation*	*Foundations topics and challenges*

S-8	SLO-1		*State space modelling of three wheeled differential drive robot*	*Vision for mobile robots*	*Introduction to path planning,*	*Types of underwater vehicles*
	SLO-2		*Derivation*	*Introduction to Visual Odometry and V-SLAM*	*Types, Challenges and Algorithms*	*Comparison*
S-9	SLO-1		*Go-goal controller*	*Multi-sensor combinations*	*D* Lite*	*Modelling of underwater dynamics*
	SLO-2		*Block diagram level understanding*	*Need and types*	*Numerical case study*	*Derivation*
S-10	SLO-1		*Cruise Controllers*		*Bug algorithms*	*Modelling of underwater vehicle*
	SLO-2		*Block diagram level understanding*		*Vector field histogram*	*Derivation*

Learning Resources	1. *Siegwart, Nourbakhsh, "Introduction to Autonomous Mobile Robots", 2nd Edition, MIT Press, 2011.* 2. *Bruno Siciliano, OussamaKhatib, "Handbook of Robotics", 2nd Edition, Springer, 2016.* 3. *PerterCorke, "Robotics, Vision and Control", 2nd Edition, Springer, 2017.*

Learning Assessment

	Bloom's Level of Thinking	Continuous Learning Assessment (50% weightage)								Final Examination (50% weightage)	
		CLA – 1 (10%)		CLA – 2 (15%)		CLA – 3 (15%)		CLA – 4 (10%)#			
		Theory	Practice	Theory	Practice	Theory	Practice	Theory	Practice	Theory	Practice
Level 1	Remember Understand	30 %	-	30 %	-	30 %	-	20 %	-	40%	-
Level 2	Apply Analyze	40 %	-	40 %	-	40 %	-	40 %	-	30%	-
Level 3	Evaluate Create	30 %	-	30 %	-	30 %	-	40 %	-	30%	-
	Total	100 %		100 %		100 %		100 %		100 %	

CLA – 4 can be from any combination of these: Assignments, Seminars, Tech Talks, Mini-Projects, Case-Studies, Self-Study, MOOCs, Certifications, Conf. Paper etc.,

Course Designers

Experts from Industry	Experts from Higher Technical Institutions	Internal Experts
1. Mr. N. Ganesh Ram, Intel Labs, ganeshram.nandakumar@intel.com	*1. Dr. R. Thiyagarajan, IIT Madras, thiyaguiitm@gmail.com*	*1. Dr. R. Senthilnathan, SRMIST*
2. Mr. Mohammed Sagheer , Wabco Technology Center, mohammedsagheer.musthafa@wabco-auto.com	*2. Dr. P. Karthikeyan, MIT Campus, Anna University, pkarthikeyan@annauniv.edu*	*2. Mr. K. Sivanathan, SRMIST*

Course Code	18MHE422T	Course Name	CONDITION MONITORING TECHNIQUES	Course Category	P	Professional Elective	L	T	P	C
							3	0	0	3

Pre-requisite Courses	18MHC202J	Co-requisite Courses	Nil	Progressive Courses	Nil
Course Offering Department	Mechatronics Engineering	Data Book / Codes/Standards	Nil		

Course Learning Rationale (CLR):	*The purpose of learning this course is to:*
CLR-1 :	*Understand the basics of failures of equipments*
CLR-2 :	*Impart the knowledge on the learning in fault diagnosis*
CLR-3 :	*Gain knowledge on the condition monitoring techniques*
CLR-4 :	*Impart the knowledge on condition monitoring of rotating electrical machines*
CLR-5 :	*Impart the knowledge on condition monitoring of machine tools*
CLR-6 :	*Study the basic knowledge of failures of equipments and knowledge on condition monitoring of different machine tools*

Course Learning Outcomes (CLO):	*At the end of this course, learners will be able to:*	Learning			Program Learning Outcomes (PLO)														
		1	2	3	1	2	3	4	5	6	7	8	9	10	11	12	13	14	15
		Level of Thinking (Bloom)	Expected Proficiency (%)	Expected Attainment (%)	Engineering Knowledge	Problem Analysis	Design & Development	Analysis, Design, Research	Modern Tool Usage	Society & Culture	Environment & Sustainability	Ethics	Individual & Team Work	Communication	Project Mgt. & Finance	Life Long Learning	PSO - 1	PSO - 2	PSO - 3
CLO-1 :	*Comprehend the basics of failures of equipments*	*1*	*85*	*80*	*H*	*L*	-	*M*	-	-	-	-	-	-	-	-	-	-	-
CLO-2 :	*Understand the learning in fault diagnosis*	*1*	*85*	*80*	*H*	*L*	-	*M*	-	-	-	-	-	-	-	-	-	-	-
CLO-3 :	*Familiarize with the condition monitoring techniques*	*1*	*85*	*80*	*H*	*L*	-	*M*	*L*	-	-	-	-	-	-	-	*M*	*H*	*H*
CLO-4 :	*Implement the condition monitoring techniques on rotating electrical machines*	*2*	*85*	*80*	*H*	*L*	-	*M*	*L*	-	-	-	-	-	-	-	*M*	*H*	*H*
CLO-5 :	*Implement the condition monitoring techniques on machine tools*	*2*	*85*	*80*	*H*	*L*	-	*M*	*L*	-	-	-	-	-	-	-	*M*	*H*	*H*
CLO-6 :	*To understand the diagnostics techniques of different machine tools*	*2*	*85*	*80*	*H*	*L*	-	*M*	*L*	-	-	-	-	-	-	-	*M*	*H*	*H*

Duration (hour)		9	9	9	9	9
S-1	SLO-1	*Introduction to condition monitoring*	*Condition monitoring of electrical machines - Introduction*	*Condition monitoring in machine tool - Introduction*	*Condition monitoring techniques for hydraulic system – introduction*	*Case study 1: Fault detection on gearboxes operating under fluctuating load con*
	SLO-2	*Theory of condition monitoring*	*Construction of electrical machines*	*Types of cutting tool in lathe*	*Elements in hydraulic systems*	*Bearing Fault diagnosis in gear box*
S-2	SLO-1	*Stages of condition monitoring*	*Structure of electrical machines and types*	*Tool wear measurement techniques – Direct method*	*Pump supervision methods and fault detection techniques*	*Case study 2: Detection of rotor – Stator rubbing in rotating machinery using acoustic emissions*
	SLO-2	*Data used for condition monitoring – Time, model and frequency domain*	*Types of insulation ageing mechanism – Thermal and electrical ageing*	*Tool wear measurement techniques – Indirect method*	*Fault detection of centrifugal pumps with vibration sensors*	*Condition monitoring of very slowly rotating machinery using AE techniques*
S-3	SLO-1	*Data processing techniques for condition monitoring*	*Types of insulation ageing mechanism – Mechanical and environmental ageing*	*Types of machine tool failures*	*Types failures in reciprocating pump*	*Case study 3: Condition monitoring for a car engine*
	SLO-2	*Data acquisition system – filter, data logging system*	*Condition monitoring techniques: Visual monitoring.*	*Fault detection and diagnosis of machine tool*	*Fault diagnosis in reciprocating pumps*	*Application of vibration diagnostics and suppression in automobile*
S-4	SLO-1	*Condition monitoring methods – vibration analysis, Thermography*	*Failure modes in electrical machines – Stator core and rotor winding failure*	*Vision based tool condition monitoring system*	*Leak detection methods in fluid power pipe line*	*Case study 4; Condition monitoring of a hydraulic system using neural networks*
	SLO-2	*Condition monitoring methods – Oil Analysis, Performance analysis*	*Failure modes in electrical machines – Electrical connection and bearing failures*	*Decision making for sensor based tool condition monitoring system*	*Leak detection with mass balance for liquid pipe line*	*Multi-layer neural networks and pattern recognition for pump fault diagnosis*
S-5	SLO-1	*Instruments for condition monitoring – Displacement and velocity measurement*	*Electrical machines temperature monitoring*	*Online tool vibration monitoring system*	*Types of failures in fluid power linear actuators*	*Case study 5: Non-destructive fault induction in an electro-hydraulic servo system*
	SLO-2	*Instruments for condition monitoring – Force and noise measurement*	*Electrical machines wear debris monitoring*	*Online tool wear monitoring system*	*Fault detection and diagnosis of cylinder*	*Failure analysis and fault simulation of an electro hydraulic servo valve*
S-6	SLO-1	*Instruments for condition monitoring – Temperature measurement*	*Electrical machines lubrication oil monitoring*	*Introduction to grinding process and its types*	*Types of failures in pneumatic and hydraulic Directional control valves*	*Case study 6; Monitoring exhaust valve leaks in diesel engines*

	SLO-2	*Instruments for condition monitoring – current and Chemical composition measurement*	*Electrical machines vibration monitoring*	*Introduction to milling process and its types*	*Fault detection and diagnosis of pneumatic and hydraulic Directional control valves*	*Monitoring vibration in diesel engines*
S-7	SLO-1	*Laser based measurement systems for condition monitoring*	*Fault detection in electrical machines – stator winding fault detection*	*Acoustic Emission based Monitoring of Grinding Wheel Dressing*	*Fault detection and diagnosis of flow control valves with pneumatic position controller*	*Case study 7: Development of an automated fluorescent dye penetrant inspection system*
	SLO-2	*Ultrasonic sound based measurement systems for condition monitoring*	*Fault detection in electrical machines – Brush gear fault detection*	*Acoustic Emission based Monitoring of Face milling*	*Fault detection and diagnosis of flow control valves with electronic position controller*	*Application of vibration analysis to monitor wear in spur gear*
S-8	SLO-1	*Types of Maintenance – Preventive, operative and shutdown maintenance*	*Fault detection in electrical machines – rotor online fault detection*	*Diagnostics techniques for bearing condition monitoring in machine tool*	*Types of failures in electro pneumatic actuator*	*Case study 8: On-line acoustic viscometry in oil condition monitoring*
	SLO-2	*Condition based maintenance*	*Fault detection in electrical machines – rotor offline fault detection*	*Sensors and signal processing techniques for bearing condition monitoring system*	*Fault detection and diagnosis of electro pneumatic actuator*	*On-line vibration monitoring for detecting fan blade damage*
S-9	SLO-1	*Diagnostics process and Techniques*	*Discharge monitoring techniques – RF coupling method*	*Condition monitoring techniques for sheet metal process*	*Real time oil oxidation monitoring system*	*Case study 9: A case study of bearing condition monitoring using Shock pulse method*
	SLO-2	*Diagnostics process and Techniques*	*Discharge monitoring techniques – capacitive coupling method*	*Remote CNC machine control*	*Oil viscosity monitoring system*	*Remote online condition monitoring for wear measurement in bearing*

Learning Resources	1. *Peter Tavner, Li Ran, Jim Penman, Howard Sedding, Condition monitoring of rotating electrical machines, 1st ed., The Institution of Engineering and Technology, London, 2008* 2. *LihuiWang and Robert X. Gao., Condition Monitoring and Control for Intelligent Manufacturing,1st ed., Springer-Verlag London Limited, 2006*	3. *Rolf Isermann, Sensors, and Fault-tolerant Systems, 1st ed., Springer Heidelberg Dordrecht London New York, 2011* 4. *Andrew C Starr and Raj B K N Rao., Condition monitoring and diagnostic engineering management, Proceedings of the 14'" international Congress, 4 - 6 September Manchester, UK, 2001*

Learning Assessment

	Bloom's Level of Thinking	Continuous Learning Assessment (50% weightage)								Final Examination (50% weightage)	
		CLA – 1 (10%)		CLA – 2 (15%)		CLA – 3 (15%)		CLA – 4 (10%)#			
		Theory	Practice	Theory	Practice	Theory	Practice	Theory	Practice	Theory	Practice
Level 1	Remember Understand	40 %	-	30 %	-	30 %	-	30 %	-	30%	-
Level 2	Apply Analyze	40 %	-	40 %	-	40 %	-	40 %	-	40%	-
Level 3	Evaluate Create	20 %	-	30 %	-	30 %	-	30 %	-	30%	-
	Total	100 %		100 %		100 %		100 %		100 %	

CLA – 4 can be from any combination of these: Assignments, Seminars, Tech Talks, Mini-Projects, Case-Studies, Self-Study, MOOCs, Certifications, Conf. Paper etc.,

Course Designers

Experts from Industry	Experts from Higher Technical Institutions	Internal Experts
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2.Bharathiraja Ramaraj, L and T Technology Services, bharathiraja.r@ltts.com	*2. Dr. T.R.Chinnusamy,A.K.T memorial college of engineering technology, email : chinnu_samy80@yahoo.co.in*	*2. Mr. M.Thirugnanam, SRMIST*

Course Code	18MHE423T	Course Name	FPGA BASED SYSTEM DESIGN	Course Category	E	Professional Elective	L	T	P	C
							3	0	0	3

Pre-requisite Courses	18MHC108J	Co-requisite Courses	Nil	Progressive Courses	Nil
Course Offering Department	Mechatronics Engineering	Data Book / Codes/Standards	Nil		

Course Learning Rationale (CLR):	*The purpose of learning this course is to:*
CLR-1 :	*Introduce types of PLDs and their differing architectures*
CLR-2 :	*Discuss different software and hardware programming language, simulation tools*
CLR-3 :	*Gain knowledge about VHDL, its design flow and various description languages for Digital Logic Design*
CLR-4 :	*Design combinational logic, sequential logic and state machine using VHDL*
CLR-5 :	*Gain knowledge of VHDL design at system level and transformation of design developed in Matlab to VHDL*
CLR-6 :	*Introduce about PLDs and developing digital logic design using VHDL code for electronic system design*

Course Learning Outcomes (CLO):	*At the end of this course, learners will be able to:*	Learning 1 Level of Thinking (Bloom)	Learning 2 Expected Proficiency (%)	Learning 3 Expected Attainment (%)
CLO-1 :	*Acquire knowledge about various Programmable Logic Devices to design an electronic system*	*1*	*75*	*70*
CLO-2 :	*Understand programming languages to develop digital design for implementation either in processors or in PLDs*	*2*	*75*	*70*
CLO-3 :	*Utilize the various description languages for developing various digital logic design*	*2*	*75*	*70*
CLO-4 :	*Develop VHDL code for Combinational logic, sequential logic and state machine design*	*3*	*75*	*70*
CLO-5 :	*Translate algorithms and models developed in MATLAB Simulink into VHDL for implementing in PLD*	*3*	*75*	*70*
CLO-6 :	*Design and develop VHDL code for implementation of digital logic in PLDs*	*3*	*75*	*70*

Program Learning Outcomes (PLO)

	1 Engineering Knowledge	2 Problem Analysis	3 Design & Development	4 Analysis, Design, Research	5 Modern Tool Usage	6 Society & Culture	7 Environment & Sustainability	8 Ethics	9 Individual & Team Work	10 Communication	11 Project Mgt. & Finance	12 Life Long Learning	13 PSO - 1	14 PSO - 2	15 PSO - 3
CLO-1	*H*	*M*	*M*	*M*	*M*	*L*	*L*	*L*	*M*	*M*	*M*	*H*	*H*	*H*	*M*
CLO-2	*H*	*M*	*M*	*H*	*H*	*L*	*L*	*L*	*M*	*M*	*M*	*H*	*H*	*H*	*L*
CLO-3	*H*	*M*	*M*	*H*	*H*	*L*	*L*	*L*	*M*	*M*	*M*	*H*	*H*	*M*	*L*
CLO-4	*H*	*H*	*M*	*H*	*H*	*L*	*L*	*L*	*M*	*M*	*M*	*H*	*H*	*H*	*L*
CLO-5	*H*	*H*	*M*	*H*	*H*	*L*	*L*	*L*	*M*	*M*	*M*	*H*	*H*	*M*	*L*
CLO-6	*H*	*H*	*M*	*H*	*H*	*L*	*L*	*L*	*M*	*M*	*H*	*H*	*H*	*H*	*H*

Duration (hour)		9	9	9	9	9
S-1	SLO-1	*Introduction to PLD's*	*Introduction to various software programming languages: C*	*Designing with Hardware description language*	*Introduction to combinational logic design*	*Digital to Analogue Conversion (DAC)*
	SLO-2	*Technology choices for digital circuit design*	*C++, Java*	*Various levels of design description*	*VHDL design for half adder*	*Digital to Analogue Conversion (DAC)*
S-2	SLO-1	*Electronic circuits: Analogue versus Digital*	*Introduction to various software programming languages: Visual Basics*	*Typical design flow using HDLs*	*Concept of multiplexer*	*VHDL Design for DAC*
	SLO-2	*Digital logic and its types*	*Scripting Languages, PHP*	*Typical design flow using HDLs*	*VHDL design for multiplexer*	*VHDL Design for DAC*
S-3	SLO-1	*Programmable Logic versus Digital Logic*	*Introduction to hardware programming languages*	*Design Entry Methods, HDL Design Entry*	*Concept of Encoder*	*Concept of Thyristor Gate Control*
	SLO-2	*Programmable Logic versus Processors*	*Types of hardware programming languages*	*Logic Synthesis with an example*	*VHDL design for Encoder*	*Concept of Thyristor Gate Control*
S-4	SLO-1	*Types of PLD: Simple Programmable Logic Device (SPLD)*	*VHDL hardware programming language*	*Entities, architectures, packages and configurations*	*Introduction to Sequential Logic Design*	*VHDL Design for Thyristor Gate Control*
	SLO-2	*Complex Programmable Logic Device (CPLD)*	*VHDL description for two input AND gate*	*Two input AND gate example*	*VHDL design for D-Latch*	*VHDL Design for Thyristor Gate Control*
S-5	SLO-1	*Field Programmable Gate Array (FPGA)*	*Verilog HDL hardware programming language*	*Key libraries and packages in HDL*	*Design of binary counter using VHDL*	*Model of DC Motor Control System*
	SLO-2	*FPGA design techniques and design constraints*	*Verilog HDL description for full adder*	*Various operators in VHDL*	*Design of binary counter using VHDL*	*Model of DC Motor Control System*
S-6	SLO-1	*PLD configuration technologies*	*Verilog-A hardware programming language*	*Dataflow description with example*	*Introduction to State Machine Design*	*Translation of DC motor Control system Design to VHDL*
	SLO-2	*PLD vendors*	*Verilog-A description for voltage amplifier*	*Dataflow description with example*	*Introduction to State Machine Design*	*Translation of DC motor Control system Design to VHDL*
S-7	SLO-1	*PLD design tools*	*System Verilog*	*Behavioral description with example*	*VHDL Design for Sequence Detector*	*Overview of Digital Filter Design*

	SLO-2	*Common basic features of design tools*	*Simulation Program with Integrated Circuit Emphasis (SPICE)*	*Behavioral description with example*	*VHDL Design for Sequence Detector*	*Overview of Digital Filter Design*
S-8	SLO-1	*Introduction to PLD design*	*Introduction to mathematical modeling*	*Structural description with example*	*VHDL design for UART receiver*	*Translation of Digital Filter Design to VHDL*
	SLO-2	*Typical PLD design flow*	*Various toolboxes for modeling different applications*	*Structural description with example*	*VHDL design for UART receiver*	*Translation of Digital Filter Design to VHDL*
S-9	SLO-1	*Technology Trends*	*Concept of Motor control system*	*Coding styles for VHDL*	*Testing of VHDL Design*	*Automation of Design translation to VHDL*
	SLO-2	*Technology Trends*	*Modeling of motor control system using Simulink*	*Coding styles for VHDL*	*Testing of VHDL Design*	*Automation of Design translation to VHDL*

Learning Resources	1. *Ian Grout, "Digital System Design with FPGA and CPLD", Newnes publishers, 2nd edition, 2008.* 2. *Peter Wilson, "Design Recipes for FPGAs", Newnes publishers, 3rd edition, 2007.* 3. *Wayne Wolf, "FPGA based system design", Prentice Hall, 1st edition, 2004.*

Learning Assessment

	Bloom's Level of Thinking	Continuous Learning Assessment (50% weightage)								Final Examination (50% weightage)	
		CLA – 1 (10%)		CLA – 2 (15%)		CLA – 3 (15%)		CLA – 4 (10%)#			
		Theory	Practice	Theory	Practice	Theory	Practice	Theory	Practice	Theory	Practice
Level 1	Remember Understand	40 %	-	30 %	-	30 %	-	30 %	-	30%	-
Level 2	Apply Analyze	40 %	-	40 %	-	40 %	-	40 %	-	40%	-
Level 3	Evaluate Create	20 %	-	30 %	-	30 %	-	30 %	-	30%	-
	Total	100 %		100 %		100 %		100 %		100 %	

CLA – 4 can be from any combination of these: Assignments, Seminars, Tech Talks, Mini-Projects, Case-Studies, Self-Study, MOOCs, Certifications, Conf. Paper etc.,

Course Designers

Experts from Industry	Experts from Higher Technical Institutions	Internal Experts
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Course Code	18MHE424T	Course Name	DESIGN AND ANALYSIS OF ALGORITHMS	Course Category	E	Professional Elective	L	T	P	C
							3	0	0	3

Pre-requisite Courses	Nil	Co-requisite Courses	Nil	Progressive Courses	Nil
Course Offering Department	Mechatronics Engineering	Data Book / Codes/Standards	Nil		

Course Learning Rationale (CLR):	*The purpose of learning this course is to:*
CLR-1 :	*Understand and apply algorithm analysis technique*
CLR-2 :	*Describe computational solution to well known problems like searching, sorting etc.*
CLR-3 :	*Understand various approaches to solve greedy and dynamic algorithms*
CLR-4 :	*Utilize back tracking and branch and bound paradigms to solve exponential time problems*
CLR-5 :	*Analyze various algorithm design techniques to solve real time problems in polynomial time*
CLR-6 :	*Understand the limitations of Algorithmic power*

Course Learning Outcomes (CLO):	*At the end of this course, learners will be able to:*	Learning 1 Level of Thinking (Bloom)	2 Expected Proficiency (%)	3 Expected Attainment (%)	PLO 1 Engineering Knowledge	2 Problem Analysis	3 Design & Development	4 Analysis, Design, Research	5 Modern Tool Usage	6 Society & Culture	7 Environment & Sustainability	8 Ethics	9 Individual & Team Work	10 Communication	11 Project Mgt. & Finance	12 Life Long Learning	13 PSO - 1	14 PSO - 2	15 PSO - 3
CLO-1 :	*Design algorithms for various computing problems*	3	80	70	L	H	-	H	L	-	-	-	L	L	-	H	-	-	-
CLO-2 :	*Estimate the computational complexity of different algorithms*	3	85	75	M	H	L	M	L	-	-	-	M	L	-	H	-	-	-
CLO-3 :	*Critically analyze the different algorithm design techniques for a given problem*	3	75	70	M	H	M	H	L	-	-	-	M	L	-	H	-	-	-
CLO-4 :	*Modify existing algorithm to improve efficiency*	3	85	80	M	H	M	H	L	-	-	-	M	L	-	H	-	-	-
CLO-5 :	*Develop an algorithm using appropriate design strategies for problem solving*	3	85	75	H	H	M	H	L	-	-	-	M	L	-	H	-	-	-
CLO-6 :	*Create algorithms that are efficient in space and time complexities by using divide conquer, greedy, backtracking techniques*	3	80	70	L	H	M	H	L	-	-	-	L	L	-	H	-	-	-

		Introduction	Divide and conquer	Greedy Method	Dynamic Programming	Backtracking
Duration (hour)		9	9	9	9	9
S-1	SLO-1	*Introduction: What is an Algorithm?*	*Divide and Conquer: General method*	*Greedy Method: General method*	*Dynamic Programming: General method*	*Backtracking: General method*
	SLO-2	*Algorithm Specification*	*Binary Search*	*Examples*	*Examples*	*N-Queens problem*
S-2	SLO-1	*Analysis Framework*	*Complexity of Binary search*	*Coin Change Problem*	*Multistage Graphs*	*Sum of subsets problem*
	SLO-2	*Performance Analysis: Space complexity*	*Recurrence equation for divide and conquer*	*Knapsack Problem using Greedy method*	*Graph algorithms*	*Graph coloring*
S-3	SLO-1	*Performance Analysis: Time complexity*	*Finding the maximum and minimum*	*Job sequencing with deadlines*	*Transitive Closure: All Pairs*	*Hamiltonian cycles*
	SLO-2	*Asymptotic Notations: Big-Oh notation (O)*	*Time complexity analysis-Examples*	*Minimum cost spanning trees*	*Dynamic programming-Longest ascending subsequence*	*Branch and Bound: Assignment Problem*
S-4	SLO-1	*Asymptotic Notations: Omega notation (Ω)*	*Algorithm for finding closest pair problem*	*Prim's Algorithm with example*	*Dynamic programming-Memorization*	*Travelling Sales Person problem-Backtracking*
	SLO-2	*Asymptotic Notations: Theta notation (Θ)*	*Merge sort algorithm*	*Kruskal's Algorithm*	*Dynamic programming-Matrix Multiplication*	*0/1Knapsack problem-Backtracking*
S-5	SLO-1	*Mathematical analysis of Non-Recursive Algorithms*	*Complexity Analysis of Merge sort*	*Example problem*	*Transitive Closure: Warshall's Algorithm*	*LC Branch and Bound solution*
	SLO-2	*Examples*	*Quick sort algorithm*	*Single source shortest paths: Dijkstra's Algorithm*	*Shortest Paths: Floyd's Algorithm*	*FIFO Branch and Bound solution*
S-6	SLO-1	*Mathematical analysis of recursive Algorithms*	*Complexity Analysis of Quick sort*	*Example problem*	*Floyd-Warshall Introduction*	*NP-Complete and NP-Hard problems: Basic concepts*
	SLO-2	*Examples*	*Best case, Worst case and Average case analysis*	*Optimal Tree problem: Huffman Trees*	*Floyd-Warshall with sample graph*	*On-deterministic algorithms*
S-7	SLO-1	*Important Problem Types: Sorting*	*Strassen's matrix multiplication*	*Optimal Tree problem: Huffman Codes*	*Floyd-Warshall complexity*	*P type problems*
	SLO-2	*Searching, String processing*	*Recurrence Relation*	*Transform and Conquer Approach: Heaps*	*Optimal Binary Search Trees*	*NP type problems*

S-8	SLO-1	*Graph Problems, Combinatorial Problems*	*Advantages of divide and conquer*	*Transform and Conquer Approach: Heap Sort*	*Knapsack problem using Dynamic method*	*NP-Complete Problems-Introduction*
	SLO-2	*Fundamental Data Structures: Stacks, Queues*	*Disadvantages of divide and conquer*	*Binomial Heaps*	*Bellman-Ford Algorithm*	*Satisfiability Problem*
S-9	SLO-1	*Graphs, Trees*	*Decrease and Conquer Approach*	*Fibonacci Heaps*	*Travelling Sales Person problem-Dynamic approach*	*NP-Hard classes*
	SLO-2	*Sets and Dictionaries.*	*Topological Sort*	*Examples of heaps and heap sort*	*Reliability design*	*Examples*

Learning Resources	1. *AnanyLevitin, Intoduction to Design and Analysis of Algorithms, 3rd ed., Pearson, 2009* 2. *Ellis Horowitz, SatrajSahini and Rajasekaran, Computer Algorithms/C++, 2nded, Universities Press,2014*	3. *Thomas H .Cormen, Charles E.Leiserson, Ronal L.Rivest,Clifford Stein., Introduction to Algorithms , 3rded.,PHI* 4. *S Sridhar, Design and Analysis of Algorithms, Oxford(Higher Education)*

Learning Assessment											
	Bloom's Level of Thinking	Continuous Learning Assessment (50% weightage)								Final Examination (50% weightage)	
		CLA – 1 (10%)		CLA – 2 (15%)		CLA – 3 (15%)		CLA – 4 (10%)#			
		Theory	Practice	Theory	Practice	Theory	Practice	Theory	Practice	Theory	Practice
Level 1	Remember Understand	40 %	-	30 %	-	30 %	-	30 %	-	30%	-
Level 2	Apply Analyze	30 %	-	40 %	-	40 %	-	40 %	-	40%	-
Level 3	Evaluate Create	30 %	-	30 %	-	30 %	-	30 %	-	30%	-
	Total	100 %		100 %		100 %		100 %		100 %	

CLA – 4 can be from any combination of these: Assignments, Seminars, Tech Talks, Mini-Projects, Case-Studies, Self-Study, MOOCs, Certifications, Conf. Paper etc.,

Course Designers		
Experts from Industry	Experts from Higher Technical Institutions	Internal Experts
1.Mr.Sribharanidharan Subramanian, ITA , IT-Analyst,sribharanidharan.s@tcs.com	*1.Dr.Rinesh.S, SVCE,Chennai, rin.iimmba@gmail.com*	*Mrs.M.Nandhini, SRMIST*
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Course Code	18MHE425T	Course Name	ADVANCED MICROCONTROLLERS AND SIGNAL PROCESSING	Course Category	P	Professional Elective	L	T	P	C
							3	0	0	3

Pre-requisite Courses	18MHC205J	Co-requisite Courses	Nil	Progressive Courses	Nil
Course Offering Department	Mechatronics Engineering	Data Book / Codes/Standards	Nil		

Course Learning Rationale (CLR):	*The purpose of learning this course is to:*
CLR-1 :	*Perceive the fundamental knowledge of Digital signal processing*
CLR-2 :	*Learn the working principle of Digital signal processor TMS320C5X*
CLR-3 :	*Apply the Knowledge in the applications of Digital signal processing*
CLR-4 :	*Know the working principle of ARM cortex processor*
CLR-5 :	*Work with the processor by using their standard Instruction sets*
CLR-6 :	*Perceive the fundamental knowledge of Digital signal processing*

Course Learning Outcomes (CLO):	*At the end of this course, learners will be able to:*	Learning 1 Level of Thinking (Bloom)	2 Expected Proficiency (%)	3 Expected Attainment (%)	PLO 1 Engineering Knowledge	2 Problem Analysis	3 Design & Development	4 Analysis, Design, Research	5 Modern Tool Usage	6 Society & Culture	7 Environment & Sustainability	8 Ethics	9 Individual & Team Work	10 Communication	11 Project Mgt. & Finance	12 Life Long Learning	13 PSO - 1	14 PSO - 2	15 PSO - 3
CLO-1 :	*Acquire the fundamental knowledge of Digital signal processing*	*1*	*90*	*85*	*H*	*L*	*L*	*L*	*L*	*L*	*L*	*L*	*L*	*L*	*L*	*L*	*M*	*L*	*L*
CLO-2 :	*Learn the working principle of Digital signal processor TMS320C5X*	*1*	*90*	*80*	*H*	*L*	*L*	*L*	*L*	*L*	*L*	*L*	*L*	*L*	*L*	*L*	*M*	*M*	*L*
CLO-3 :	*Apply the Knowledge in the applications of Digital signal processing*	*2*	*85*	*80*	*H*	*M*	*M*	*M*	*M*	*L*	*L*	*L*	*M*	*L*	*M*	*M*	*M*	*H*	*M*
CLO-4 :	*Learn the working principle of ARM cortex processor*	*2*	*90*	*85*	*H*	*L*	*L*	*L*	*L*	*L*	*L*	*L*	*L*	*L*	*L*	*L*	*M*	*M*	*M*
CLO-5 :	*Have knowledge to Work with the processor by using their standard Instruction set*	*3*	*85*	*80*	*H*	*M*	*M*	*M*	*M*	*L*	*L*	*L*	*L*	*L*	*L*	*L*	*H*	*H*	*H*
CLO-6 :	*Gain knowledge about different applications using ARM and DSP controllers*	*3*	*85*	*80*	*H*	*H*	*H*	*H*	*H*	*L*	*L*	*L*	*M*	*L*	*L*	*M*	*M*	*H*	*H*

		Introduction	DFT and its applications	DSP Processor	ARM Cortex Processor	System Design – Case Study
Duration (hour)		9	9	9	9	9
S-1	SLO-1	*Introduction to Micro- controller based system design*	*Discrete Fourier Transform(DFT) and its properties*	*Introduction to DSP processors*	*Introduction to ARM processors*	*Comparison chart of various controllers*
	SLO-2	*Issues and challenges.*	*Signal conditioning system*	*Types of DSP processors*	*Types of ARM processor*	*Parameter selection of Controllers*
S-2	SLO-1	*Van-New-Mann architecture*	*Fast Fourier Transform(FFT) and its properties*	*Architecture: Block diagram of DSP processor TMS320C5X*	*Block diagram of ARM architecture*	*Analog to Digital conversion: Flash ADC*
	SLO-2	*Mechatronics design elements*	*Fast Fourier Transform(FFT) and its properties*	*Architecture DSP processor TMS320C5X*	*Block diagram of ARM architecture*	*Analog to Digital conversion: Successive approximation*
S-3	SLO-1	*Harvard architecture*	*DIT-FFT*	*Instruction set of DSP processor TMS320C5X*	*ARM organization : 3 stage*	*Digital to Analog conversion working principle*
	SLO-2	*Modified Harvard architecture*	*Problems based on DIT-FFT*	*Arithmetic Instructions*	*ARM organization : 5 stage*	*Types of DAC*
S-4	SLO-1	*RISC, CISC*	*DIF-FF*	*Logical instructions*	*ARM instruction set*	*Power convertors*
	SLO-2	*ASIP, Superscalar, VLIW*	*Problems based on DIF-FF*	*Load instructions*	*Data processing & Data transfer instructions*	*Power convertor applications*
S-5	SLO-1	*Superscalar architecture of Pentium*	*FIR Digital filter design*	*Multiply/Accumulate (MAC) operation*	*Multiply instruction*	*Power inverters*
	SLO-2	*Superscalar architecture of Pentium multicore processors*	*Problems based on FIR Digital filter design*	*Branching Instructions*	*Co processor instructions*	*Power inverter application*
S-6	SLO-1	*Types of Discrete time signals*	*IIR digital filter design*	*Compare, Select, and Store Unit (CSSU)*	*Addressing modes of ARM processor*	*Temperature sensors and its types*
	SLO-2	*Properties of Discrete time signals*	*Problems based on IIR digital filter design*	*Construction and operation of BLDC motor*	*Input and Output Modules, Mnemonics for programming*	*Temperature sensor applications*
S-7	SLO-1	*Principles of Digital Signal Processing (DSP)*	*Direct form-I structure for FIR and IIR systems*	*Addressing modes of DSP processor TMS320C5X*	*Thumb instruction set*	*Stepper motor control using DSP processor*
	SLO-2	*Sampling*	*Problems*	*Pressure control valve*	*Comparison of Thump and ARM instruction set*	*Stepper motor control using ARM processor*

S-8	SLO-1	*Convolution of discrete-time samples*	*Direct form-II structure for FIR and IIR systems*	*Writing optimized DSP codes*	*Writing optimized ARM codes*	*DC machine control using DSP processor*
	SLO-2	*Properties of Convolution*	*Problems*	*Writing optimized DSP codes*	*Writing optimized ARM codes*	*DC machine control using ARM processor*
S-9	SLO-1	*Correlation of discrete-time samples*	*Cascade structure for FIR and IIR systems*	*Simple programs using DSP codes*	*Basic ARM assembly language programs*	*AC machine control using DSP processor*
	SLO-2	*Properties of Correlation*	*Problems*	*Kinematic chains, Cams actuation with example, Gear trains with example*	*Basic ARM assembly language programs*	*AC machine control using ARM processor*

Learning Resources	1. *Steve Furber, "ARM System-on-chip Architecture", Pearson Education, India, 2000.* 2. *Joseph Yiu, "The Definitive Guide to ARM Cortex Processors", 3rd edition, Newnes Publication, 2013*	3. *John G Proakis and Dimitris G Manolakis, "Digital Signal Processing- Principles, Algorithms and Applications", 4th edition, Prentice Hall of India Limited, 2007.* 4. *M Bhaskar and B Venkataramani, "Digital Signal Processors: Architecture, Programming and Application", 2nd Edition, Mcgraw Higher Ed, 2010*

Learning Assessment

	Bloom's Level of Thinking	Continuous Learning Assessment (50% weightage)								Final Examination (50% weightage)	
		CLA – 1 (10%)		CLA – 2 (15%)		CLA – 3 (15%)		CLA – 4 (10%)#			
		Theory	Practice	Theory	Practice	Theory	Practice	Theory	Practice	Theory	Practice
Level 1	Remember Understand	40 %	-	40 %	-	30 %	-	30 %	-	30%	-
Level 2	Apply Analyze	40 %	-	40 %	-	40 %	-	40 %	-	40%	-
Level 3	Evaluate Create	20 %	-	20 %	-	30 %	-	30 %	-	30%	-
	Total	100 %		100 %		100 %		100 %		100 %	

CLA – 4 can be from any combination of these: Assignments, Seminars, Tech Talks, Mini-Projects, Case-Studies, Self-Study, MOOCs, Certifications, Conf. Paper etc.,

Course Designers

Experts from Industry	Experts from Higher Technical Institutions	Internal Experts
1. Mr. Ragavendrarao, Hardware Architect,, Intel technology Pvt. Ltd, Bangalore, ragavendra.r.r@intel.com	*1. Dr. Priestly Shan, Dean, School of Electrical, Electronics and Communication Engineering, Galgotias University, New Delhi, dean.seece@galgotiasuniversity.edu.in.*	*1. Ms. Cross T. Asha Wise, SRMIST*
2. Dr.K.Kathikeyan,R&DSpecialist,ABB India Ltd., Bangalore, India, sayalkarthik@yahoo.co.in	*2. Dr. DivyaC.,Professor, Centre for Information Technology and Engineering, ManonmaniamSundaranar university, Thirunelveli, cdivya@msuniv.ac.in*	*2. Ms. Sasikala D., SRMIST*

Course Code	18MHE426T	Course Name	ROBOT KINEMATICS AND DYNAMICS	Course Category	E	Professional Elective	L	T	P	C
							3	0	0	3

Pre-requisite Courses	Nil	Co-requisite Courses	Nil	Progressive Courses	Nil
Course Offering Department	Mechatronics Engineering	Data Book / Codes/Standards		Nil	

Course Learning Rationale (CLR):	*The purpose of learning this course is to:*
CLR-1 :	*Understand the complexity and method of solving inverse kinematics for an manipulator robot*
CLR-2 :	*Understand the concept of jacobian and singularity for manipulator*
CLR-3 :	*Understand and solve dynamics problem for the manipulator*
CLR-4 :	*Understand the various position and force control scheme and architecture*
CLR-5 :	*Understand the parallel configuration of robot*

Course Learning Outcomes (CLO):	*At the end of this course, learners will be able to:*	Learning 1: Level of Thinking (Bloom)	Learning 2: Expected Proficiency (%)	Learning 3: Expected Attainment (%)	PLO 1: Engineering Knowledge	PLO 2: Problem Analysis	PLO 3: Design & Development	PLO 4: Analysis, Design, Research	PLO 5: Modern Tool Usage	PLO 6: Society & Culture	PLO 7: Environment & Sustainability	PLO 8: Ethics	PLO 9: Individual & Team Work	PLO 10: Communication	PLO 11: Project Mgt. & Finance	PLO 12: Life Long Learning	PLO 13: PSO - 1	PLO 14: PSO - 2	PLO 15: PSO - 3
CLO-1 :	*Solve the inverse kinematics problem for the various configuration of serial manipulator*	2	80	70	H	H	L	L	-	-	-	-	-	-	L	H	H	M	-
CLO-2 :	*Compute the Jacobian matrix and singularity points for a manipulator robot*	2	80	70	H	H	L	M	-	-	-	-	M	L	-	H	H	M	-
CLO-3 :	*Compute the dynamic model of a serial manipulator*	2	80	70	H	H	L	M	-	-	-	-	M	-	-	H	H	M	-
CLO-4 :	*Understand the mathematical concept of various control schemes used for manipulator robots*	2	80	70	H	H	L	M	-	-	-	-	M	-	-	H	H	M	-
CLO-5 :	*Understand the parallel configuration of robot*	2	80	70	H	H	L	M	-	-	-	-	M	-	-	H	H	M	-

		Forward and Inverse Kinematics	Manipulator Jacobian and Singularity	Dynamics	Position and force control	Parallel Manipulator
Duration (hour)		8	10	10	10	7
S-1	SLO-1	*Forward Kinematics of 6 DOF articulated arm*	*Description/Notation for time varying position and orientation*	*Introduction to dynamics*	*Review of position control*	*Introduction to Parallel Manipulators*
	SLO-2	*Forward Kinematics of 6 DOF articulated arm*	*Example*	*Inertia, Centrifugal force, coriolis force etc*	*Control of Mass- spring damper system*	*Comparison with serial and parallel manipulator*
S-2	SLO-1	*Forward Kinematics of a Stanford Manipulator*	*Linear velocity vector for rigid bodies*	*Understanding dynamics of a simple system- mass spring damper system*	*Modelling of 1 DOF manipulator Joint*	*Various configuration of Parallel manipulator*
	SLO-2	*Forward Kinematics of a Stanford Manipulator*	*Angular velocity vector for rigid bodies*	*Inverse and forward dynamics*	*Deriving the mathematical model*	*Degree of freedom computation of parallel manipulator*
S-3	SLO-1	*Inverse Kinematics Introduction*	*Manipulator Jacobian*	*Lagrangian Formulation*	*Partitioned PD (PPD)control scheme*	*Forward and Inverse kinamtics of a parallel manipulator*
	SLO-2	*Issues in Inverse Kinematics*	*Importance of Jacobain matrix*	*Computing generalized torque/force through Lagrangian Euler method*	*Architecture and difference from PD control*	*Difficulty in forward kinematics*
S-4	SLO-1	*Algebraic and geometric method for RRR manipulator*	*Linear Velocity Jacobian*	*Dynamic model of a 2 R Planar manipulator using LE method*	*Introduction to force control*	*Inverse Kinematics of a planar parallel manipulator*
	SLO-2	*Algebraic and geometric method for RRR manipulator*	*Derivation for RR planar manipulator*	*Dynamic model of a 2 R Planar manipulator using LE method*	*Application of force control*	*Inverse Kinematics of a planar parallel manipulator*
S-5	SLO-1	*Inverse Kinematics Computation- Closed loop solution*	*Linear and angular velocity Jacobian Computation*	*Newton Euler Formulation*	*Frame work for force /position control scheme*	*Inverse Kinematics of a spatial parallel manipulator*
	SLO-2	*Case study- spherical wrist*	*Linear and angular velocity Jacobian Computation*	*Computing generalized torque/force through Newton Euler method*	*Define- Artificial and natural constraints*	*Inverse Kinematics of a spatial parallel manipulator*
S-6	SLO-1	*Inverse kinematics of articulated arm (3 DOF)*	*Concept of Singularity*	*Dynamic model of a 2 R Planar manipulator using LE method*	*Case study to define artificial and natural constraint*	*Velocity analysis*
	SLO-2	*Inverse kinematics of articulated arm (3 DOF)*	*Types and Consequences*	*Dynamic model of a 2 R Planar manipulator using LE method*	*Case study to define artificial and natural constraint*	*Jacobian computation*

S-7	SLO-1	*Inverse kinematics of Stanford manipulator*	*Singularity Computation using Jacobian*	*Dynamic model of a inverted pendulum*	*Description of force control task*	*Workspace analysis*
	SLO-2	*Inverse kinematics of Stanford manipulator*	*Example using RR Manipulator*	*Dynamic model of a inverted pendulum*	*Example- Peg in hole assembly*	*Example*
S-8	SLO-1	*Computation consideration for inverse kinematics*	*Jacobian Computation for RPY wrist*	*Dynamic model of a SCARA robot*	*Force control of mass spring system*	
	SLO-2	*Example*	*Singularity Computation for RPY wrist*	*Dynamic model of a SCARA robot*	*Force control of mass spring system*	
S-9	SLO-1		*Jacobian Computation for articulated arm*	*Static Forces in manipulator*	*Dynamics based control*	
	SLO-2		*Singularity Computation for articulated arm*	*Static Forces in manipulator- Example*	*General dynamics representation*	
S-10	SLO-1		*Work space Analysis*	*Jacobian in force domain*	*Computed torque control*	
	SLO-2		*Work space Analysis*	*Derivation- Static force computation of a planar RR manipulator*	*Architecture*	

Learning Resources	1. *John J. Craig, "Introduction to Robotics Mechanics and Control", 3rd edition, Pearson, 2008.* 2. *Mark W. Spong and M. Vidyasagar, "Robot Dynamics and Control", 2nd edition, Wiley India, 2008.* 3. *J.P. Merlet, "Parallel Robots", 2nd edition, Springer, 2006.* 4. *Saeed B.Niku, "Introduction to Robotics Analysis, Systems and Applications", 2nd edition, Prentice Hall of India, 2009.*	5. *Robert J. Schilling, "Fundamentals of Robotics Analysis and Control", 5th edition, Prentice Hall of India Learning, 2009.* 6. *Mittal R.K., and Nagrath I.J., "Robotics and Control", 1st edition, Tata McGraw Hill, 2007.* 7. *Fu K., Gonzalez R., and Lee C. S. G., "Robotics: Control, Sensing, Vision and Intelligence", 1st edition McGraw Hill, 2008.* 8. *Tsuneo Yohikwa, "Foundations of Robotics Analysis and Control", 2nd edition, MIT Press, 2003*

Learning Assessment

	Bloom's Level of Thinking	Continuous Learning Assessment (50% weightage)								Final Examination (50% weightage)	
		CLA – 1 (10%)		CLA – 2 (15%)		CLA – 3 (15%)		CLA – 4 (10%)#			
		Theory	Practice	Theory	Practice	Theory	Practice	Theory	Practice	Theory	Practice
Level 1	Remember Understand	40 %	-	30 %	-	30 %	-	30 %	-	30%	-
Level 2	Apply Analyze	40 %	-	40 %	-	40 %	-	40 %	-	40%	-
Level 3	Evaluate Create	20 %	-	30 %	-	30 %	-	30 %	-	30%	-
	Total	100 %		100 %		100 %		100 %		100 %	

CLA – 4 can be from any combination of these: Assignments, Seminars, Tech Talks, Mini-Projects, Case-Studies, Self-Study, MOOCs, Certifications, Conf. Paper etc.,

Course Designers		
Experts from Industry	Experts from Higher Technical Institutions	Internal Experts
1.Mr.Ganesh Ram, Intel Labs ,Bangalore, ganeshram.nandakumar.@intel.com	*1. Dr., R. Thiyagarajan, Visiting faculty, IIT Madras, thiyaguiitm@gmail.com*	*1. Mr. Ranjith Pillai R, SRMIST*
2. Mr. Mohammed Sagheer ,Wabco Technology Center ,India, mohammedsagheer.musthafa@wabco-auto.com	*2. Dr., P Karthikeyan, MIT,Anna University, pkarthikeyan@annauniv.edu*	*2. Dr.rSenthilnathan, SRMIST*

Course Code	18MHE427T	Course Name	SYSTEMS ENGINEERING	Course Category	E	Professional Elective	L	T	P	C
							3	0	0	3

Pre-requisite Courses	Nil	Co-requisite Courses	Nil	Progressive Courses	Nil
Course Offering Department	Mechatronics Engineering	Data Book / Codes/Standards		Nil	

Course Learning Rationale (CLR):	*The purpose of learning this course is to:*
CLR-1 :	*Gain the knowledge of systems engineering*
CLR-2 :	*Identify the need for complex systems*
CLR-3 :	*Utilize the management skills in systems engineering*
CLR-4 :	*Gain knowledge of systems analysis*
CLR-5 :	*Introduce the analysis concepts in systems engineering*
CLR-6 :	*Gain knowledge of Engineering design*

		Learning			Program Learning Outcomes (PLO)														
		1	2	3	1	2	3	4	5	6	7	8	9	10	11	12	13	14	15
Course Learning Outcomes (CLO):	*At the end of this course, learners will be able to:*	Level of Thinking (Bloom)	Expected Proficiency (%)	Expected Attainment (%)	Engineering Knowledge	Problem Analysis	Design & Development	Analysis, Design, Research	Modern Tool Usage	Society & Culture	Environment & Sustainability	Ethics	Individual & Team Work	Communication	Project Mgt. & Finance	Life Long Learning	PSO - 1	PSO - 2	PSO - 3
CLO-1 :	*Knowledge of systems engineering*	2	75	70	H	H	M	H	M	-	-	-	-	-	-	H	H	H	H
CLO-2 :	*Knowledge of systems complexity*	3	75	70	H	H	M	H	M	-	-	-	-	-	-	H	M	M	M
CLO-3 :	*Application of the management skills in systems engineering*	3	75	70	H	H	M	H	M	-	-	-	-	-	-	H	M	M	M
CLO-4 :	*Knowledge of systems analysis*	3	75	70	H	H	M	H	M	-	-	-	-	-	-	H	M	M	M
CLO-5 :	*knowledge of analysis concepts*	3	75	70	H	H	M	H	M	-	-	-	-	-	-	H	M	M	M
CLO-6 :	*Interpret the knowledge of Engineering Design*	3	75	70	H	H	M	H	H	-	-	-	-	-	-	H	H	H	H

		Introduction to Systems Engineering	Complex Systems	Systems Engineering Management	Systems Analysis	Engineering Design
Duration (hour)		9	9	9	9	9
S-1	SLO-1	*Origin of Systems Engineering*	*Complex System Structure*	*Managing Systems Development*	*Need Analysis*	*Prototype Development*
	SLO-2	*Origin of Systems Engineering*	*Complex System Structure*	*Managing Systems Development*	*Need Analysis*	*Prototype Development*
S-2	SLO-1	*Examples of Systems Engineering*	*Building Blocks*	*Risks of Systems Engineering*	*Functional Analysis and Allocation*	*Development Testing and Risk Reduction*
	SLO-2	*Examples of Systems Engineering*	*Building Blocks*	*Risks of Systems Engineering*	*Functional Analysis and Allocation*	*Development Testing and Risk Reduction*
S-3	SLO-1	*Systems Engineering Field*	*Hierarchy and Interfaces*	*Work Breakdown Structure (WBS)*	*Model-Based Systems Engineering (MBSE)*	*Probability of data analysis*
	SLO-2	*Systems Engineering Field*	*Hierarchy and Interfaces*	*Work Breakdown Structure (WBS)*	*Model-Based Systems Engineering (MBSE)*	*Hypothesis testing*
S-4	SLO-1	*Systems Engineering View point*	*Complex System Interactions*	*Systems Engineering Management Plan (SEMP)*	*Requirement Analysis*	*Implementing system building blocks*
	SLO-2	*Systems Engineering View point*	*Complex System Interactions*	*Systems Engineering Management Plan (SEMP)*	*Requirement Analysis*	*Implementing system building blocks*
S-5	SLO-1	*Domain of Systems Engineering*	*System Complexity*	*Systems Risk Management*	*Decision Making*	*Reliability and Redundancy*
	SLO-2	*Domain of Systems Engineering*	*System Complexity*	*Systems Risk Management*	*Decision Making*	*Reliability and Redundancy*
S-6	SLO-1	*Approaches of Systems Engineering*	*Complex System Environment*	*Systems Architecture*	*Modeling for Decisions*	*Concepts of Maintainability, Availability and Producibility*
	SLO-2	*Approaches of Systems Engineering*	*Complex System Environment*	*Systems Architecture*	*Modeling for Decisions*	*Concepts of Maintainability, Availability and Producibility*
S-7	SLO-1	*Activities of Systems Engineering*	*Systems Engineering methods*	*Performance Requirements*	*Simulation Analysis*	*Systems Integration*
	SLO-2	*Activities of Systems Engineering*	*Systems Engineering methods*	*Performance Requirements*	*Simulation Analysis*	*Systems Integration*
S-8	SLO-1	*Perspectives of Systems Engineering*	*Life cycle and Evolutionary characteristics*	*System Requirements Development*	*System Modeling Languages*	*Testing and evaluating total system*
	SLO-2	*Perspectives of Systems Engineering*	*Life cycle and Evolutionary characteristics*	*System Requirements Development*	*System Modeling Languages*	*Testing and evaluating total system*
S-9	SLO-1	*Systems Engineering Products*	*Systems testing throughout development*	*Systems Validating Requirements*	*Trade-off Analysis*	*Development to Production*
	SLO-2	*Systems Engineering Products*	*Systems testing throughout development*	*Systems Validating Requirements*	*Trade-off Analysis*	*Development to Production*

Learning Resources	1. *Kossiakoff, A. Sweet, Seymour, S., W.N., Biemer, S.M., "Systems Engineering Principles and Practice", John Wiley & Sons, 2nd Edition, 2011.* 2. *Blanchard, B.S. and Fabrycky, W.J., "Systems Engineering and Analysis", Prentice Hall,4th Edition, 2005.* 3. *Zeigler, B.P., H. Praehofer, T.G. Kim., "Theory of Modeling and Simulation", Academic Press,2nd Edition, 2000.*	4. *Groover. M.P., "Automation, production systems and computer integrated manufacturing", 3rd edition, Prentice Hall of India, 2007.* 5. *Gharajedaghi, J., "Systems Thinking, Managing Chaos and Complexity: A Platform for Design Business Architecture", Butterworth Heinemann, 2nd Edition, , 2005.*

Learning Assessment

	Bloom's Level of Thinking	Continuous Learning Assessment (50% weightage)								Final Examination (50% weightage)	
		CLA – 1 (10%)		CLA – 2 (15%)		CLA – 3 (15%)		CLA – 4 (10%)#			
		Theory	Practice	Theory	Practice	Theory	Practice	Theory	Practice	Theory	Practice
Level 1	Remember Understand	30 %	-	30 %	-	30 %	-	30 %	-	30%	-
Level 2	Apply Analyze	40 %	-	40 %	-	40 %	-	40 %	-	40%	-
Level 3	Evaluate Create	30 %	-	30 %	-	30 %	-	30 %	-	30%	-
	Total	100 %		100 %		100 %		100 %		100 %	

CLA – 4 can be from any combination of these: Assignments, Seminars, Tech Talks, Mini-Projects, Case-Studies, Self-Study, MOOCs, Certifications, Conf. Paper etc.,

Course Designers

Experts from Industry	Experts from Higher Technical Institutions	Internal Experts
1. Mr. K.P.Srinivasan, Visteon Automotive Electronics Limited, Chennai, psriniv1@visteon.com	*1. Dr. P. Karthikeyan, Anna University, Chennai, pkarthikeyan@mitindia.edu*	*1. Dr. T. Muthuramalingam, SRMIST*
2. Mr. S. EllanChezhiyan, Keyence Microscope Limited, Chennai, ellanchezhian@gmail.com	*2. Dr. D. Saravanakumar, VIT University, Chennai, saravanakumar.d@vit.ac.in.*	*2. Dr. M. Mohamed Rabik, SRMIST*

Course Code	18MHE501T	Course Name	ROBOTICS	Course Category	E	Professional Elective	L	T	P	C
							3	0	0	3

Pre-requisite Courses	Nil	Co-requisite Courses	Nil	Progressive Courses	Nil
Course Offering Department	Mechatronics Engineering	Data Book / Codes/Standards	Nil		

Course Learning Rationale (CLR):	*The purpose of learning this course is to:*
CLR-1 :	*Introduce the various architecture of Industrial robot*
CLR-2 :	*Understand the concept of vectors and transformation used in robotics*
CLR-3 :	*Formulate the forward kinematics of manipulators*
CLR-4 :	*Introduce the various actuators, transmission elements and sensors used in robot*
CLR-5 :	*Introduce the various control strategy and work cell layout*
CLR-6 :	*Understand the terminologies and various mathematical concepts in manipulator robotics*

		Learning			Program Learning Outcomes (PLO)														
		1	2	3	1	2	3	4	5	6	7	8	9	10	11	12	13	14	15
Course Learning Outcomes (CLO):	*At the end of this course, learners will be able to:*	Level of Thinking (Bloom)	Expected Proficiency (%)	Expected Attainment (%)	Engineering Knowledge	Problem Analysis	Design & Development	Analysis, Design, Research	Modern Tool Usage	Society & Culture	Environment & Sustainability	Ethics	Individual & Team Work	Communication	Project Mgt. & Finance	Life Long Learning	PSO - 1	PSO - 2	PSO - 3
CLO-1 :	*Understand various terminologies and configuration of an industrial robot*	*2*	*80*	*70*	*H*	*M*	*M*	*H*	*M*	-	-	-	-	-	-	*H*	*H*	-	-
CLO-2 :	*Understand the application of vectors and transformation applied to robotics*	*2*	*80*	*70*	*H*	*H*	*M*	*H*	*M*	-	-	-	-	-	-	*H*	*H*	-	-
CLO-3 :	*Solve the forward kinematic model of the manipulators*	*2*	*80*	*70*	*H*	*H*	*M*	*H*	*M*	-	-	-	*H*	-	-	*H*	*H*	-	-
CLO-4 :	*Understand the various actuators, sensors and transmission used in robot*	*2*	*80*	*70*	*H*	*H*	*H*	*H*	*M*	-	-	-	*M*	-	-	*H*	*H*	-	-
CLO-5 :	*Understand the various types of control used in robot*	*2*	*80*	*70*	*H*	*H*	*M*	*H*	*M*	-	-	-	*M*	-	-	*H*	*H*	-	-
CLO-6 :	*Get conversant with fundamental terminologies and mathematical concepts to solve kinematics problem*	*2*	*80*	*70*	*H*	*H*	*M*	*H*	*M*	-	-	-	*M*	-	-	*H*	*H*	-	-

		Introduction to Robotics	Transformations	Manipulator Kinematics	Introduction to sensors and actuators in robotics	Trajectory planning and work cell
Duration (hour)		9	12	11	8	8
S-1	SLO-1	*Introduction to Robotics- History, laws of robotics*	*Review of Vectors*	*Introduction to kinematics*	*Basic Actuators*	*Types of Robot control*
	SLO-2	*Classification based on application*	*Vector representation of points and bodies*	*Forward and inverse kinematics*	*Selection of actuators*	*Cartesian and joint space scheme trajectory planning*
S-2	SLO-1	*Definition of work volume*	*Translation-numerical problem*	*Geometric and algebraic approach*	*Transmission elements*	*Force control*
	SLO-2	*Classification based on work volume*	*Rotation-numerical problem solving*	*Forward kinematics of RR,RRR planar manipulator using geometric approach*	*Selection*	*Case study- Mass Spring system*
S-3	SLO-1	*Precision, repeatability, accuracy in terms of robotics*	*Representing rotation- rotation matrix*	*Geometric approach for RRP spatial manipulator*	*Harmonic drives*	*Position Control*
	SLO-2	*Co ordinate systems and Degree of freedom*	*Numerical problem solving*	*Comparison of geometric and algebraic approach*	*Advantage of harmonic drives over other transmission elements*	*Case Study- 1 DOF joint model*
S-4	SLO-1	*Various joints in robot, links*	*Representing Rotation- Euler angles*	*D-H formulation for manipulator kinematics*	*Force sensors – Importance and types, working Principle*	*Hybrid force position control*
	SLO-2	*Configuration and operational space*	*Numerical problem solving*	*D-H formulation for manipulator kinematics*	*Maltese Cross Configuration*	*Case study*
S-5	SLO-1	*Anatomy of robot and wrist configuration*	*Representing Rotation- Equivalent axis representation*	*Difference between standard and modified DH convention*	*Tactile sensor- Importance and use*	*Robot Cell Layout*
	SLO-2	*Example*	*Numerical problem solving*	*Example – kinematics of RR planar manipulator using both convention*	*Tactile sensor- Various type and its working*	*Robot Cell Layout*
S-6	SLO-1	*Robot end effectors*	*Difference between current axis and fixed axis representation*	*Forward kinematics of 3 DOF RRP manipulator*	*Slip sensor- Importance and use*	*Safety Monitoring*
	SLO-2	*Various Types*	*Numerical problem solving*	*Forward kinematics of 3 DOF RRP manipulator*	*Slip sensor- Various type and its working*	*Error Detection and Recovery*

S-7	SLO-1	*Gripper type*	*Homogeneous transformation*	*Forward kinematics of 3 DOF RRR spatial manipulator*	*Vision system for robot*	*Robot cycle time analysis*
	SLO-2	*Design of mechanical gripper and grasping*	*Numerical problem solving*	*Forward kinematics of 3 DOF RRR spatial manipulator*	*Architecture*	*Robot cycle time analysis*
S-8	SLO-1	*Various gripper in robot*	*Operators and mapping concept*	*Forward Kinematics of RPY wrist*	*Case study on vision system*	*Economic analysis of robot*
	SLO-2	*Selection criteria*	*Case study- numerical problem solving*	*Forward Kinematics of RPY wrist*	*Case study on vision system*	*Economic analysis of robot*
S-9	SLO-1	*Interpreting various data in the the robot data sheet*	*Compound Transformation*	*Forward kinematics of 4DOF SCARA robot*		
	SLO-2	*Interpreting various data in the the robot data sheet*	*Case Study*	*Forward kinematics of 4DOF SCARA robot*		
S-10	SLO-1		*Operators and mapping concept*	*Introduction to inverse kinematics*		
	SLO-2		*Case study- numerical*	*Inverse kinematics of RR planar manipulator- geometric approach*		
S-11	SLO-1		*Compound transformation*	*Issues in inverse kinematics*		
	SLO-2		*Case study*	*Issues in inverse kinematics*		
S-12	SLO-1		*Case study of transformations in robotics*			
	SLO-2		*Case study of transformations in robotics*			

Learning Resources	*1. Mikell P. Groover, "Industrial Robotics", McGraw Hill, 2nd edition, 2012.* *2. John J. Craig, "Introduction to Robotics", 3rd Edition, Addison Wesley, ISE 2008.* *3. Deb S.R., "Robotics Technology and Flexible Automation", 2nd edition, Tata McGraw - Hill Publishing Company Limited, 2012.*	*4. Arthor Critchlow, "Introduction to Robotics",1st edition, Macmillan, 2009.* *5. Mohsen Shahinpoor, "A Robot Engineering Text Book", 1st edition, Harper and Row, 2004* *6. Sterling Kinney J, "Indeterminate Structural Analysis", 1st edition, Narosa Publishing House, 1987.*

Learning Assessment

	Bloom's Level of Thinking	Continuous Learning Assessment (50% weightage)								Final Examination (50% weightage)	
		CLA – 1 (10%)		CLA – 2 (15%)		CLA – 3 (15%)		CLA – 4 (10%)#			
		Theory	Practice	Theory	Practice	Theory	Practice	Theory	Practice	Theory	Practice
Level 1	Remember / Understand	40 %	-	30 %	-	30 %	-	30 %	-	30%	-
Level 2	Apply / Analyze	40 %	-	40 %	-	40 %	-	40 %	-	40%	-
Level 3	Evaluate / Create	20 %	-	30 %	-	30 %	-	30 %	-	30%	-
	Total	100 %		100 %		100 %		100 %		100 %	

CLA – 4 can be from any combination of these: Assignments, Seminars, Tech Talks, Mini-Projects, Case-Studies, Self-Study, MOOCs, Certifications, Conf. Paper etc.,

Course Designers

Experts from Industry	Experts from Higher Technical Institutions	Internal Experts
1.Mr.Ganesh Ram, Intel Labs ,Bangalore, ganeshram.nandakumar.@intel.com	*1. Dr., R. Thiyagarajan, IIT Madras, thiyaguiitm@gmail.com*	*1. Ranjith Pillai R, SRMIST*
2. Mr. Mohammed Sagheer ,Wabco Technology Center ,India, mohammedsagheer.musthafa@wabco-auto.com	*2. Dr., P Karthikeyan, MIT, Anna University, pkarthikeyan@annauniv.edu*	*2. Dr. R Senthilnathan, SRMIST*

Course Code	18MHE502T	Course Name	MECHANICS OF MANIPULATION	Course Category	E	Professional Elective	L	T	P	C
							3	0	0	3

Pre-requisite Courses	18MHE501T-Robotics	Co-requisite Courses	Nil	Progressive Courses	Nil
Course Offering Department	Mechatronics Engineering	Data Book / Codes/Standards	Nil		

Course Learning Rationale (CLR):	*The purpose of learning this course is to:*	Learning			Program Learning Outcomes (PLO)														
		1	2	3	1	2	3	4	5	6	7	8	9	10	11	12	13	14	15
CLR-1 :	*Understand the complexity and method of solving inverse kinematics for an manipulator robot*	Level of Thinking (Bloom)	Expected Proficiency (%)	Expected Attainment (%)	Engineering Knowledge	Problem Analysis	Design & Development	Analysis, Design, Research	Modern Tool Usage	Society & Culture	Environment & Sustainability	Ethics	Individual & Team Work	Communication	Project Mgt. & Finance	Life Long Learning	PSO - 1	PSO - 2	PSO - 3
CLR-2 :	*Understand the concept of Jacobian and static forces applied to manipulator*																		
CLR-3 :	*Learn the importance of singularity and workspace in manipulator robot*																		
CLR-4 :	*Understand and solve dynamics problem for the manipulator*																		
CLR-5 :	*Understand the parallel configuration of robot*																		
CLR-6 :	*To get an overview of challenges involved in manipulator robotics*																		
Course Learning Outcomes (CLO):	*At the end of this course, learners will be able to:*																		
CLO-1 :	*Solve the inverse kinematics problem for serial manipulators*	*2*	*80*	*70*	*H*	*M*	*M*	*H*	*M*	-	-	-	-	-	-	*H*	*H*	-	-
CLO-2 :	*Compute the Jacobian matrix and static forces in manipulator*	*2*	*80*	*70*	*H*	*H*	*M*	*H*	*M*	-	-	-	-	-	-	*H*	*H*	-	-
CLO-3 :	*Understand the important concept of singularity and its computation*	*2*	*80*	*70*	*H*	*H*	*M*	*H*	*M*	-	-	-	*H*	-	-	*H*	*H*	-	-
CLO-4 :	*Compute the dynamic model of a serial manipulator*	*2*	*80*	*70*	*H*	*H*	*H*	*H*	*M*	-	-	-	*M*	-	-	*H*	*H*	-	-
CLO-5 :	*Understand the parallel configuration of robot*	*2*	*80*	*70*	*H*	*H*	*M*	*H*	*M*	-	-	-	*M*	-	-	*H*	*H*	-	-
CLO-6 :	*Get conversant with overall challenges involved in manipulators*	*2*	*80*	*70*	*H*	*H*	*M*	*H*	*M*	-	-	-	*M*	-	-	*H*	*H*	-	-

		Manipulator Kinematics	Velocity Analysis	Singularity and Workspace analysis	Dynamic Modelling	Parallel Manipulator
Duration (hour)		9	11	10	8	7
S-1	SLO-1	*Forward kinematics of 6 DOF articulated arm*	*Description/Notation for time varying position and orientation*	*Concept of Singularity*	*Introduction to dynamics*	*Introduction to parallel manipulators*
	SLO-2	*Forward kinematics of 6 DOF articulated arm*	*Example*	*Types and consequences*	*Inertia, centrifugal force, coriolis force etc*	*Comparison with serial and parallel manipulator*
S-2	SLO-1	*Forward kinematics of a Stanford Manipulator*	*Linear velocity vector for rigid bodies*	*Singularity computation using Jacobian*	*Understanding dynamics of a simple system- mass spring damper system*	*Various configuration of parallel manipulator*
	SLO-2	*Forward kinematics of a Stanford Manipulator*	*Angular velocity vector for rigid bodies*	*Example using RR Manipulator*	*Inverse and forward dynamics*	*Degree of freedom computation of parallel manipulator*
S-3	SLO-1	*Inverse kinematics Introduction*	*Manipulator Jacobian*	*Singularity computation of RPY wrist*	*Lagrangian formulation*	*Forward and inverse kinematics of a parallel manipulator*
	SLO-2	*Issues in inverse kinematics*	*Importance of Jacobain matrix*	*Singularity computation of RPY wrist*	*Computing generalized torque/force through Lagrangian-Euler (LE) method*	*Challenges in forward kinematics*
S-4	SLO-1	*Algebraic and geometric method for RRR manipulator*	*Linear velocity Jacobian*	*Singularity computation of 6 DOF articulated arm*	*Dynamic model of a RR Planar manipulator using LE method*	*Inverse Kinematics of a planar parallel manipulator*
	SLO-2	*Algebraic and geometric method for RRR manipulator*	*Derivation for RR planar manipulator*	*Singularity computation of 6 DOF articulated arm*	*Dynamic model of a RR Planar manipulator using LE method*	*Inverse Kinematics of a planar parallel manipulator*
S-5	SLO-1	*Inverse kinematics Computation- Closed loop solution*	*Linear and angular velocity Jacobian computation*	*Work space analysis*	*Newton-Euler Formulation*	*Inverse Kinematics of a spatial parallel manipulator*
	SLO-2	*Case study- spherical wrist*	*Linear and angular velocity Jacobian computation*	*Work space analysis*	*Computing generalized torque/force through Newton Euler method*	*Inverse Kinematics of a spatial parallel manipulator*
S-6	SLO-1	*Inverse kinematics of articulated arm (6 DOF)*	*Jacobian Computation for RPY wrist*	*Introduction to Trajectory Planning*	*Dynamic model of a RR Planar manipulator using LE method*	*Velocity analysis*

	SLO-2	*Inverse kinematics of articulated arm (6 DOF)*	*Jacobian computation for RPY wrist*	*Joint space and Cartesian space*	*Dynamic model of a RR Planar manipulator using LE method*	*Jacobian computation*
S-7	SLO-1	*Inverse kinematics of Stanford manipulator*	*Jacobian computation for articulated arm*	*Joint space trajectory planning*	*Dynamic model of a inverted pendulum*	*Workspace analysis*
	SLO-2	*Inverse kinematics of Stanford manipulator*	*Jacobian computation for articulated arm*	*Example of cubic polynomial*	*Dynamic model of a inverted pendulum*	*Example*
S-8	SLO-1	*Computation consideration for inverse kinematics*	*Static forces in manipulator*	*Joint space trajectory planning via points*	*Dynamic model of a SCARA robot*	
	SLO-2	*Example*	*Static forces in manipulator- Example*	*Cubic polynomial via points*	*Dynamic model of a SCARA robot*	
S-9	SLO-1	*Forward and Inverse Kinematics in robot control*	*Jacobian in force domain*	*Cartesian space trajectory planning*		
	SLO-2	*Example*	*Derivation*	*Case study*		
S-10	SLO-1		*Static force computation of a planar RR manipulator*	*Problem in Cartesian space planning*		
	SLO-2		*Static force computation of a planar RR manipulator*	*Example*		
S-11	SLO-1		*Cartesian transformation of velocities and forces*			
	SLO-2		*Example*			

Learning Resources	1. *John J. Craig, "Introduction to Robotics Mechanics and Control", 3rd edition, Pearson, 2008.* 2. *Mark W. Spong and M. Vidyasagar, "Robot Dynamics and Control", 2nd edition, Wiley India, 2008.* 3. *J.P. Merlet, "Parallel Robots", 2nd edition, Springer, 2006.* 4. *Saeed B.Niku, "Introduction to Robotics Analysis, Systems and Applications", 2nd edition, Prentice Hall of India, 2009.*	5. *Robert J. Schilling, "Fundamentals of Robotics Analysis and Control", 5th edition, Prentice Hall of India Learning, 2009.* 6. *Mittal R.K., and Nagrath I.J., "Robotics and Control", 1st edition, Tata McGraw Hill, 2007.* 7. *Fu K., Gonzalez R., and Lee C. S. G., "Robotics: Control, Sensing, Vision and Intelligence", 1st edition* 8. *McGraw Hill, 2008.8. Tsuneo Yohikwa, "Foundations of Robotics Analysis and Control", 2nd edition, MIT Press, 2003.*

Learning Assessment

	Bloom's Level of Thinking	Continuous Learning Assessment (50% weightage)								Final Examination (50% weightage)	
		CLA – 1 (10%)		CLA – 2 (15%)		CLA – 3 (15%)		CLA – 4 (10%)#			
		Theory	Practice	Theory	Practice	Theory	Practice	Theory	Practice	Theory	Practice
Level 1	Remember Understand	40 %	-	30 %	-	30 %	-	30 %	-	30%	-
Level 2	Apply Analyze	40 %	-	40 %	-	40 %	-	40 %	-	40%	-
Level 3	Evaluate Create	20 %	-	30 %	-	30 %	-	30 %	-	30%	-
	Total	100 %		100 %		100 %		100 %		100 %	

CLA – 4 can be from any combination of these: Assignments, Seminars, Tech Talks, Mini-Projects, Case-Studies, Self-Study, MOOCs, Certifications, Conf. Paper etc.,

Course Designers

Experts from Industry	Experts from Higher Technical Institutions	Internal Experts
1.Mr.Ganesh Ram, Intel Labs ,Bangalore, ganeshram.nandakumar.@intel.com	*1. Dr., R. Thiyagarajan, Visiting faculty, IIT Madras, thiyaguiitm@gmail.com*	*1. Dr. G. Murali, SRMIST*
2. Mr. Mohammed Sagheer ,Wabco Technology Center ,India, mohammedsagheer.musthafa@wabco-auto.com	*2. Dr., P Karthikeyan, MIT,Anna University, pkarthikeyan@annauniv.edu*	*2. Ranjith Pillai R, SRMIST*

Course Code	18MHE503T	Course Name	MOBILE ROBOTICS	Course Category	E	Professional Elective	L	T	P	C
							3	0	0	3

Pre-requisite Courses	Nil	Co-requisite Courses	Nil	Progressive Courses	18MHE510T - Planning and Decision Making in Robotics
Course Offering Department	Mechatronics Engineering	Data Book / Codes / Standards	Nil		

Course Learning Rationale (CLR):	*The purpose of learning this course is to:*
CLR-1 :	*Formulate the challenges in developing autonomous mobile robots*
CLR-2 :	*Abstract kinematic control of wheeled mobile robots*
CLR-3 :	*Understand the challenges involved in sensory perception for mobile robots*
CLR-4 :	*Understand the mechanics of legged robots for locomotion*
CLR-5 :	*Comprehend the challenges and configurations of aerial and underwater mobile robots*
CLR-6 :	*Build the foundations of mobile robots in various modalities*

Course Learning Outcomes (CLO):	*At the end of this course, learners will be able to:*	Learning 1 Level of Thinking (Bloom)	2 Expected Proficiency (%)	3 Expected Attainment (%)
CLO-1 :	*Appreciate the various problems to be addressed in autonomous mobile robots*	3	80	75
CLO-2 :	*Understand the various types and configurations of wheeled and legged mobile robots*	3	80	75
CLO-3 :	*Formulate the kinematics of wheeled and legged mobile robots of popular configurations*	2	70	65
CLO-4 :	*Build the dynamic model of multi-rotor aerial and underwater robots*	2	75	70
CLO-5 :	*Understand the issues in interpreting proprioceptive and exteroceptive sensory data on-board mobile robots*	2	85	80
CLO-6 :	*Build the required foundation for developing autonomous mobile robots.*	2	80	75

Program Learning Outcomes (PLO)

	1 Engineering Knowledge	2 Problem Analysis	3 Design & Development	4 Analysis, Design, Research	5 Modern Tool Usage	6 Society & Culture	7 Environment & Sustainability	8 Ethics	9 Individual & Team Work	10 Communication	11 Project Mgt. & Finance	12 Life Long Learning	13 PSO - 1	14 PSO - 2	15 PSO - 3
CLO-1	H	H	M	L	L	-	-	-	L	L	-	L	H	M	-
CLO-2	H	H	M	M	L	-	-	-	M	L	-	L	H	M	-
CLO-3	H	M	L	M	L	-	-	-	M	L	-	L	H	M	-
CLO-4	H	M	M	M	M	-	-	-	M	L	-	L	H	M	-
CLO-5	H	M	M	M	M	-	-	-	M	L	-	L	H	M	-
CLO-6	H	M-	M	M	M	-	-	-	L	L	-	L	H	M	-

		Introduction	Kinematics and Control of Mobile Robots	Sensors for Mobile Robots	Legged Robots	Aerial and Underwater Robots
Duration (hour)		6	10	10	9	10
S-1	SLO-1	*Mobile robots vs. manipulators*	*Kinematic constraints of a fixed standard wheel*	*Sensors for mobile robots*	*Introduction to limbed systems*	*Non-ground modality*
	SLO-2	*Introduction to autonomous mobile robots*	*Derivation*	*Definitions, classification*	*Comparison with wheeled systems*	*Case studies*
S-2	SLO-1	*Locomotion aspects of mobile robots*	*Kinematic constraints of a omni-directional wheel*	*Characteristics applicable to mobile robots*	*Configurations of limbed systems*	*Aerial robots*
	SLO-2	*Locomotion aspects of mobile robots*	*Derivation*	*Characteristics applicable to mobile robots*	*Case studies*	*Types and comparison*
S-3	SLO-1	*Introduction to wheeled mobile robots*	*Forward kinematic of three wheeled differential drive robot*	*Physical and computational attributes of sensors applicable to mobile robots*	*Conceptual design of limbed systems*	*Multi-rotor aerial robot*
	SLO-2	*Wheel types*	*Derivation*	*Sensor noise and sensor aliasing*	*Design issues*	*Types and applications*
S-4	SLO-1	*Wheeled configurations*	*Forward kinematics of a three wheeled omni-directional robot*	*GPS and heading sensors*	*Kinematics of quad-limbed configuration*	*Quadrotor aerial robot*
	SLO-2	*Two, three, four, five and six wheeled*	*Derivation*	*Principles, challenges and interpretation*	*Derivation*	*Modelling of dynamics*
S-5	SLO-1	*Maneuverability, controllability*	*Degree of freedom, differential degrees of freedom,*	*Light and sound based ranging*	*Control strategy*	*Modelling of flight controller*
	SLO-2	*Stability of mobile robots*	*Holonomic and non-holonomic constraints, degree of maneuverability*	*Principles, challenges and interpretation*	*Model of control algorithm for legged robot*	*Derivation*
S-6	SLO-1	*Wheeled locomotion*	*Mobility analysis of various wheeled configurations*	*Wheel odometry*	*Design of biped configuration*	*Commercial flight controllers*
	SLO-2	*Case studies*	*Mobility analysis of various wheeled configurations*	*Algorithm*	*Kinematics of a biped configuration*	*Specifications and selection criteria*
S-7	SLO-1		*Workspace and trajectory considerations*	*Wheel odometry critical analysis*	*Design case study of a complete humanoid*	*Underwater vehicles*

	SLO-2		*Comparison*	*Wheel odometry error reduction*	*Considerations and challenges*	*Foundations topics and challenges*
S-8	SLO-1		*State space modelling of three wheeled differential drive robot*	*Vision for mobile robots*	*Mechanical system design*	*Types of underwater vehicles*
	SLO-2		*Derivation*	*Techniques and purpose*	*Case study*	*Comparison*
S-9	SLO-1		*Go-goal controller*	*Multi-sensor combinations*	*Electrical system design*	*Modelling of underwater dynamics*
	SLO-2		*Block diagram level model*	*Need and types*	*Case study*	*Derivation*
S- 10	SLO-1		*Cruise controllers*	*Sensor fusion algorithms*		*Modelling of underwater vehicle*
	SLO-2		*Block diagram level model*	*Types and selection*		*Derivation*

Learning Resources	1. *Siegwart, Nourbakhsh, "Introduction to Autonomous Mobile Robots", 2nd Edition, MIT Press, 2011.* 2. *Bruno Siciliano, Oussama Khatib, "Handbook of Robotics", 2nd Edition, Springer, 2016.* 3. *Perter Corke, "Robotics, Vision and Control", 2nd Edition, Springer, 2017.*

Learning Assessment											
	Bloom's Level of Thinking	Continuous Learning Assessment (50% weightage)								Final Examination (50% weightage)	
		CLA – 1 (10%)		CLA – 2 (15%)		CLA – 3 (15%)		CLA – 4 (10%)#			
		Theory	Practice	Theory	Practice	Theory	Practice	Theory	Practice	Theory	Practice
Level 1	Remember Understand	30 %	-	30 %	-	30 %	-	30 %	-	30%	-
Level 2	Apply Analyze	40 %	-	40 %	-	40 %	-	40 %	-	40%	-
Level 3	Evaluate Create	30 %	-	30 %	-	30 %	-	30 %	-	30%	-
	Total	100 %		100 %		100 %		100 %		100 %	

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2. Mr. Mohammed Sagheer ,Wabco Technology Center, mohammedsagheer.musthafa@wabco-auto.com	*2. Dr. P. Karthikeyan, MIT Campus, Anna University, pkarthikeyan@annauniv.edu*	*2. Mr. K. Sivanathan, SRMIST*

Course Code	18MHE504T	Course Name	ROBOT CONTROL	Course Category	E	Professional Elective	L	T	P	C
							3	0	0	3

Pre-requisite Courses	18MHE501T - Robotics	Co-requisite Courses	Nil	Progressive Courses	Nil
Course Offering Department	Mechatronics Engineering	Data Book / Codes/Standards	Nil		

Course Learning Rationale (CLR):	*The purpose of learning this course is to:*
CLR-1 :	*Understand the position control schemes in robot*
CLR-2 :	*Define the importance of force control in robot application*
CLR-3 :	*Learn the force/position control and trajectory control schemes in robotics*
CLR-4 :	*Get familiar with the nonlinear systems and its control strategy*
CLR-5 :	*Learn the various programming methods in robot*
CLR-6 :	*To get an insight of the role of kinematics and dynamics in control*

Course Learning Outcomes (CLO):	*At the end of this course, learners will be able to:*	Learning 1 Level of Thinking (Bloom)	2 Expected Proficiency (%)	3 Expected Attainment (%)	PLO 1 Engineering Knowledge	2 Problem Analysis	3 Design & Development	4 Analysis, Design, Research	5 Modern Tool Usage	6 Society & Culture	7 Environment & Sustainability	8 Ethics	9 Individual & Team Work	10 Communication	11 Project Mgt. & Finance	12 Life Long Learning	13 PSO - 1	14 PSO - 2	15 PSO - 3
CLO-1 :	*Understand various position control schemes and its implementation*	2	80	70	H	M	M	H	M	-	-	-	-	-	-	H	H	-	-
CLO-2 :	*Apply various force control schemes*	2	80	70	H	H	M	H	M	-	-	-	-	-	-	H	H	-	-
CLO-3 :	*Derive the force/position and trajectory control schemes for manipulators*	2	80	70	H	H	M	H	M	-	-	-	H	-	-	H	H	-	-
CLO-4 :	*Learn the complexities of nonlinear systems and various control schemes*	2	80	70	H	H	H	H	M	-	-	-	M	-	-	H	H	-	-
CLO-5 :	*Understand the various programming methods in robotics*	2	80	70	H	H	M	H	M	-	-	-	M	-	-	H	H	-	-
CLO-6 :	*Learn various position control schemes and its implementation*	2	80	70	H	H	M	H	M	-	-	-	M	-	-	H	H	-	-

		Introduction to Position control	Introduction to Force control	Force/Position Control	Introduction to non linear control	Introduction to ROS
Duration (hour)		10	11	12	6	6
S-1	SLO-1	*Review of position control*	*Introduction to force control*	*Introduction to hybrid force position control problem*	*Introduction to nonlinear and time varying systems*	*Robot language classification*
	SLO-2	*Mass- spring damper system*	*Application of force control*	*Example*	*General representation*	*Programming methods: Lead through method, teach pendent method*
S-2	SLO-1	*Various linear control schemes*	*Frame work for force control scheme*	*Hybrid force/position control architecture*	*Control problem for manipulator*	*Syntax features and applications of various programming languages*
	SLO-2	*Characteristics of linear control*	*Define- Artificial and natural constraints*	*Example*	*Practical considerations*	*Examples*
S-3	SLO-1	*Position control of second order system*	*Case study to define artificial and natural constraint*	*Selection matrices*	*Ulyanovsk stability analysis*	*Inter locking commands*
	SLO-2	*PI implementation*	*Case study to define artificial and natural constraint*	*Case study to describe selection matrices*	*Example*	*Safety features*
S-4	SLO-1	*Position control of second order system*	*Description of force control task*	*Case study for hybrid force position control scheme*	*Introduction to nonlinear controllers*	*Introduction to Robot Operating System (ROS)*
	SLO-2	*PD implementation*	*Example- Peg in hole assembly*	*Case study for hybrid force position control scheme*	*Description of fuzzy based control*	*ROS examples*
S-5	SLO-1	*Position control of second order system*	*Force control of mass spring system*	*Trajectory control*	*Case study for fuzzy based control*	*Introduction to programming using ROS Industrial ROS*
	SLO-2	*PID implementation*	*Force control of mass spring system*	*Cartesian and joint space control*	*Use of Lyapunov criteria to understand stability*	*ROS examples*
S-6	SLO-1	*Modelling of 1 DOF manipulator Joint*	*Dynamics based control*	*Cubic polynomial trajectories*	*Introduction to sliding mode control*	*Programming for point to point /continuous Operations*

	SLO-2	*Deriving the mathematical model*	*General dynamics representation*	*Derivation*	*Example*	*Case Study*
S-7	SLO-1	*Partitioned PD (PPD)control scheme*	*Computed torque control*	*Point o point motion without via points*		
	SLO-2	*Architecture and difference from PD control*	*Architecture*	*Derivation*		
S-8	SLO-1	*Application of partitioned PD control scheme to 1 DOF manipulator joint*	*Impedance force/toque control*	*Point to point motion with via points*		
	SLO-2	*Analysis*	*Example*	*Derivation*		
S-9	SLO-1	*Modeling the PPD with external disturbance*	*Force tracking characteristics of impedance control*	*Linear function with parabolic blend*		
	SLO-2	*Architecture with external disturbance*	*Example of manipulator interaction with environment*	*Linear function with parabolic blend - example*		
S-10	SLO-1	*Partitioned PID control scheme*	*Passive compliance*	*Cartesian space techniques*		
	SLO-2	*Architecture*	*Example*	*Description of path - example*		
S-11	SLO-1		*Active compliance*	*Defining straight line path*		
	SLO-2		*Compliance through softening position gain*	*Derivation*		
S-12	SLO-1			*Implementation method*		
	SLO-2			*Implementation example*		

Learning Resources	1. *John J. Craig, "Introduction to Robotics", 3rd edition, Addison Wesley, ISE 2008.* 2. *R.K Mittal and I J Nagrath , "Robotics and control Tata McGraw", 5th edition, Hill, 2003.*	3. *S.K Saha,"Introduction to Robotics" , 2nd edition, Tata McGraw Hill, 2008.* 4. *Mikell P. Groover, "Industrial Robotics", McGraw Hill, 2nd edition, 2012.* 5. *Aaron Martinez,"Learning ROS for robotics programming", 1st edition, PACKT Publishing, 2013.*

Learning Assessment

	Bloom's Level of Thinking	Continuous Learning Assessment (50% weightage)								Final Examination (50% weightage)	
		CLA – 1 (10%)		CLA – 2 (15%)		CLA – 3 (15%)		CLA – 4 (10%)#			
		Theory	Practice	Theory	Practice	Theory	Practice	Theory	Practice	Theory	Practice
Level 1	Remember Understand	40 %	-	30 %	-	30 %	-	30 %	-	30%	-
Level 2	Apply Analyze	40 %	-	40 %	-	40 %	-	40 %	-	40%	-
Level 3	Evaluate Create	20 %	-	30 %	-	30 %	-	30 %	-	30%	-
	Total	100 %		100 %		100 %		100 %		100 %	

CLA – 4 can be from any combination of these: Assignments, Seminars, Tech Talks, Mini-Projects, Case-Studies, Self-Study, MOOCs, Certifications, Conf. Paper etc.,

Course Designers		
Experts from Industry	Experts from Higher Technical Institutions	Internal Experts
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2. Mr. Mohammed Sagheer ,Wabco Technology Center ,India, mohammedsagheer.musthafa@wabco-auto.com	*2. Dr., P Karthikeyan, MIT,Anna University, pkarthikeyan@annauniv.edu*	*2. Ranjith Pillai R, SRMIST*

Course Code	18MHE505T	Course Name	COMPUTER VISION AND ITS APPLICATIONS	Course Category	E	Professional Elective	L	T	P	C
							3	0	0	3

Pre-requisite Courses	Nil	Co-requisite Courses	Nil	Progressive Courses	18MHE506T - Advanced Computer Vision
Course Offering Department	Mechatronics Engineering	Data Book / Codes/Standards	Nil		

Course Learning Rationale (CLR):	*The purpose of learning this course is to:*
CLR-1 :	*Obtain motivation for approaching vision technology from a biological inspiration*
CLR-2 :	*Appreciate the mathematics of projection based system*
CLR-3 :	*Understand the various specifications of vision hardware*
CLR-4 :	*Understand basics of image data and develop some basic image processing algorithms for enhancement and analysis*
CLR-5 :	*Get introduced about computer vision applied for 3-D scene reconstruction.*
CLR-6 :	*Understand the foundations of the vision as a potential technology for automata*

Course Learning Outcomes (CLO):	*At the end of this course, learners will be able to:*	Learning 1 Level of Thinking (Bloom)	Learning 2 Expected Proficiency (%)	Learning 3 Expected Attainment (%)	PLO 1 Engineering Knowledge	PLO 2 Problem Analysis	PLO 3 Design & Development	PLO 4 Analysis, Design, Research	PLO 5 Modern Tool Usage	PLO 6 Society & Culture	PLO 7 Environment & Sustainability	PLO 8 Ethics	PLO 9 Individual & Team Work	PLO 10 Communication	PLO 11 Project Mgt. & Finance	PLO 12 Life Long Learning	PLO 13 PSO - 1	PLO 14 PSO - 2	PLO 15 PSO - 3
CLO-1 :	*Formulate the mathematical expressions of geometric camera modelling and calibration*	3	80	75	H	H	M	L	L	-	-	-	L	L	-	L	H	M	-
CLO-2 :	*Interpret the specifications of vision hardware*	3	85	80	H	H	M	M	L	-	-	-	M	L	-	L	H	M	-
CLO-3 :	*Develop of basic image processing algorithms*	2	70	65	H	M	L	M	L	-	-	-	M	L	-	L	H	M	-
CLO-4 :	*Apply some algorithms for feature extraction*	2	75	70	H	M	M	M	M	-	-	-	M	L	-	L	H	M	-
CLO-5 :	*Understand the foundations of stereo vision technique*	2	85	80	H	M	M	M	M	-	-	-	M	L	-	L	H	M	-
CLO-6 :	*Handle applications involving image data for automata*	2	80	75	H	M-	M	M	M	-	-	-	L	L	-	L	H	M	-

		Introduction	Vision Hardware	Image Processing	Image Analysis	3-D Vision
Duration (hour)		8	9	10	9	9
S-1	SLO-1	*Introduction to Vision*	*Scene constraints*	*Vision software basics*	*Feature extraction*	*Introduction to the multi-view geometry*
	SLO-2	*Terminologies of fields*	*Fundamentals of lighting*	*Types and selection*	*Region features and classification - types*	*Scene reconstruction and motion estimation problem*
S-2	SLO-1	*Comparison of biological and computer vision*	*Light sources*	*Basics of digital image*	*Key point features*	*Geometry of a stereo vision system*
	SLO-2	*Specifications and limitations*	*Types, selection criteria*	*Sampling, quantization effects*	*Applications*	*Correspondence problem*
S-3	SLO-1	*Projective geometry*	*Lighting techniques*	*Point operations*	*Corner detection*	*Epipolar geometry*
	SLO-2	*Basics*	*Types and selection criteria*	*2-D convolution*	*Harris corner detection*	*Estimation of fundamental and essential matrix*
S-4	SLO-1	*Modelling of geometric image formation*	*Lenses, specifications*	*Image smoothing in spatial domain*	*Critical analysis of Harris corner detection*	*Epipolar constraint*
	SLO-2	*Derivation*	*Optical filters, specifications*	*Image sharpening and edge detection in spatial domain*	*Limitations and motivation for going beyond corner detection*	*Applications of epipolar constraint*
S-5	SLO-1	*Modelling of camera distortion and artifacts*	*Image sensors*	*Discrete Fourier Transform (DFT)*	*Key point descriptors*	*Application of epipolar constraint in image stitching*
	SLO-2	*Derivation*	*Specifications*	*Frequency domain filtering basics*	*Motivation and applications*	*Implementation details*
S-6	SLO-1	*Camera calibration*	*CCD sensor specifications*	*Smoothing sharpening in frequency domain*	*Scale Invariant Feature Transform (SIFT) key point descriptor*	*Epipolar rectification*

	SLO-2	*Methods of camera calibration*	*CMOS sensor specifications*	*Smoothing sharpening in frequency domain*	*Scale space construction and difference of Gaussian*	*Metric reconstruction*
S-7	SLO-1	*Estimation of projection matrix*	*Comparison of CCD and CMOS*	*Morphological image processing*	*Filtering of low contrast features*	*Non-metrical reconstruction types*
	SLO-2	*Derivation*	*Advanced sensor technologies*	*Erosion, dilation, opening and closing*	*SIFT descriptor*	*Multi-view stereo vision*
S-8	SLO-1	*Experimental performance assessment in computer vision*	*Camera computer interfaces*	*Color image processing motivation*	*Matching algorithms*	*Issues and challenges*
	SLO-2	*Metrics and example usage*	*Types and selection*	*HSI space color image processing*	*Gray-level and correlation based matching*	*Applications of stereo vision*
S-9	SLO-1		*Application case studies*	*Application case studies*	*Descriptor based matching*	*Visual odometry case study*
	SLO-2		*Hardware selection exercise*	*Image smoothing and sharpening*	*Implementation details*	*Application in driverless cars*
S-10	SLO-1			*Application case studies*		
	SLO-2			*Morphology and colour processing*		

Learning Resources	1. *Rafael C. Gonzales, Richard.E.Woods, "Digital Image Processing, 4th Edition, Pearson Education", 2018.* 2. *Emanuele Trucco, Alessandro Verri, "Introductory Techniques For 3D Computer Vision", 1st Edition, Prentice Hall, 1998.* 3. *Alexander Hornberg, "Handbook of Machine Vision", 2nd Edition, Wiley, 2006.* 4. *WileyForsyth and Ponce, Computer Vision: A Modern Approach, 2nd Edition, Pearson, 2015.*

Learning Assessment											
	Bloom's Level of Thinking	Continuous Learning Assessment (50% weightage)								Final Examination (50% weightage)	
		CLA – 1 (10%)		CLA – 2 (15%)		CLA – 3 (15%)		CLA – 4 (10%)#			
		Theory	Practice	Theory	Practice	Theory	Practice	Theory	Practice	Theory	Practice
Level 1	Remember Understand	30 %	-	30 %	-	30 %	-	20 %	-	40%	-
Level 2	Apply Analyze	40 %	-	40 %	-	40 %	-	40 %	-	30%	-
Level 3	Evaluate Create	30 %	-	30 %	-	30 %	-	40 %	-	30%	-
	Total	100 %		100 %		100 %		100 %		100 %	

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Course Code	18MHE506T	Course Name	ADVANCED COMPUTER VISION	Course Category	E	Professional Elective	L	T	P	C
							3	0	0	3

Pre-requisite Courses	18MHE505T - Computer Vision and Its Applications	Co-requisite Courses	Nil	Progressive Courses	18MHE507T - Vision Guided Robotics
Course Offering Department	Mechatronics Engineering	Data Book / Codes/Standards	Nil		

Course Learning Rationale (CLR):	*The purpose of learning this course is to:*
CLR-1 :	*To understand the various active methods of reconstruction techniques*
CLR-2 :	*To comprehend various segmentation techniques used in computer vision tasks*
CLR-3 :	*The understand various recognition*
CLR-4 :	*To get introduced to classical neural networks and machine learning basics*
CLR-5 :	*To understand deep learning techniques for computer vision tasks*
CLR-6 :	*Application specific deep learning networks*

		Learning			Program Learning Outcomes (PLO)														
		1	2	3	1	2	3	4	5	6	7	8	9	10	11	12	13	14	15
Course Learning Outcomes (CLO):	*At the end of this course, learners will be able to:*	Level of Thinking (Bloom)	Expected Proficiency (%)	Expected Attainment (%)	Engineering Knowledge	Problem Analysis	Design & Development	Analysis, Design, Research	Modern Tool Usage	Society & Culture	Environment & Sustainability	Ethics	Individual & Team Work	Communication	Project Mgt. & Finance	Life Long Learning	PSO - 1	PSO - 2	PSO - 3
CLO-1 :	*To be able to appreciate the mathematics of basic computer vision principles*	*3*	*80*	*75*	*H*	*H*	*M*	*L*	*L*	-	-	-	*L*	*L*	-	*L*	*H*	*M*	-
CLO-2 :	*To be able to understand the active computer vision techniques and shape from focus*	*3*	*85*	*80*	*H*	*H*	*M*	*M*	*L*	-	-	-	*M*	*L*	-	*L*	*H*	*M*	-
CLO-3 :	*To be able to comprehend clustering and segmentation methods*	*2*	*70*	*65*	*H*	*M*	*L*	*M*	*L*	-	-	-	*M*	*L*	-	*L*	*H*	*M*	-
CLO-4 :	*To be able to understand recognition principles and basic mathematics of the same*	*2*	*75*	*70*	*H*	*M*	*M*	*M*	*M*	-	-	-	*M*	*L*	-	*L*	*H*	*M*	-
CLO-5 :	*To appreciate neural networks and deep neural networks based learning for computer vision tasks*	*2*	*85*	*80*	*H*	*M*	*M*	*M*	*M*	-	-	-	*M*	*L*	-	*L*	*H*	*M*	-
CLO-6 :	*To implement deep learning for common computer vision tasks*	*2*	*80*	*75*	*H*	*M*	*M*	*M*	*M*	-	-	-	*L*	*L*	-	*L*	*H*	*M*	-

		Shape From Focus and Active Methods	Segmentation	Recognition	Deep Learning	Augmented Reality and Mixed Reality
Duration (hour)		8	10	7	10	10
S-1	SLO-1	*Modelling image focus*	*Introduction to segmentation*	*Introduction to recognition*	*Convolutional neural networks*	*The Reality–Virtuality continuum*
	SLO-2	*Modelling image focus*	*Types*	*Challenges and approaches*	*Convolution, pooling*	*The Reality–Virtuality continuum*
S-2	SLO-1	*Shape from focus*	*Introduction to clustering*	*K-nearest neighbor algorithm*	*Activation functions, initialization*	*Virtual, augmented and mixed reality, an historical perspective*
	SLO-2	*Principle and hardware required*	*Methods relevant to computer vision*	*Principle and underlying mathematics*	*Dropout, batch normalization*	*Industrial applicability of virtual, augmented and mixed reality*
S-3	SLO-1	*Focus measures*	*Agglomerative clustering*	*Numerical problem solving for a sample recognition using K-nearest*	*Deep learning hardware*	*Design and implementation of an immersive user experience*
	SLO-2	*Scene reconstruction*	*Principle and underlying mathematics*	*Numerical problem solving for a sample recognition using K-nearest*	*CPU, GPU, TPU*	*Design and implementation of an immersive user experience*
S-4	SLO-1	*Active methods*	*Numerical problem on agglomerative clustering*	*Principal Component Analysis (PCA)*	*Tuning neural networks*	*The VR-AR-MR system architecture*
	SLO-2	*Comparison with passive techniques*	*Numerical problem on agglomerative clustering*	*Principle and underlying mathematics*	*Best practices*	*The VR-AR-MR system architecture*
S-5	SLO-1	*Laser triangulation*	*K-means clustering*	*Numerical problem solving for a sample recognition using PCA*	*Training neural networks*	*Tracking system*
	SLO-2	*Principle, working and specifications*	*Principle and underlying mathematics*	*Numerical problem solving for a sample recognition using PCA*	*Update rules, ensembles*	*Tracking system*
S-6	SLO-1	*Structured light reconstruction*	*Numerical problem on agglomerative clustering*	*Linear Discriminant Analysis (LDA)*	*Data augmentation*	*Visual, aural, and haptic display*

	SLO-2	*Principle, working and specifications*	*Numerical problem on agglomerative clustering*	*Principle and underlying mathematics*	*Transfer learning*	*Design principles*
S-7	SLO-1	*LIDAR*	*Mean-shift clustering*	*Numerical problem solving for a sample recognition using LDA*	*Popular CNN architectures For image classification*	*Usability guidelines*
	SLO-2	*Principle, working and specifications*	*Principle and underlying mathematics*	*Numerical problem solving for a sample recognition using LDA*	*Challenges addressed and novelty*	*Usability guidelines*
S-8	SLO-1	*Application case studies of active methods*	*Numerical problem on agglomerative clustering*		*Popular CNN architectures for object detection*	*Common Interaction Techniques for Mixed Reality*
	SLO-2	*Application case studies of active methods*	*Numerical problem on agglomerative clustering*		*Challenges addressed and novelty*	*Common Navigation Techniques*
S-9	SLO-1		*Introduction to classification*		*Applications of deep learning - semantic segmentation*	*Interaction design process*
	SLO-2		*Types, applications*		*Applications of deep learning or instance segmentation*	*Interaction design process*
S-10	SLO-1		*Linear classifiers*		*Applications of deep learning - activity understanding*	*Future of computer computer vision*
	SLO-2		*Implementation details*		*Types*	*Open problems*

Learning Resources	1. *WileyForsyth and Ponce, Computer Vision: A Modern Approach, 2nd Edition, Pearson, 2015.* 2. *Ian Goodfellow and Yoshua Bengio and Aaron Courville, Deep Learning, 1st Edition, MIT Press, 2016.* 3. *Rafael C. Gonzales, Richard.E.Woods, "Digital Image Processing, 4th Edition, Pearson Education", 2018.* 4. *Emanuele Trucco, Alessandro Verri, "Introductory Techniques For 3D Computer Vision", 1st Edition, Prentice Hall, 1998.* 5. *Kharis O'Connell, "Designing Mixed Reality", 1st Edition, O' Reilly, 2016.*

Learning Assessment

	Bloom's Level of Thinking	Continuous Learning Assessment (50% weightage)								Final Examination (50% weightage)	
		CLA – 1 (10%)		CLA – 2 (15%)		CLA – 3 (15%)		CLA – 4 (10%)#			
		Theory	Practice	Theory	Practice	Theory	Practice	Theory	Practice	Theory	Practice
Level 1	Remember Understand	30 %	-	30 %	-	30 %	-	20 %	-	40%	-
Level 2	Apply Analyze	40 %	-	40 %	-	40 %	-	40 %	-	30%	-
Level 3	Evaluate Create	30 %	-	30 %	-	30 %	-	40 %	-	30%	-
	Total	100 %		100 %		100 %		100 %		100 %	

CLA – 4 can be from any combination of these: Assignments, Seminars, Tech Talks, Mini-Projects, Case-Studies, Self-Study, MOOCs, Certifications, Conf. Paper etc.,

Course Designers

Experts from Industry	Experts from Higher Technical Institutions	Internal Experts
1. Mr. N. Ganesh Ram, Intel Labs, ganeshram.nandakumar@intel.com	*1. Dr. R. Thiyagarajan, IIT Madras, thiyaguiitm@gmail.com*	*1. Dr. R. Senthilnathan, SRMIST*
2. Mr. Mohammed Sagheer , Wabco Technology Center, mohammedsagheer.musthafa@wabco-auto.com	*2. Dr. P. Karthikeyan, MIT Campus, Anna University, pkarthikeyan@annauniv.edu*	*2. Mr. K. Sivanathan, SRMIST*

Course Code	18MHE507T	Course Name	VISION GUIDED ROBOTICS	Course Category	E	Professional Elective	L	T	P	C
							3	0	0	3

Pre-requisite Courses	18MHE505T - Computer Vision and Its Applications	Co-requisite Courses	Nil	Progressive Courses	Nil
Course Offering Department	Mechatronics Engineering	Data Book / Codes/Standards	Nil		

Course Learning Rationale (CLR):	*The purpose of learning this course is to:*
CLR-1 :	*To understand how computer vision aids in manipulator's guidance*
CLR-2 :	*To understand how computer vision aids in mobile robot's guidance*
CLR-3 :	*To get awareness about visual servoing techniques*
CLR-4 :	*To get awareness about visual slam and visual odometry*
CLR-5 :	*To gain knowledge about optical flow methods and their applications*
CLR-6 :	*To get to knwo about the advanced approaches in visual servoing*

Course Learning Outcomes (CLO):	*At the end of this course, learners will be able to:*	Learning 1: Level of Thinking (Bloom)	Learning 2: Expected Proficiency (%)	Learning 3: Expected Attainment (%)
CLO-1 :	*To be able to appreciate the various roles of computer vision in manipulator and mobile robotics*	*3*	*80*	*75*
CLO-2 :	*To be able to comprehend the basics mathematics of visual servoing architectures*	*3*	*85*	*80*
CLO-3 :	*To be able to appreciate the applications of computer vision for mobile robotics*	*2*	*70*	*65*
CLO-4 :	*To be able to implement optical flow methods to understand motion related features from images*	*2*	*75*	*70*
CLO-5 :	*To have the competency in developing tracking algorithms based on vision data*	*2*	*85*	*80*
CLO-6 :	*To be conversant in the futuristic approaches in visual servoing*	*2*	*80*	*75*

Program Learning Outcomes (PLO)

	1 Engineering Knowledge	2 Problem Analysis	3 Design & Development	4 Analysis, Design, Research	5 Modern Tool Usage	6 Society & Culture	7 Environment & Sustainability	8 Ethics	9 Individual & Team Work	10 Communication	11 Project Mgt. & Finance	12 Life Long Learning	13 PSO - 1	14 PSO - 2	15 PSO - 3
CLO-1	H	H	M	L	L	-	-	-	L	L	-	L	H	M	-
CLO-2	H	H	M	M	L	-	-	-	M	L	-	L	H	M	-
CLO-3	H	M	L	M	L	-	-	-	M	L	-	L	H	M	-
CLO-4	H	M	M	M	M	-	-	-	M	L	-	L	H	M	-
CLO-5	H	M	M	M	M	-	-	-	M	L	-	L	H	M	-
CLO-6	H	M-	M	M	M	-	-	-	L	L	-	L	H	M	-

		Introduction	Visual Servoing	Vision for Mobile Robots	Optical Flow and Tracking	Advanced Topics
Duration (hour)		8	10	10	10	7
S-1	SLO-1	*Introduction to vision for Robotics*	*Mathematical formulation of visual servo problem*	*Introduction to simultaneous localization and mapping*	*Formulation of the motion analysis*	*Hybrid visual servoing, partitioned visual servoing*
	SLO-2	*Significance of vision as a external state sensing technology*	*Derivation*	*Visual SLAM (VSLAM)*	*Formulation of the motion analysis*	*Switching schemes in visual servoing*
S-2	SLO-1	*Vision for manipulators*	*Classification of visual servoing architectures*	*VSLAM Basics*	*Motion field of rigid objects*	*Joint space control of eye-in-hand*
	SLO-2	*Vision for mobile robots*	*Classification of visual servoing architectures*	*VSLAM Basics*	*Aperture problem*	*Joint space control of eye-in-hand*
S-3	SLO-1	*Modelling velocity of a rigid object*	*Image based visual servoing (IBVS)*	*VSLAM approaches*	*Optical flow*	*Joint space control of eye-to-hand systems*
	SLO-2	*Derivation*	*Interaction matrix derivation*	*VSLAM approaches*	*Motion field*	*Joint space control of eye-to-hand systems*
S-4	SLO-1	*Camera configurations in vision guided robots*	*Geometrical interpretation of IBVS*	*Introduction to visual odometry (VO)*	*Brightness constancy equation*	*Motion based segmentation*
	SLO-2	*Camera configurations in vision guided robots*	*Derivation*	*Introduction to visual odometry (VO)*	*Validity*	*Motion based segmentation*
S-5	SLO-1	*Triangulation*	*Stability analysis*	*VO - motion from image feature correspondences*	*Estimating motion field - differential techniques*	*Structure from motion (SFM)*
	SLO-2	*Derivation*	*Stability analysis*	*VO - motion from image feature correspondences*	*Estimating motion field - differential techniques*	*Multi-view SFM*

S-6	SLO-1	*Basic equation of triangulation*	*IBVS with stereo vision system – a case study*	*VO – motion from 3-D structure*	*Estimating motion field - feature based techniques*	*Retrieving 3-D structure*
	SLO-2	*Derivation*	*IBVS with stereo vision system – a case study*	*VO – motion from 3-D structure*	*Estimating motion field - feature based techniques*	*Retrieving 3-D structure*
S-7	SLO-1	*Vision based pose estimation*	*IBVS with other geometrical features*	*Comparison between VSLAM techniques*	*Target tracking*	*Motion from motion field*
	SLO-2	*Detailed description of any one approach*	*Direct estimation*	*VO calibration techniques*	*Challenges and solutions*	*Motion from motion field*
S-8	SLO-1		*Position based visual servoing*	*Application case study on VSLAM*	*Kalman filtering basics*	
	SLO-2		*Point feature based motion*	*Application case study on VSLAM*	*Kalman filtering basics*	
S-9	SLO-1		*Pose based motion*	*Application case study on VSLAM*	*Kalman tracking*	
	SLO-2		*Pose based motion*	*Application case study on VSLAM*	*Kalman tracking*	
S-10	SLO-1		*Calibration for visual servoing systems*	*Application case study on VO*	*Application case study on visual tracking*	
	SLO-2		*Calibration for visual servoing systems*	*Application case study on VO*	*Application case study on visual tracking*	

Learning Resources	1. *WileyForsyth and Ponce, Computer Vision: A Modern Approach, 2nd Edition, Pearson, 2015.* 2. *Bruno Siciliano, Oussama Khatib, Springer Handbook of Robotics, 2nd Edition, Springer, 2016.* 3. *D. Scaramuzza and F. Fraundorfer, "Visual Odometry [Tutorial]," in IEEE Robotics & Automation Magazine, vol. 18, no. 4, pp. 80-92, Dec. 2011.* 4. *F. Fraundorfer and D. Scaramuzza, "Visual Odometry : Part II: Matching, Robustness, Optimization, and Applications," in IEEE Robotics & Automation Magazine, vol. 19, no. 2, pp. 78-90, June 2012.*

Learning Assessment

	Bloom's Level of Thinking	Continuous Learning Assessment (50% weightage)								Final Examination (50% weightage)	
		CLA – 1 (10%)		CLA – 2 (15%)		CLA – 3 (15%)		CLA – 4 (10%)#			
		Theory	Practice	Theory	Practice	Theory	Practice	Theory	Practice	Theory	Practice
Level 1	Remember Understand	30 %	-	30 %	-	30 %	-	20 %	-	40%	-
Level 2	Apply Analyze	40 %	-	40 %	-	40 %	-	40 %	-	30%	-
Level 3	Evaluate Create	30 %	-	30 %	-	30 %	-	40 %	-	30%	-
	Total	100 %		100 %		100 %		100 %		100 %	

CLA – 4 can be from any combination of these: Assignments, Seminars, Tech Talks, Mini-Projects, Case-Studies, Self-Study, MOOCs, Certifications, Conf. Paper etc.,

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2. Mr. Mohammed Sagheer , Wabco Technology Center, mohammedsagheer.musthafa@wabco-auto.com	*2. Dr. P. Karthikeyan, MIT Campus, Anna University, pkarthikeyan@annauniv.edu*	*2. Mr. K. Sivanathan, SRMIST*

Course Code	18MHE508T	Course Name	ADVANCED ROBOTICS	Course Category	E	Professional Elective	L	T	P	C
							3	0	0	3

Pre-requisite Courses	15MHE501T - Robotics	Co-requisite Courses	Nil	Progressive Courses	Nil
Course Offering Department	Mechatronics Engineering	Data Book / Codes/Standards	Nil		

Course Learning Rationale (CLR):	*The purpose of learning this course is to:*
CLR-1 :	*Learn the concepts of singularity, statics and to compute dynamics of complex configuration*
CLR-2 :	*Understand the concepts and challenges involved in multirobot systems*
CLR-3 :	*Understand modeling of flexible robots*
CLR-4 :	*Learn the complexities of wheeled mobile robot in uneven terrain*
CLR-5 :	*Introduce the advanced concepts of robotics like coorperative robot, haptics and telerobotic systems*
CLR-6 :	*get an understanding about the current state of the art research topics in robotics*

Course Learning Outcomes (CLO):	*At the end of this course, learners will be able to:*	Learning 1 Level of Thinking (Bloom)	2 Expected Proficiency (%)	3 Expected Attainment (%)	PLO 1 Engineering Knowledge	2 Problem Analysis	3 Design & Development	4 Analysis, Design, Research	5 Modern Tool Usage	6 Society & Culture	7 Environment & Sustainability	8 Ethics	9 Individual & Team Work	10 Communication	11 Project Mgt. & Finance	12 Life Long Learning	13 PSO - 1	14 PSO - 2	15 PSO - 3
CLO-1 :	*Understand the approaches to solve for singularity and dynamics of manipulator*	2	80	70	H	M	M	H	M	-	-	-	-	-	-	H	H	-	-
CLO-2 :	*Learn the concept of multirobot systems and its research challenges*	2	80	70	H	H	M	H	M	-	-	-	-	-	-	H	H	-	-
CLO-3 :	*Understand the modeling and control of flexible robots*	2	80	70	H	H	M	H	M	-	-	-	H	-	-	H	H	-	-
CLO-4 :	*Understand mathematical concepts of defining the wheeled mobile robot in uneven terrain*	2	80	70	H	H	H	H	M	-	-	-	M	-	-	H	H	-	-
CLO-5 :	*Learn the importance and complexities of coorperative robot, haptics and telerobotic systems*	2	80	70	H	H	M	H	M	-	-	-	M	-	-	H	H	-	-
CLO-6 :	*Ability to address current advanced topics of research in the field of robotics*	2	80	70	H	H	M	H	M	-	-	-	M	-	-	H	H	-	-

		Manipulator Robots	Multi Robot Systems	Modelling and control of flexible robots	Wheeled Mobile Robot	Advanced Topics
Duration (hour)		8	7	10	8	12
S-1	SLO-1	*Jacobian for serial manipulator*	*Architecture of multirobot systems*	*Introduction to flexible robots*	*Introduction to wheeled mobile robot (WMR)*	*Introduction to cooperative manipulators*
	SLO-2	*Numerical*	*History and application*	*Application*	*Two and three wheeled WMR on flat surfaces*	*Historical overview*
S-2	SLO-1	*Jacobian for parallel Manipulators*	*Communication*	*Models of flexible Links*	*Concepts of slip*	*Introduction to kinematics and statics*
	SLO-2	*Numerical*	*Example*	*Numerical*	*Slip Modelling*	*Example*
S-3	SLO-1	*Singularity analysis*	*Introduction to swarm robots*	*Models of flexible Joints*	*World and terrain models for natural environment*	*Dynamics and load distribution*
	SLO-2	*Loss and gain of degree of freedom*	*Example*	*Numerical*	*Model*	*Example*
S-4	SLO-1	*Statics and force transformation matrix for Stewart Gough platform*	*Heterogeneity*	*Kinematic Modelling of multilink flexible robots*	*Dynamic environments*	*Control of cooperative manipulator*
	SLO-2	*Derivation*	*Heterogeneity*	*Numerical*	*Example*	*Example*
S-5	SLO-1	*Singularity analysis of Stewart Gough platform*	*Task allocation and learning*	*Kinematic modelling of multilink flexible robots*	*WMR on uneven terrain*	*Overview of haptics*
	SLO-2	*Numerical Analysis*	*Case study*	*Numerical*	*Example*	*Importance*
S-6	SLO-1	*Introduction to recursive dynamics*	*Control challenges*	*Introduction to dynamics of flexible link manipulator*	*Design of slip free motion on uneven terrain*	*Haptic device design*
	SLO-2	*Numerical procedure*	*Communication for control of networked robots*	*Notations and terms*	*Design*	*Example*
S-7	SLO-1	*Dynamics of Stewart Gough platform*	*Communication for perception*	*Dynamic computation*	*Dynamics and static stability of three wheeled WMR on uneven terrain*	*Haptic rendering*

	SLO-2	*Numerical*	*Control for perception*	*Numerical*	*Numerical analysis*	
S-8	SLO-1	*Simulation and experimental case study on control of parallel manipulator*		*Control of flexible link manipulator*	*Case study of wheeled mobile robot on uneven terrain*	*Control and stability of haptic interfaces*
	SLO-2	*Case Study*		*Control equation*	*Case Study*	*Example*
S-9	SLO-1			*Numerical simulation for planar 2 link flexible manipulator*		*Introduction to tele robotic systems*
	SLO-2			*Simulation*		*Application*
S-10	SLO-1			*Simulation for planar 2 link flexible manipulator*		*Control architecture*
	SLO-2			*Simulation*		*Example*
S-11	SLO-1					*Bilateral control and force feedback*
	SLO-2					*Example*
S-12	SLO-1					*Communication and networking*
	SLO-2					*Example*

Learning Resources	1. *John J. Craig, "Introduction to Robotics Mechanics and Control", 3rd edition, Pearson, 2008.* 2. *Mark W. Spong and M. Vidyasagar, "Robot Dynamics and Control", 2nd edition, Wiley India, 2008.* 3. *J.P. Merlet, "Parallel Robots", 2nd edition, Springer, 2006.* 4. *Siciliano, B., and Khatib, O. (Editors), Handbook ofRobotics, 2nd edition, Springer, 2016.*	5. *Robert J. Schilling, "Fundamentals of Robotics Analysis and Control", 5th edition, Prentice Hall of India, 2009.* 6. *Mittal R.K., and Nagrath I.J., "Robotics and Control", 1st edition, Tata McGraw Hill, 2007.* 7. *Fu K., Gonzalez R., and Lee C. S. G., "Robotics: Control, Sensing, Vision and Intelligence", 1st edition, McGraw Hill, 2008.* 8. *Tsuneo Yohikwa, "Foundations of Robotics Analysis and Control", 2nd edition, MIT Press, 2003.*

Learning Assessment

	Bloom's Level of Thinking	Continuous Learning Assessment (50% weightage)								Final Examination (50% weightage)	
		CLA – 1 (10%)		CLA – 2 (15%)		CLA – 3 (15%)		CLA – 4 (10%)#			
		Theory	Practice	Theory	Practice	Theory	Practice	Theory	Practice	Theory	Practice
Level 1	Remember Understand	40 %	-	30 %	-	30 %	-	30 %	-	30%	-
Level 2	Apply Analyze	40 %	-	40 %	-	40 %	-	40 %	-	40%	-
Level 3	Evaluate Create	20 %	-	30 %	-	30 %	-	30 %	-	30%	-
	Total	100 %		100 %		100 %		100 %		100 %	

CLA – 4 can be from any combination of these: Assignments, Seminars, Tech Talks, Mini-Projects, Case-Studies, Self-Study, MOOCs, Certifications, Conf. Paper etc.,

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2. Mr. Mohammed Sagheer,Wabco Technology Center ,India, mohammedsagheer.musthafa@wabco-auto.com	*2. Dr., P Karthikeyan, MIT,Anna University, pkarthikeyan@annauniv.edu*	*2. Dr.R. Senthilnathan, SRMIST*

Course Code	18MHE509T	Course Name	APPLIED ROBOTICS	Course Category	E	Professional Elective	L	T	P	C
							3	0	0	3

Pre-requisite Courses	Nil	Co-requisite Courses	Nil	Progressive Courses	Nil
Course Offering Department	Mechatronics Engineering	Data Book / Codes/Standards	Nil		

Course Learning Rationale (CLR):	*The purpose of learning this course is to:*
CLR-1 :	*Understand the various types of industrial, field and service robots and their characteristics and capabilities*
CLR-2 :	*Equip with the knowledge of mathematical modeling of specialized robots*
CLR-3 :	*Familiarize with the operation of robots and processes involved*
CLR-4 :	*Select the right robot with required configurations and specifications for given applications*
CLR-5 :	*Familiarize with the applications of various field and service robots*

Course Learning Outcomes (CLO):	*At the end of this course, learners will be able to:*	Learning 1: Level of Thinking (Bloom)	Learning 2: Expected Proficiency (%)	Learning 3: Expected Attainment (%)	PLO 1: Engineering Knowledge	PLO 2: Problem Analysis	PLO 3: Design & Development	PLO 4: Analysis, Design, Research	PLO 5: Modern Tool Usage	PLO 6: Society & Culture	PLO 7: Environment & Sustainability	PLO 8: Ethics	PLO 9: Individual & Team Work	PLO 10: Communication	PLO 11: Project Mgt. & Finance	PLO 12: Life Long Learning	PLO 13: PSO - 1	PLO 14: PSO - 2	PLO 15: PSO - 3
CLO-1 :	*Recognize the various types of industrial, field and service robots and their characteristics and capabilities*	2	75	70	H	H	L	H	L	-	-	-	-	-	-	H	H	H	H
CLO-2 :	*Develop mathematical modeling of specialized robots*	3	75	70	H	H	M	H	H	-	-	-	-	-	-	H	M	M	M
CLO-3 :	*Familiarize with the operation of robots and processes involved*	3	75	70	H	H	M	H	M	-	-	-	-	-	-	H	M	M	M
CLO-4 :	*Decide the right robot with required configurations and specifications for given applications*	3	75	70	H	H	M	H	M	-	-	-	-	-	-	H	M	M	M
CLO-5 :	*Utilize the field and service robots for various applications*	3	75	70	H	H	M	H	M	-	-	-	-	-	-	H	M	M	M

		Applications of Robots in Industries	Underwater and Aerial Robots	Field robots	Robots in Surgery and Rehabilitation	Entertainment and Personal Robots
Duration (hour)		9	10	9	9	8
S-1	SLO-1	*Introduction to Robotics- Overview of syllabus*	*Autonomous Underwater vehicles (AUV)*	*Forestry- Robot locomotion*	*Medical robotics- Introduction*	*Cleaning robots*
	SLO-2	*A short history of Industrial robots*	*Autonomous Surface Vehicles (ASV)*	*Forestry automation*	*core concepts- technology*	*Cleaning robots*
S-2	SLO-1	*Typical applications & robot configurations*	*Modeling of AUV*	*SLAM in forestry*	*Medical robotic systems*	*Lawn moving robots*
	SLO-2	*Typical applications & robot configurations*	*Modeling of AUV*	*Autonomous robots for silviculture and treatment*	*Medical robotic systems*	*Lawn moving robots*
S-3	SLO-1	*Robots in welding*	*Modeling of ASV*	*Broad acre Applications*	*Medical robotic systems-research areas and applications*	*Smart appliances and smart homes*
	SLO-2	*Robots in welding*	*Modeling of ASV*	*Automatic guidance- sowing weeding- spraying*	*Medical robotic systems-research areas and applications*	*Smart appliances and smart homes*
S-4	SLO-1	*Car body assembly & Painting*	*Sensor systems and actuation systems*	*Automatic guidance- sowing weeding- spraying*	*Rehabilitation and health care robotics- overview-*	*The role of robots in education*
	SLO-2	*Car body assembly & Painting*	*Motion control system -guidance and control*	*Broad-acre harvesting*	*Rehabilitation and health care robotics- overview-*	*Educational robotic platforms*
S-5	SLO-1	*Material transfer and automation*	*Challenges in Localization of AUV & ASV*	*Horticulture: picking of fruits*	*Physical therapy and training robots*	*Robots and informal learning venues*
	SLO-2	*Machining*	*Remotely operated vehicles (ROVs)*	*Horticulture: picking of fruits*	*Physical therapy and training robots*	*Robots and informal learning venues*
S-6	SLO-1	*Kinematics and mechanisms review*	*Remotely operated vehicles, types and applications*	*Robot milking-sheep shearing*	*Aids for people with disabilities*	*Social robots that interact with people*
	SLO-2	*Kinematics and mechanisms review*	*Gliders*	*slaughtering-livestock inspection*	*Aids for people with disabilities*	*Social robot embodiment*

S-7	SLO-1	Tasks descriptions- teaching and programming	History of Unmanned aerial vehicles (UAV)	Robots in construction	Smart prostheses and orthoses	Multimodal Communication
	SLO-2	Tasks descriptions- teaching and programming	Different configurations of fixed and rotary wing aerial vehicles	Unsolved problems in construction- future directions	Smart prostheses and orthoses	Expressive emotion-based interaction
S-8	SLO-1	End-effectors	Kinematics and dynamics of quadcopter	Robots for hazardous applications-enabling technologies	Diagnosis and monitoring	Socio-cognitive skills
	SLO-2	End-effectors and System integration	Modeling of Quad rotor aerial vehicle	Search and rescue robots	Diagnosis and monitoring	Promising robots- open issues
S-9	SLO-1	Challenges in system integration	Overall Control system for UAVs	Disaster characteristics and impact on robots	Open challenges in using robots in medical applications	
	SLO-2	Approaches to system integration	Guidance and Navigation of UAV	Robots actually used at disaster	Future directions	
S-10	SLO-1		Applications of UAVs			
	SLO-2		Applications of UAVs			

Learning Resources	1. Bruno Siciliano, Oussama Khatib, "Handbook of Robotics", 2nd Edition, Springer, 2016. 2. Yangsheng Xu Huihuan Qian Xinyu Wu, "Household and service robots", 1st edition, Elsevier Ltd, 2015 3. Aleksandar Lazinica, "Mobile Robots Towards new applications", 1st edition, Advanced Robotic Systems International, 2006 4. Gregory Dudek, Michael Jenkin, "Computational Principles of Mobile Robotics", 2nd Edition, Oxford University Press, 2010 5. L Marques,A de Almeida,M o Tokhi,G SVirk,"Advances in Mobile Robotics", 1st edition, World Scientific Publishing Co. Pte. Ltd. 2008

Learning Assessment

	Bloom's Level of Thinking	Continuous Learning Assessment (50% weightage)								Final Examination (50% weightage)	
		CLA – 1 (10%)		CLA – 2 (15%)		CLA – 3 (15%)		CLA – 4 (10%)#			
		Theory	Practice	Theory	Practice	Theory	Practice	Theory	Practice	Theory	Practice
Level 1	Remember Understand	30 %	-	30 %	-	30 %	-	30 %	-	30%	-
Level 2	Apply Analyze	40 %	-	40 %	-	40 %	-	40 %	-	40%	-
Level 3	Evaluate Create	30 %	-	30 %	-	30 %	-	30 %	-	30%	-
	Total	100 %		100 %		100 %		100 %		100 %	

CLA – 4 can be from any combination of these: Assignments, Seminars, Tech Talks, Mini-Projects, Case-Studies, Self-Study, MOOCs, Certifications, Conf. Paper etc.,

Course Designers

Experts from Industry	Experts from Higher Technical Institutions	Internal Experts
1. Dr. Guna Surendra, Gossamsetti, Hitachi, Japan. surendra.gossamsetti.bu@hitachi.com	1. Dr. R. Thiyagarajan, IIT Madras, thiyaguiitm@gmail.com	1. Mr. K. Sivanathan, SRMIST
2. Mr. Visweswaran Jagadeesan , National Instruments. visweswaran.jagadeesan@ni.com	2. Dr. P. Karthikeyan, MIT Campus, Anna University, pkarthikeyan@annauniv.edu	2. Mr. Ranjit Pillai, SRMIST

Course Code	18MHE510T	Course Name	PLANNING AND DECISION MAKING IN ROBOTICS	Course Category	E	Professional Elective	L	T	P	C
							3	0	0	3

Pre-requisite Courses	Nil	Co-requisite Courses	Nil	Progressive Courses	Nil
Course Offering Department	Mechatronics Engineering	Data Book / Codes/Standards	Nil		

Course Learning Rationale (CLR):	*The purpose of learning this course is to:*	Learning			Program Learning Outcomes (PLO)														
		1	2	3	1	2	3	4	5	6	7	8	9	10	11	12	13	14	15
CLR-1 :	*To understand the mathematical foundations of planning algorithms*	Level of Thinking (Bloom	Expected Proficiency (%)	Expected Attainment (%)	Engineering Knowledge	Problem Analysis	Design & Development	Analysis, Design, Research	Modern Tool Usage	Society & Culture	Environment & Sustainability	Ethics	Individual & Team Work	Communication	Project Mgt. & Finance	Life Long Learning	PSO - 1	PSO - 2	PSO - 3
CLR-2 :	*To get awareness of various algorithms used in localization of mobile robots*																		
CLR-3 :	*To get exposed to common algorithmic strategies for path planning of mobile robots*																		
CLR-4 :	*To get an understanding of motion control algorithms required for autonomous vehicles*																		
CLR-5 :	*To get awareness of strategies to simultaneously localize and map the environment*																		
Course Learning Outcomes (CLO):	*At the end of this course, learners will be able to:*																		
CLO-1 :	*Comprehend the mathematical foundations of localization and path planning algorithms*	*3*	*80*	*75*	*H*	*H*	*M*	*L*	*L*	-	-	-	*L*	*L*	-	*L*	*H*	*M*	-
CLO-2 :	*Implement localization algorithms based on probabilistic and optimal state estimation*	*3*	*85*	*80*	*H*	*H*	*M*	*M*	*L*	-	-	-	*M*	*L*	-	*L*	*H*	*M*	-
CLO-3 :	*Appreciate practical aspects of implementation of motion control algorithms for autonomous vehicles*	*2*	*70*	*65*	*H*	*M*	*L*	*M*	*L*	-	-	-	*M*	*L*	-	*L*	*H*	*M*	-
CLO-4 :	*Develop path planning algorithms for local and global path planning*	*2*	*75*	*70*	*H*	*M*	*M*	*M*	*M*	-	-	-	*M*	*L*	-	*L*	*H*	*M*	-
CLO-5 :	*Implement algorithms for simultaneous localization and mapping*	*2*	*85*	*80*	*H*	*M*	*M*	*M*	*M*	-	-	-	*M*	*L*	-	*L*	*H*	*M*	-

		Introduction	Localization	Control	Optical Flow and Tracking	Advanced Topics
Duration (hour)		8	10	10	10	7
S-1	SLO-1	*Review of probability theory*	*Markov localization*	*Robot Motion*	*Motion planning*	*Introduction to SLAM*
	SLO-2	*Uniform distribution*	*Formulation, advantages and limitation*	*Smoothing Algorithm*	*Global and local path planning*	*Problem definition and Mathematical basis*
S-2	SLO-1	*Probability after sense*	*Numerical problem for Markov localization*	*Path Smoothing*	*Motivation and challenges*	*Taxonomy of SLAM problem*
	SLO-2	*Normalize distribution*	*Numerical problem for Markov localization*	*Zero Data Weight*	*Approaches*	*SLAM Paradigms*
S-3	SLO-1	*Phit and Pmiss*	*Introduction to optimal state estimation problem*	*PID control*	*A* star search*	*Extended Kalman Filter (EKF) SLAM*
	SLO-2	*Sum of probabilities*	*State estimator for localization*	*Implementation aspects of proportional control*	*Numerical example*	*Mathematical basics*
S-4	SLO-1	*Sense function*	*Gaussian introduction*	*Implementation aspects of integral control*	*D* lite search*	*Numerical example for EKF*
	SLO-2	*Exact motion*	*Variance comparison*	*Implementation aspects of derivative control*	*Numerical example*	*Numerical example for EKF*
S-5	SLO-1	*Move function*	*Maximize Gaussian*	*Systematic Bias*	*Expansion grid*	*Introduction to particle filters*
	SLO-2	*Bayes rule*	*Measurement and motion*	*Systematic Bias*	*Numerical example*	*Introduction to particle filters*
S-6	SLO-1	*Theorem of total probability*	*Parameter update*	*PID Tuning for autonomous mobile systems*	*Dynamic programming*	*Mathematical formulation of particle filter in the context of SLAM*
	SLO-2	*Numerical problems*	*New mean variance*	*PID Tuning for autonomous mobile systems*	*Numerical example*	*Mathematical formulation of particle filter in the context of SLAM*

S-7	SLO-1	*Introduction to localization*	*Gaussian motion*	*Parameter optimization*	*Vector field histogram*	*Fast SLAM*
	SLO-2	*Types and Challenges*	*Kalman filter pseudocode*	*Parameter optimization*	*Numerical example*	*Fast SLAM for point landmark example*
S-8	SLO-1	*Belief Representation*	*Kalman prediction*		*Selection of global and local path planning algorithms*	*Derivation*
	SLO-2	*Types and comparison*	*Kalman prediction*		*Application case study*	*Real world challenges and examples*
S-9	SLO-1	*Map representation*	*Kalman filter design*			*Application case study for EKF based SLAM*
	SLO-2	*Types*	*Kalman filter design*			*Application case study for EKF based SLAM*
S-10	SLO-1	*Types and comparison of map representation strategies*	*Kalman matrices*			*Application case study for Particle Filter based SLAM*
	SLO-2	*Types and comparison of map representation strategies*	*Sensor fusion using Kalman filter*			*Application case study for Particle Filter based SLAM*

Learning Resources	1. *Bruno Siciliano, Oussama Khatib, Springer Handbook of Robotics, 2nd Edition, Springer, 2016.* 2. *Siegwart, Nourbakhsh, "Introduction to Autonomous Mobile Robots", 2nd Edition, MIT Press, 2011.* 3. *Perter Corke, "Robotics, Vision and Control", 2nd Edition, Springer, 2017.*

Learning Assessment

	Bloom's Level of Thinking	Continuous Learning Assessment (50% weightage)								Final Examination (50% weightage)	
		CLA – 1 (10%)		CLA – 2 (15%)		CLA – 3 (15%)		CLA – 4 (10%)#			
		Theory	Practice	Theory	Practice	Theory	Practice	Theory	Practice	Theory	Practice
Level 1	Remember Understand	30 %	-	30 %	-	30 %	-	20 %	-	40%	-
Level 2	Apply Analyze	40 %	-	40 %	-	40 %	-	40 %	-	30%	-
Level 3	Evaluate Create	30 %	-	30 %	-	30 %	-	40 %	-	30%	-
	Total	100 %		100 %		100 %		100 %		100 %	

CLA – 4 can be from any combination of these: Assignments, Seminars, Tech Talks, Mini-Projects, Case-Studies, Self-Study, MOOCs, Certifications, Conf. Paper etc.,

Course Designers

Experts from Industry	Experts from Higher Technical Institutions	Internal Experts
1. Mr. N. Ganesh Ram, Intel Labs, ganeshram.nandakumar@intel.com	*1. Dr. R. Thiyagarajan, IIT Madras, thiyaguiitm@gmail.com*	*1. Dr. R. Senthilnathan, SRMIST*
2. Mr. Mohammed Sagheer , Wabco Technology Center, mohammedsagheer.musthafa@wabco-auto.com	*2. Dr. P. Karthikeyan, MIT Campus, Anna University, pkarthikeyan@annauniv.edu*	*2. Mr. K. Sivanathan, SRMIST*

Course Code	18MHE511T	Course Name	ARTIFICIAL INTELLIGENCE FOR ROBOTICS AND VISION	Course Category	E	Professional Elective	L	T	P	C
							3	0	0	3

Pre-requisite Courses	Nil	Co-requisite Courses	Nil	Progressive Courses	Nil
Course Offering Department	Mechatronics Engineering	Data Book / Codes/Standards	Nil		

Course Learning Rationale (CLR):	*The purpose of learning this course is to:*
CLR-1 :	*Obtain motivation for artificial intelligence and machine learning in robotics and vision*
CLR-2 :	*Appreciate the mathematics behind artificial intelligence*
CLR-3 :	*Understand the idea behind fuzzy logic for decision making*
CLR-4 :	*Understand the basics neural networks and deep learning philosophy*
CLR-5 :	*Get exposed to convolutional neural networks and its applications to vision guided robotics tasks*
CLR-6 :	*get awareness of deep neural networks for sequence modelling and reinforcement learning*

Course Learning Outcomes (CLO):	At the end of this course, learners will be able to:	Learning 1: Level of Thinking (Bloom)	2: Expected Proficiency (%)	3: Expected Attainment (%)	PLO 1: Engineering Knowledge	2: Problem Analysis	3: Design & Development	4: Analysis, Design, Research	5: Modern Tool Usage	6: Society & Culture	7: Environment & Sustainability	8: Ethics	9: Individual & Team Work	10: Communication	11: Project Mgt. & Finance	12: Life Long Learning	13: PSO - 1	14: PSO - 2	15: PSO - 3
CLO-1 :	*Formulate the mathematical basics of fuzzy and neural networks*	3	80	75	H	H	M	L	L	-	-	-	L	L	-	L	H	M	-
CLO-2 :	*Apply fuzzy logic problems to robotics applications*	3	85	80	H	H	M	M	L	-	-	-	M	L	-	L	H	M	-
CLO-3 :	*Develop neural networks for simple classification tasks*	2	70	65	H	M	L	M	L	-	-	-	M	L	-	L	H	M	-
CLO-4 :	*Exhibit conversant skill and knowledge with deep learning philosophy and training concepts*	2	75	70	H	M	M	M	M	-	-	-	M	L	-	L	H	M	-
CLO-5 :	*Implement convolutional neural networks for simple computer vision tasks*	2	85	80	H	M	M	M	M	-	-	-	M	L	-	L	H	M	-
CLO-6 :	*Implement deep recurrent neural networks and reinforcement network for simple robot guidance tasks*	2	80	75	H	M-	M	M	M	-	-	-	L	L	-	L	H	M	-

		Introduction	Fuzzy Logic	Classical Neural Networks	CNN	RNN and Reinforcement Learning
Duration (hour)		8	10	10	8	10
S-1	SLO-1	*Introduction to artificial intelligence (AI)*	*Introduction to Fuzzy sets*	*Overview of biological neuro-system*	*Conventional neural networks vs. Deep learning in the context of computer vision*	*Unfolding computational graphs*
	SLO-2	*Intelligent agent*	*Classical and Fuzzy sets*	*Mathematical models of neurons*	*Support vector machine*	*Unfolding computational graphs*
S-2	SLO-1	*Categorization of AI*	*Overview of classical sets*	*ANN architecture*	*Numerical example*	*Recurrent neural networks*
	SLO-2	*Overview of different forms of learning*	*Membership function*	*Learning rules*	*Softmax*	*Deep recurrent networks*
S-3	SLO-1	*Overview of different forms of learning*	*Fuzzy rule generation*	*Learning paradigms*	*Numerical example*	*Long Short Term Memory (LSTM)*
	SLO-2	*Statistical decision theory*	*Fuzzy rule generation*	*Supervised, unsupervised semi-supervised and reinforcement Learning*	*Numerical example*	*Long Short Term Memory*
S-4	SLO-1	*Regression*	*Operations on fuzzy sets*	*Multi-layer perceptrons*	*Convolutional neural networks*	*Autoencoders*
	SLO-2	*Regression*	*Numerical examples*	*Multi-layer perceptrons*	*Convolution, pooling*	*Applications of autoencoders*
S-5	SLO-1	*Numerical problems*	*Fuzzy Arithmetic*	*Numerical problems based on perceptron*	*Activation functions*	*Reinforcement learning numerical example*
	SLO-2	*Numerical problems*	*Numerical examples*	*Numerical problems based on perceptron*	*Initialization*	*Reinforcement learning numerical example*
S-6	SLO-1	*Evaluation of learning algorithms and cross-validation*	*Fuzzy Logic*	*Backpropagation*	*Deep learning hardware*	*Deep reinformcement learning, Motivation*
	SLO-2	*Evaluation of learning algorithms and cross-validation*	*Fuzzification*	*Backpropagation*	*CPU, GPU, TPU*	*Examples for reinforcement learning*

S-7	SLO-1	*Applications of AI in robotics*	*Fuzzy sets*	*Numerical problems for back propagation*	*Best practices in training*	*Markov decision process*
	SLO-2	*Applications of AI in robotics*	*Defuzzification*	*Numerical problems for back propagation*	*Training neural networks*	*Major components of RL*
S-8	SLO-1		*Application case study for manipulator robotics application*	*Introduction of neuro-fuzzy systems*	*Data augmentation*	*Q-learning*
	SLO-2		*Application case study for manipulator robotics application*	*Introduction of neuro-fuzzy Systems*	*Transfer learning*	*Numerical example*
S-9	SLO-1		*Application case study for mobile robotics application*	*Architecture of neuro-fuzzy Networks*		*Deep Q-learning (DQN)*
	SLO-2		*Application case study for mobile robotics application*	*Architecture of neuro-fuzzy Networks*		*DQN training, best practices*
S-10	SLO-1			*Numerical example for neuro-fuzzy system*		*Application case study for deep reinforcement learning*
	SLO-2			*Numerical example for neuro-fuzzy system*		*Application case study for deep reinforcement learning*

Learning Resources	1. *Bruno Siciliano, Oussama Khatib, "Handbook of Robotics", 2nd Edition, Springer, 2016* 2. *Ian Goodfellow and Yoshua Bengio and Aaron Courville, "Deep Learning", 1st Edition, MIT Press, 2016.* 3. *Simon Haykin, "Neural Networks and Learning Machines: A Comprehensive Foundation", 3rd Edition, Pearson, 2011.* 4. *Timothy J Ross, "Fuzzy Logic with Engineering Applications", 3rd Edition, Wiley, 2011.*

Learning Assessment

	Bloom's Level of Thinking	Continuous Learning Assessment (50% weightage)								Final Examination (50% weightage)	
		CLA – 1 (10%)		CLA – 2 (15%)		CLA – 3 (15%)		CLA – 4 (10%)#			
		Theory	Practice	Theory	Practice	Theory	Practice	Theory	Practice	Theory	Practice
Level 1	Remember Understand	30 %	-	30 %	-	30 %	-	20 %	-	40%	-
Level 2	Apply Analyze	40 %	-	40 %	-	40 %	-	40 %	-	30%	-
Level 3	Evaluate Create	30 %	-	30 %	-	30 %	-	40 %	-	30%	-
	Total	100 %		100 %		100 %		100 %		100 %	

CLA – 4 can be from any combination of these: Assignments, Seminars, Tech Talks, Mini-Projects, Case-Studies, Self-Study, MOOCs, Certifications, Conf. Paper etc.,

Course Designers		
Experts from Industry	Experts from Higher Technical Institutions	Internal Experts
1. Mr. N. Ganesh Ram, Intel Labs, ganeshram.nandakumar@intel.com	*1. Dr. R. Thiyagarajan, IIT Madras, thiyaguiitm@gmail.com*	*1. Dr. R. Senthilnathan, SRMIST*
2. Mr. Mohammed Sagheer , Wabco Technology Center, mohammedsagheer.musthafa@wabco-auto.com	*2. Dr. P. Karthikeyan, MIT Campus, Anna University, pkarthikeyan@annauniv.edu*	*2. Mr. K. Sivanathan, SRMIST*

Course Code	18MHE512T	Course Name	SYSTEMS ENGINEERING AND MANAGEMENT FOR ROBOTICS	Course Category	E	Professional Elective	L	T	P	C
							3	0	0	3

Pre-requisite Courses	Nil	Co-requisite Courses	Nil	Progressive Courses	Nil
Course Offering Department	Mechatronics Engineering	Data Book / Codes/Standards	Nil		

Course Learning Rationale (CLR):	*The purpose of learning this course is to:*
CLR-1 :	*Understand the foundations of systems engineering*
CLR-2 :	*Recognize the conflicting requirements of modern engineering systems like robots and their life cycle stages through some relevant case studies and appreciate the need for system engineering*
CLR-3 :	*Gain sound knowledge on technical ,management, organizational and tailoring processes involved in system engineering and their analysis*
CLR-4 :	*Comprehend the cross-cutting system engineering methods and activities*
CLR-5 :	*Apply the knowledge of system engineering to solve the problems associated with complex engineering systems*

Course Learning Outcomes (CLO):	*At the end of this course, learners will be able to:*	Learning 1: Level of Thinking (Bloom)	Learning 2: Expected Proficiency (%)	Learning 3: Expected Attainment (%)	1 Engineering Knowledge	2 Problem Analysis	3 Design & Development	4 Analysis, Design, Research	5 Modern Tool Usage	6 Society & Culture	7 Environment & Sustainability	8 Ethics	9 Individual & Team Work	10 Communication	11 Project Mgt. & Finance	12 Life Long Learning	13 PSO - 1	14 PSO - 2	15 PSO - 3
CLO-1 :	*Familiarize the foundations of systems engineering*	2	75	70	H	H	M	H	M	-	-	-	-	-	-	H	H	H	H
CLO-2 :	*Identify the conflicting requirements of modern engineering systems and their life cycle stages*	3	75	70	H	H	M	H	M	-	M	-	-	-	-	H	M	M	M
CLO-3 :	*Acquire knowledge on technical ,management, organizational and tailoring processes involved in system engineering*	3	75	70	H	H	M	H	M	-	M	M	-	-	M	H	M	M	M
CLO-4 :	*Realize the cross-cutting system engineering methods and activities*	3	75	70	H	H	M	H	M	-	M	M	-	-	M	H	M	M	M
CLO-5 :	*Apply the knowledge of system engineering to solve the problems in robotics and other complex engineering systems*	3	75	70	H	H	M	H	H	-	M	M	-	-	M	H	M	M	M

		Foundations of Systems Engineering (SE) and Life Cycle Stages	Technical Process of Systems Engineering	Management Process of Systems Engineering	Organizational and Tailoring Processes and Applications of System Engineering	Cross-cutting SE Methods and Activities
Duration (hour)		9	9	9	9	9
S-1	SLO-1	*Introduction, definition and concepts of systems*	*Business or Mission Analysis Process*	*Project planning process*	*Life cycle model management process*	*Modeling and simulation*
	SLO-2	*The hierarchy within a system*	*Stakeholder needs and requirements*	*Project assessment and control process*	*Infrastructure management process*	*Modeling and simulation*
S-2	SLO-1	*Definition of systems of systems*	*System requirements Definition Process*	*Decision management process*	*Portfolio management process*	*Model based system engineering*
	SLO-2	*Enabling systems and definition of Systems Engineering(SE)*	*System requirements Definition Process*	*Decision management process*	*Human resource management process*	*Model based system engineering*
S-3	SLO-1	*Origins and Evolution of system engineering*	*Architecture definition process*	*Risk management process*	*Quality management process*	*Function-based system engineering*
	SLO-2	*Use and value of system engineering*	*Architecture definition process*	*Risk management process*	*Knowledge management process*	*Object-oriented system engineering*
S-4	SLO-1	*System science and system thinking*	*Design definition process*	*Configuration management process*	*Tailoring process*	*Prototyping, Interface management*
	SLO-2	*System engineering leadership and professional development*	*Design definition process*	*Configuration management process*	*Tailoring process*	*Integrated product and process development*
S-5	SLO-1	*Introduction to Life cycle and its characteristics*	*System analysis process*	*Information management process*	*Tailoring for Automotive systems, Biomedical and healthcare systems*	*Integrated product and process development*
	SLO-2	*Life cycle stages*	*Implementation process*	*Information management process*	*Tailoring for defense and aerospace systems*	*Lean and agile system engineering*
S-6	SLO-1	*Life cycle approaches*	*Integration process*	*Measurement Process*	*Tailoring for infrastructure systems*	*Affordability analysis*
	SLO-2	*Life cycle approaches*	*Verification process*	*Measurement Process*	*Tailoring for space systems and ground transportation systems*	*Electromagnetic compatibility*

S-7	SLO-1	*Deciding what is best for organization, project or team*	*Transition process*	*Quality assurance process*	*Application of SE for product line management*	*Environmental /impact analysis, interoperability analysis*
	SLO-2	*Case study-1 Design for safety-Radiation therapy*	*Validation process*	*Quality assurance process*	*Application of SE for product line management*	*Logistics, manufacturing and producibility analysis*
S-8	SLO-1	*Case study-2 Need for prototyping system-Super high speed train in China*	*Operation process*	*Agreement process-introduction*	*Application of SE for services*	*Reliability and maintainability*
	SLO-2	*Case study -3 Cyber security considerations-The stuxnet attack*	*Maintenance process*	*Acquisition process*	*Application of SE for services*	*Resilience engineering*
S-9	SLO-1	*Case study-4 Design for maintainability-Incubators*	*Disposal process*	*Acquisition process*	*Application of SE for Enterprises*	*System safety and security engineering*
	SLO-2	*Concluding remarks on necessity of SE by relating to the above case studies*	*Concluding remarks on technical process*	*Supply process*	*Application of SE for small and micro enterprises*	*Value engineering*

Learning Resources	1. *David D.Walden, Garry J.Roelder, Kevin J.Forsberg, R.Douglas Hamelin, Thomas M.Shortell., "INCOSE Systems Engineering Handbook- A Guide for System Life Cycle Processes and Activities", 4th Edition, Wiley, 2015* 2. *Kossiakoff, A. Sweet, Seymour, S., W.N., Biemer, S.M., "Systems Engineering Principles and Practice", 2nd Edition, John Wiley & Sons, 2011.*	3. *Charles S.Wassen., "System Engineering Analysis, Design and Development" Wiley, 2016.* 4. *Blanchard, B.S. and Fabrycky, W.J., "Systems Engineering and Analysis", 4th Edition, Prentice Hall, 2005.* 5. *Zeigler, B.P., H. Praehofer, T.G. Kim., "Theory of Modeling and Simulation", 2nd Edition, Academic Press, 2000.*

Learning Assessment

	Bloom's Level of Thinking	Continuous Learning Assessment (50% weightage)								Final Examination (50% weightage)	
		CLA – 1 (10%)		CLA – 2 (15%)		CLA – 3 (15%)		CLA – 4 (10%)#			
		Theory	Practice	Theory	Practice	Theory	Practice	Theory	Practice	Theory	Practice
Level 1	Remember Understand	30 %	-	30 %	-	30 %	-	30 %	-	30%	-
Level 2	Apply Analyze	40 %	-	40 %	-	40 %	-	40 %	-	40%	-
Level 3	Evaluate Create	30 %	-	30 %	-	30 %	-	30 %	-	30%	-
	Total	100 %		100 %		100 %		100 %		100 %	

CLA – 4 can be from any combination of these: Assignments, Seminars, Tech Talks, Mini-Projects, Case-Studies, Self-Study, MOOCs, Certifications, Conf. Paper etc.,

Course Designers

Experts from Industry	Experts from Higher Technical Institutions	Internal Experts
1. Mr. Elayaraj Sivaraj, Tesla, California, elayaraj@hotmail.com	*1. Dr. Manivannan P V, Indian Institute of Techonology, Chennai, pvm@iitm.ac.in*	*1. Mr. K.Sivanathan, SRMIST*
2. Mr. Visweswaran Jagadeesan , National Instruments, Bangalore visweswaran.jagadeesan@ni.com	*2. Dr. D. Sathia Narayanan, National Institute of Ocean Technology, Chennai, sathianarayanan@niot.res.in.*	*2. Dr.R.Senthilnathan, SRMIST*

ACADEMIC CURRICULA

Professional Elective Courses

NANOTECHNOLOGY

Regulations - 2018

SRM INSTITUTE OF SCIENCE AND TECHNOLOGY

(Deemed to be University u/s 3 of UGC Act, 1956)

Kattankulathur, Kancheepuram, Tamil Nadu, India

Course Code	18NTE301T	Course Name	CARBON NANOTECHNOLOGY	Course Category	E	Professional Elective	L	T	P	C
							3	0	0	3

Pre-requisite Courses	Nil	Co-requisite Courses	Nil	Progressive Courses	Nil
Course Offering Department	Nanotechnology	Data Book / Codes/Standards	Nil		

Course Learning Rationale (CLR):	*The purpose of learning this course is to:*
CLR-1 :	*Acquire knowledge various forms of carbon*
CLR-2 :	*Understands the use of carbon forms in applications*
CLR-3 :	*Understands the physical and chemical properties of fullerenes*
CLR-4 :	*Understands the physical and chemical properties of graphene*
CLR-5 :	*Understands the physical and chemical properties of carbon nanotubes*
CLR-6 :	*Acquire knowledge about various synthesis forms*

Course Learning Outcomes (CLO):	*At the end of this course, learners will be able to:*	Learning 1	Learning 2	Learning 3	Program Learning Outcomes (PLO) 1	2	3	4	5	6	7	8	9	10	11	12	13	14	15
		Level of Thinking (Bloom)	Expected Proficiency (%)	Expected Attainment (%)	Engineering Knowledge	Problem Analysis	Design & Development	Analysis, Design, Research	Modern Tool Usage	Society & Culture	Environment & Sustainability	Ethics	Individual & Team Work	Communication	Project Mgt. & Finance	Life Long Learning	PSO - 1	PSO - 2	PSO - 3
CLO-1 :	*Analyze the geometry of various carbon nanostructures*	2	80	75	H	H	H	H	M	M	M	H	H	H	M	H	H	H	H
CLO-2 :	*Differentiate the structure and properties of different carbon nanostructure*	2	80	70	H	H	M	H	M	M	M	H	M	H	M	H	M	M	M
CLO-3 :	*Elucidate the uses of Fullerenes, Carbon nanotubes and Graphene in different applications*	2	75	70	H	M	H	H	M	H	H	M	H	H	H	H	H	H	H
CLO-4 :	*Analyze the geometry of various carbon nano tubes*	2	80	75	M	H	H	M	H	H	H	H	H	H	M	H	H	H	H
CLO-5 :	*Analyze the various synthesis and characterization techniques of carbon nanostructures*	2	80	70	H	H	H	H	H	M	M	H	M	H	M	H	H	H	H
CLO-6 :	*Demonstrate the applications of carbon nanostructures*	2	80	75	H	M	M	H	M	M	M	H	H	H	M	H	H	M	H

Duration (hour)		9	9	9	9	9
S-1	SLO-1	*Introduction*	*Fullerenes*	*Carbon Nanotubes*	*Graphene*	*Introduction to thin films*
	SLO-2	*Carbon molecules*	*Structure of fullerenes*	*Structure of Carbon Nanotubes*	*Structure of Graphene*	*Carbon thin films*
S-2	SLO-1	*Nature of carbon bond*	*Bonding of fullerenes*	*Nomenclature of Carbon Nanotubes*	*Synthesis of Graphene*	*Amorphous nature*
	SLO-2	*New carbon structures*	*Nomenclature*	*Electronic properties of Carbon Nanotubes (CNTs)*	*Characterization of Graphene*	*Crystalline nature*
S-3	SLO-1	*Discovery of C60*	*C60 and higher fullerenes*	*Synthesis of Single Wall CNTs (SWCNTs)*	*Properties of Graphene*	*Chemical vapor deposition (CVD): Diamond*
	SLO-2	*Structure of C60*	*Growth mechanisms*	*Production of SWCNTs*	*Electrical properties of Graphene*	*Structure of CVD diamond*
S-4	SLO-1	*C60 crystal*	*Production*	*Synthesis of Multi Wall CNTs (SWCNTs)*	*Magnetic properties of Graphene*	*Synthesis of CVD diamond*
	SLO-2	*From graphene sheet to a nanotube*	*Purification*	*Production of MWCNTs*	*Band structure of Graphene*	*Physical properties of CVD diamond*
S-5	SLO-1	*Single wall and multi walled nanotubes*	*Fullerene preparation by pyrolysis of hydrocarbons*	*Growth mechanism of CNTs*	*Phonon modes in Graphene*	*Chemical properties of CVD diamond*
	SLO-2	*Zigzag nanotubes*	*Partial combustion of hydrocarbons*	*Analysis of Carbon Nanotubes by X-ray diffraction*	*Raman modes in Graphene*	*CVD diamond as wear resistant coating*
S-6	SLO-1	*Armchair nanotubes*	*Physical properties*	*Analysis of carbon nanotubes by Raman Spectroscopy*	*Layer dependence of Raman spectra*	*CVD diamond as bio-chemical sensors*
	SLO-2	*Chirality in nanotubes*	*Chemical properties*	*Carbon nanotubes as Transistors*	*Raman spectroscopy of Graphene under strain*	*Optical applications: infrared windows, lenses, X-ray Windows*

S-7	SLO-1	*Structure of defective nanotubes*	*Hydrogenation*	*Carbon nanotubes as Field Effect Transistors (FET)*	*Infrared spectroscopy of Graphene*	*Amorphous carbon thin films*
	SLO-2	*Bonding of defective nanotubes*	*Applications of fullerenes*	*Carbon nanotubes as sensors*	*X-Ray diffraction of Graphene*	*Amorphous carbon films (a:C)*
S-8	SLO-1	*Cylindrical nanotubes*	*Fullerenes in solar cell*	*Carbon nanotubes as bio-sensors*	*EELS of Graphene*	*Hydrogen amorphous carbon films (a:C-H)*
	SLO-2	*Euler's theorem*	*Fullerenes as donor systems*	*Carbon nanotubes as gas sensors*	*Graphene in solar cell applications*	*Physical properties of amorphous carbon film*
S-9	SLO-1	*Euler's theorem in cylindrical nanotubes*	*Fullerenes as acceptor systems*	*Carbon nanotubes in dye degradation*	*Graphene as gas sensors*	*Chemical properties of amorphous carbon film*
	SLO-2	*Euler's theorem in defective nanotubes*	*Fullerenes as chemical sensors*	*Carbon nanotubes in photo-catalytic activities*	*Graphene in dye degradation (photo-catalytic activities)*	*Amorphous carbon film as anti-reflection and anti-corrosive coatings*

Learning Resources	*1. Anke Krueger, "Carbon Materials and Nanotechnology", Wiley-VCH , 2010* *2 Yury Gogotsi, "Carbon Nanomaterials", Taylor and Francis, Second edition, 2014* *3. C. N. R. Rao, Ajay K. Sood, "Graphene: Synthesis, Properties, and Phenomena"- Wiley- VCH, 2013*	*4. Wonbong Choi, Jo-won Lee, "Graphene: Synthesis and Applications" CRC Press, Taylor and Francis, 2012*

Learning Assessment

	Bloom's Level of Thinking	Continuous Learning Assessment (50% weightage)								Final Examination (50% weightage)	
		CLA – 1 (10%)		CLA – 2 (15%)		CLA – 3 (15%)		CLA – 4 (10%)#			
		Theory	Practice	Theory	Practice	Theory	Practice	Theory	Practice	Theory	Practice
Level 1	Remember Understand	30 %	-	30 %	-	30 %	-	30 %	-	30%	-
Level 2	Apply Analyze	40 %	-	40 %	-	40 %	-	40 %	-	40%	-
Level 3	Evaluate Create	30 %	-	30 %	-	30 %	-	30 %	-	30%	-
	Total	100 %		100 %		100 %		100 %		100 %	

CLA – 4 can be from any combination of these: Assignments, Seminars, Tech Talks, Mini-Projects, Case-Studies, Self-Study, MOOCs, Certifications, Conf. Paper etc.,

Course Designers		
Experts from Industry	Experts from Higher Technical Institutions	Internal Experts
1. Dr. D.K. Aswal, National Physical Laboratory, dkaswal@nplindia.org	*1. Dr. V. Subramaniyam, IIT Madras, manianvs@iitm.ac.in*	*1. Dr. M.Navaneethan, SRMIST*
2. Dr. S. Sudhakar, CSIR-CECRI, sudhakar@cecri.res.in	*2. Dr. S. Balakumar, University of Madras, balakumar@iunom.ac.in*	*2. Dr. E. Senthil Kumar, SRMIST*

Course Code	18NTE302T	Course Name	PHYSICS OF SOLID STATE DEVICES	Course Category	E	Professional Elective	L	T	P	C
							3	0	0	3

Pre-requisite Courses	Nil	Co-requisite Courses	Nil	Progressive Courses	Nil
Course Offering Department	Nanotechnology	Data Book / Codes/Standards	Nil		

Course Learning Rationale (CLR):	The purpose of learning this course is to:
CLR-1 :	*Get knowledge in the design and working principle of solid state devices*
CLR-2 :	*Understand the physics of p-n junction*
CLR-3 :	*Familiarize with the concept of metal/semiconductor junctions and semiconductor heterojunctions*
CLR-4 :	*Describe the operation of basic semiconductor diodes*
CLR-5 :	*Understand the theory of various types of transistors*
CLR-6:	*Acquire knowledge on the materials and working of solid-state optoelectronic devices like LEDs, Solar cells, Photodetectors, Lasers, etc*

Course Learning Outcomes (CLO):	At the end of this course, learners will be able to:	Learning 1 Level of Thinking (Bloom)	Learning 2 Expected Proficiency (%)	Learning 3 Expected Attainment (%)	PLO 1 Engineering Knowledge	PLO 2 Problem Analysis	PLO 3 Design & Development	PLO 4 Analysis, Design, Research	PLO 5 Modern Tool Usage	PLO 6 Society & Culture	PLO 7 Environment & Sustainability	PLO 8 Ethics	PLO 9 Individual & Team Work	PLO 10 Communication	PLO 11 Project Mgt. & Finance	PLO 12 Life Long Learning	PLO 13 PSO - 1	PLO 14 PSO - 2	PLO 15 PSO - 3
CLO-1 :	*Realize importance of semiconducting materials and p-n junction for development of solid state devices*	2	80	75	H	H	H	H	H	H	H	H	H	H	M	H	H	H	H
CLO-2 :	*Use knowledge of physics to understand the workingof semiconductor devices*	2	80	70	H	H	H	H	M	M	M	H	H	H	L	H	M	M	M
CLO-3 :	*Develop analytical approaches to understand semiconductor devices*	2	75	70	H	L	H	H	H	H	H	H	H	H	M	H	H	H	H
CLO-4 :	*Develop in depth understanding on the principle of working of different solid state devices*	2	80	75	H	H	H	H	M	M	H	H	H	H	M	H	H	H	H
CLO-5 :	*Distinguish the design principles of various solid state devices*	2	80	70	H	M	H	H	M	M	H	H	H	H	L	H	H	H	H
CLO6:	*Design two-terminal and three-terminal electronic devices*	2	80	70	H	H	H	H	M	M	M	H	H	H	L	H	M	M	M

Duration (hour)		9	9	9	9	9
S-1	SLO-1	*Concept of p-n junction*	*Understand what a metal-semiconductor contact is.*	*Study fundamentals of BJT operation*	*Principle and types of field-effect transistors*	*Understand optical generation of carriers in a p-n junction*
	SLO-2	*Physics of the p-n junction formation*	*Qualitative characteristics of energy band formation*	*Operation modes of a BJT*	*Principle of operation of JFET*	*Types of Photodiodes*
S-2	SLO-1	*Energy band diagram of a p-n junction*	*Understand the ideal junction properties*	*Understand the structure and working of p-n-p and n-p-n transistors*	*Concept of pinch-off and saturation*	*Solar radiation and ideal conversion efficiency of a solar cell*
	SLO-2	*Estimation of the electric field, electric potential, and built-in potential*	*Theoretical considerations in estimating the barrier height*	*Band diagram and static characteristics*	*Derive I-V characteristics of JFET*	*Physics of solar cell*
S-3	SLO-1	*Depletion approximation and estimation of space charge width*	*Nonideal effects on the barrier height*	*Factors involved in transistor amplification*	*GaAs epitaxial layers for MESFET – Principle of working*	*Device configuration and technology roadmap, solar cell materials*
	SLO-2	*Depletion layer capacitance and its estimation*	*Qualitative explanation of image-force-induced lowering of the potential barrier*	*BJT fabrication*	*Concept of high-electron mobility transistors - III-V semiconductor materials*	*Familiarize with the solar cell parameters and efficiency calculation*
S-4	SLO-1	*Linearly graded junction in thermal equilibrium*	*Current transport processes in metal-semiconductor contacts*	*Analysis of minority carrier distribution*	*Basic working and fabrication of MOSFET*	*Design principle of photodetector*
	SLO-2	*Arbitrary doping profile and understanding the doping profile from $1/C^2$-V plot*	*Comparison of the Schottky barrier diode and the p-n junction diode*	*Solution of the diffusion equation in the base region*	*Knowledge on modes of operation and short channel MOSFET*	*Types of photodetectors and characteristics*
S-5	SLO-1	*Qualitative description of charge flow in a p-n junction*	*Metal-semiconductor Ohmic contacts*	*Evaluation of the terminal currents*	*Short channel effects in MOSFET*	*How light-emitting diodes work?*
	SLO-2	*Ideal current-voltage characteristics of a p-n junction*	*Concept of ideal nonrectifying and tunneling barriers*	*Non ideal effects in BJT*	*Advanced MOSFET structures*	*Basic device structure and the concept of radiative recombination*

S-6	SLO-1	*Derivation of Shockley equation (ideal-diode equation)*	*Methods to experimentally measure the barrier height*	*Deviations from the basic theory and indicate situations in which each effect is important*	*Metal Gate-High-k and Enhanced Channel Mobility Materials and Strained Si FETs*	*Materials of choice and technology roadmap*
	SLO-2	*Generation-recombination process and its effect*	*Current-voltage and capacitance-voltage measurements*	*The physical mechanisms of the current gain limiting factors*	*Complementary MOS structure and its formation*	*Specifications used in denoting the practical LED bulbs*
S-7	SLO-1	*Reverse bias breakdown mechanisms in a pn junction*	*Photoelectric measurements*	*The voltage breakdown mechanisms in abipolar transistor*	*CMOS process integration*	*Physics of laser action*
	SLO-2	*Zener and Avalanche breakdown*	*Figure of merit of ohmic contacts and its determination, the concept of specific contact resistance*	*The current-limiting factors from the current components in the transistor*	*Concept of modulation doping in HEMT*	*Gain knowledge of stimulated emission and population inversion*
S-8	SLO-1	*Transient behavior of a p-n junction*	*Isotype and anisotype semiconductor heterojunctions - energy band diagrams*	*Frequency limitations of transistors*	*Basic device structure of AlGaAs/GaAs HEMT and I-V characteristics*	*Fabrication of p-n junction laser*
	SLO-2	*Concept of Noise in semiconductor devices*	*Current density equations and physical interpretation*	*The voltage breakdown mechanisms in a bipolar transistor*	*Output characteristics and channel related phenomenon*	*Emission spectra*
S-9	SLO-1	*Terminal functions of a p-n junction diode, The concept of tunnel diode*	*Introduction to two-dimensional electron gas*	*Heterojunction BJT*	*Dynamic effects in MOS capacitors – The Charge-coupled device*	*Familiarize with the structure and need of heterojunction lasers*
	SLO-2	*p-n junction as rectifier, Zener diode, Varistor, and Varactor*	*Concept of quantum well and superlattice structures*	*Schottky and Photo transistors*	*Basic CCD structure and its applications*	*Materials for semiconductor lasers and quantum cascade lasers*

Learning Resources	1. *S M Sze, Kwok k. Ng, "Physics of semiconductor devices" – John Wiley & Sons, Inc., 2007* 2. *Ben G. Streetman, Sanjay Kumar Banerjee, "Solid State Electronic Devices", Pearson Education Ltd, 2016*	3. *Donald A. Neamen, "Semiconductor Physics and Devices: Basic Principles" – McGraw Hill, Fourth Edition, 2011.*

Learning Assessment

	Bloom's Level of Thinking	Continuous Learning Assessment (50% weightage)								Final Examination (50% weightage)	
		CLA – 1 (10%)		CLA – 2 (15%)		CLA – 3 (15%)		CLA – 4 (10%)#			
		Theory	Practice	Theory	Practice	Theory	Practice	Theory	Practice	Theory	Practice
Level 1	Remember Understand	30 %	-	30 %	-	30 %	-	30 %	-	30%	-
Level 2	Apply Analyze	40 %	-	40 %	-	40 %	-	40 %	-	40%	-
Level 3	Evaluate Create	30 %	-	30 %	-	30 %	-	30 %	-	30%	-
	Total	100 %		100 %		100 %		100 %		100 %	

CLA – 4 can be from any combination of these: Assignments, Seminars, Tech Talks, Mini-Projects, Case-Studies, Self-Study, MOOCs, Certifications, Conf. Paper etc.,

Course Designers

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1. Dr. D.K. Aswal, National Physical Laboratory, dkaswal@nplindia.org	*1. Prof. M.S. Ramachandra Rao, IITM Chennai, msrrao@iitm.ac.in*	*1. Dr. S. Chandramohan, SRMIST*
2. Dr. S. Sudhakar, CSIR-CECRI, sudhakar@cecri.res.in	*2. Prof. T. Som, Institute of Physics, tsom@iopb.res.in*	*2. Dr. E. Senthil Kumar, SRMIST*

Course Code	18NTE303T	Course Name	MOLECULAR SPECTROSCOPY AND ITS APPLICATIONS	Course Category	E	Professional Elective	L	T	P	C
							3	0	0	3

Pre-requisite Courses	Nil	Co-requisite Courses	Nil	Progressive Courses	Nil
Course Offering Department	Nanotechnology	Data Book / Codes/Standards	Nil		

Course Learning Rationale (CLR):	The purpose of learning this course is to:
CLR-1 :	*Acquire the knowledge in the basic concepts of interaction of radiation with matter and rotational spectroscopy*
CLR-2 :	*Comprehend the principles of vibrational spectroscopy*
CLR-3 :	*Understand the principles and techniques involved in of Raman scattering*
CLR-4 :	*Emphasize the significance of various techniques in electronic spectroscopy*
CLR-5 :	*Expose to concepts and applications of magnetic resonance*
CLR-6 :	*Focus on relevant theory, concepts, and techniques for understanding the spectrum of molecules*

Course Learning Outcomes (CLO):	At the end of this course, learners will be able to:	Learning 1: Level of Thinking (Bloom)	2: Expected Proficiency (%)	3: Expected Attainment (%)	PLO 1: Engineering Knowledge	2: Problem Analysis	3: Design & Development	4: Analysis, Design, Research	5: Modern Tool Usage	6: Society & Culture	7: Environment & Sustainability	8: Ethics	9: Individual & Team Work	10: Communication	11: Project Mgt. & Finance	12: Life Long Learning	13: PSO - 1	14: PSO - 2	15: PSO - 3
CLO-1 :	*Interpret the processes of absorption and radiation and analyse the rotational motion in molecules*	2	80	75	H	M	H	H	H	M	M	H	H	H	M	H	H	H	H
CLO-2 :	*Analyze the vibrational spectra of diatomic and polyatomic molecules*	2	80	70	H	M	M	H	M	M	M	H	M	H	M	H	M	M	M
CLO-3 :	*Analyze the Raman spectra and various non-linear Raman techniques*	2	75	70	H	M	M	H	H	M	M	M	M	H	H	H	H	H	H
CLO-4 :	*Elucidate the various optical processes involved in the electronic spectra.*	2	80	75	M	H	M	M	H	H	H	H	H	H	M	H	H	H	H
CLO-5 :	*Apply the concept magnetic resonance in chemical analysis and structure determination.*	2	80	70	H	M	M	H	H	M	M	H	M	H	M	H	H	H	H
CLO-6 :	*Critique the applicability of a spectroscopic approach in the analysis of a molecular structure*	2	80	75	H	M	M	H	H	M	M	H	H	H	M	H	H	M	H

Duration (hour)		9	9	9	9	9
S-1	SLO-1	*Electromagnetic spectrum, spectral regions*	*Vibrational energy of a diatomic molecule*	*Born oppenheimer approximation*	*Quantum theory of Raman scattering*	*Magnetic moments*
	SLO-2	*Types of molecular energies*	*Classical approach*	*Vibrational coarse structure*	*Classical theory of Raman scattering*	*Quantization*
S-2	SLO-1	*Interaction of light with matter*	*Wave mechanical approach*	*Band system and vibrational transitions*	*Rotational Raman spectra*	*Larmor precession*
	SLO-2	*Methods of obtaining a spectrum, components of a spectrometer*	*Morse curve and energy levels of a diatomic molecule*	*Progressions and sequences*	*Vibrational Raman spectra*	*Resonance condition in Nuclear magnetic resonance (NMR)*
S-3	SLO-1	*Spectral line width and broadening of spectral lines*	*Selection rules for vibration*	*Franck condon principle*	*Mutual exclusion principle*	*Spin –spin relaxation*
	SLO-2	*Intensity of spectral lines*	*Fundamental overtones and hotbands in the vibrational spectrum*	*Intensity of vibrational electronic spectra*	*Polarization of Raman scattered light*	*Spin-lattice relaxation*
S-4	SLO-1	*Absorption and emission of radiation*	*Accidental degeneracy*	*Rotational fine structure*	*Raman spectrometer*	*NMR spectrometer*
	SLO-2	*Spontaneous and stimulated processes*	*Diatomic vibrating rotator*	*Assignment of bands in a fine structure*	*Analysis of Raman spectra*	*Chemical shift*
S-5	SLO-1	*Einstein's co-efficients and its derivation*	*Selection rules for vibration-rotation*	*Dissociation energy and dissociation products*	*Structure determination using Raman spectroscopy*	*Factors contributing to screening*
	SLO-2	*Laser as a spectroscopic light source*	*Vibrations of polyatomic molecules*	*Predissociation*	*Raman investigation of phase transitions*	*Double resonance technique*
S-6	SLO-1	*Classification of molecules based on moment of inertia*	*Normal vibrations of CO_2 and H_2O molecules*	*Electronic absorption spectra*	*Resonance Raman scattering*	*NMR imaging*

	SLO-2	Rotational spectra of rigid diatomic molecules	Interpretation of IR spectra	Electronic angular momentum in diatomic molecules	Surface enhanced Raman scattering	Fourier transform NMR techniques
S-7	SLO-1	Rigid rotator	Group frequencies and various regions in IR spectrum	Dissipation of energy by excited molecule	Non-linear Raman phenomena-preliminaries	^{13}C NMR
	SLO-2	Isotope effect in rotational spectra, Intensity of rotational lines	Perturbation of group frequencies: mass effects	Jablonski diagram	Hyper Raman effect	Electron spin resonance
S-8	SLO-1	Non-rigid rotator	Perturbation of group frequencies: inductive effects	Phosphorescene	Stimulated Raman scattering	Resonance condition in Electron spin resonance (ESR)
	SLO-2	Vibrational excitation effect and Λ doubling	Fourier transform infrared spectroscopy: principle and interferometer arrangement	Fluorescence	Inverse Raman effect	ESR spectrometer
S-9	SLO-1	Microwave spectrometer	Elucidation of molecular structure using IR spectroscopy	Photoelectron spectroscopy: principle	Coherent Antistokes Raman scattering	Nuclear- electron spin coupling
	SLO-2	Applications of rotational spectroscopy	Identification of molecular constituents using IR spectroscopy	Photoelectron spectroscopy: instrumentation	Photo acoustic Raman scattering	Applications of ESR spectroscopy

Learning Resources	1 .Peter Atkins, Julio de Paula Atkins, "Physical Chemistry", W. H. Freeman and Company, New York, 2010 2. Collin Banwell, Mc Cash, "Fundamentals of Molecular Spectroscopy", McGraw Hill publishing, 2001	3. G.Aruldhas,"Molecular structure and spectroscopy" ,Prentice Hall, 2001 4. P.S.Sindhu, "Fundamentals of molecular spectroscopy" New age international publishers,2006

Learning Assessment

	Bloom's Level of Thinking	Continuous Learning Assessment (50% weightage)								Final Examination (50% weightage)	
		CLA – 1 (10%)		CLA – 2 (15%)		CLA – 3 (15%)		CLA – 4 (10%)#			
		Theory	Practice	Theory	Practice	Theory	Practice	Theory	Practice	Theory	Practice
Level 1	Remember Understand	30 %	-	30 %	-	30 %	-	30 %	-	30%	-
Level 2	Apply Analyze	40 %	-	40 %	-	40 %	-	40 %	-	40%	-
Level 3	Evaluate Create	30 %	-	30 %	-	30 %	-	30 %	-	30%	-
	Total	100 %		100 %		100 %		100 %		100 %	

CLA – 4 can be from any combination of these: Assignments, Seminars, Tech Talks, Mini-Projects, Case-Studies, Self-Study, MOOCs, Certifications, Conf. Paper etc.,

Course Designers

Experts from Industry	Experts from Higher Technical Institutions	Internal Experts
1. Dr. D.K. Aswal, National Physical Laboratory, dkaswal@nplindia.org	1. Dr.G.Aravind, IIT Madras, garavind@iitm.ac.in	1. Dr. R.Annie Sujatha, SRMIST
2. Dr. Krishna Surendra Muvvala, Saint Gobain Research India, India, Krishna.muvvala@saintgobain.com	2. Dr. M. S. Ramachandra Rao, IIT Madras, msrrao@iitm.ac.in	2. Dr. E.SenthilKumar, SRMIST

Course Code	18NTE304T	Course Name	NANOTRIBOLOGY	Course Category	E	Professional Elective Course	L	T	P	C
							3	0	0	3

Pre-requisite Courses	Nil	Co-requisite Courses	Nil	Progressive Courses	Nil
Course Offering Department	Nanotechnology	Data Book / Codes/Standards	Nil		

Course Learning Rationale (CLR):	*The purpose of learning this course is to:*
CLR-1 :	*Acquire knowledge on nanotribology*
CLR-2 :	*Understand lubrication and related theories*
CLR-3 :	*Gain insight on surfaces forces and its measurement techniques*
CLR-4 :	*Know about mechanisms involved in tribology related mechanical properties*
CLR-5 :	*Enhance the knowledge on friction and wear and their importance*
CLR-6 :	*Attain knowledge on tribological applications in day to day life*

Course Learning Outcomes (CLO):	*At the end of this course, learners will be able to:*	Learning 1: Level of Thinking (Bloom)	2: Expected Proficiency (%)	3: Expected Attainment (%)	PLO 1: Engineering Knowledge	2: Problem Analysis	3: Design & Development	4: Analysis, Design, Research	5: Modern Tool Usage	6: Society & Culture	7: Environment & Sustainability	8: Ethics	9: Individual & Team Work	10: Communication	11: Project Mgt. & Finance	12: Life Long Learning	13: PSO - 1	14: PSO - 2	15: PSO - 3
CLO-1 :	*Strong knowledge in the basic tribological concepts required for nanotechnology*	2	80	75	H	M	H	H	H	M	M	H	H	H	M	H	H	H	H
CLO-2 :	*Identify, formulate, and solve engineering problem of interacting surfaces in relative motion*	2	80	70	H	M	M	H	M	M	M	H	M	M	M	H	M	M	M
CLO-3 :	*Emphasize the knowledge of scientific disciplines in understanding tribological phenomenon*	2	75	70	H	M	H	H	H	H	H	M	H	H	H	M	H	H	H
CLO-4 :	*Realize the significance of lubrication, friction and wear*	2	80	75	H	H	M	M	M	H	H	H	H	M	M	H	H	H	M
CLO-5 :	*Familiar in the importance of modifying surface properties*	2	80	70	H	M	H	H	H	M	M	H	M	H	M	H	M	M	H
CLO-6 :	*Utilize nanotribological principles for any applications*	2	80	75	H	M	M	H	H	M	M	H	H	H	M	M	H	M	H

Duration (hour)		9	9	9	9	9
S-1	SLO-1	*History of tribology-origin*	*Surface Forces*	*Lubrication*	*Scale Effects in Mechanical Properties*	*Applications of Tribology*
	SLO-2	*Significance of micro/nanotribology*	*Methods used to study surface forces*	*Lubricant States*	*Nomenclature*	*Introduction to various tribological phenomenon*
S-2	SLO-1	*Tribology in design-Methods of solution of tribological problems*	*Force laws*	*Viscosity of lubricant*	*Yield strength and Hardness*	*Bio-Tribology*
	SLO-2	*Purpose of lubrication*	*Surface force apparatus (SFA)*	*Fluid film lubrication*	*Shear strength at the interface*	*Tribology in the human body*
S-3	SLO-1	*Modes of lubrication- hydrodynamic*	*Force between dry surface*	*Theories of hydrodynamics lubrication*	*Scale dependence on surface roughness and contact parameters*	*Tribology in the artificial organs*
	SLO-2	*Hydrostaticlubrication*	*Force between surfaces in liquid*	*Lubrication design of typical mechanical elements*	*Dependence of contact parameters on load*	*Tribology in medical devices*
S-4	SLO-1	*Boundary lubrication*	*Adhesion*	*Transformation*	*Scale effects in friction*	*Natural human synovial joints*
	SLO-2	*Elastohydrodynamic lubrication*	*Capillary forces*	*Parameter of surface topography*	*Adhesion Friction*	*Total joint replacements*
S-5	SLO-1	*Extreme pressure lubrication*	*Modes of deformation*	*Friction- Basic laws of friction*	*Two body deformation*	*Wind turbine Tribology*
	SLO-2	*Lubricants - types and lubricating oils*	*Description of AFM/FFM*	*Static and kinetic friction*	*Three body deformation*	*Biorefining*
S-6	SLO-1	*Lubricant properties-effect of temperature and pressure*	*Other measurement techniques*	*Friction of materials*	*Ratchet mechanism*	*Coating applications- sliding bearings*

	SLO-2	*Oxidation stability*	*Surface roughness*	*Solid – solid contact*	*Meniscus Analysis*	*Rolling contact*
S-7	SLO-1	*Thermal conductivity*	*Friction force*	*Liquid mediated contact*	*Total value of coefficient of friction*	*Bearings*
	SLO-2	*Type of additives*	*Scratching*	*Interfacing temperature of sliding Surfaces*	*Transformation from elastic to plastic regime*	*Gears*
S-8	SLO-1	*Bearings- classification based on mode of lubrication*	*Wear and machining*	*Wear-Laws of wear*	*Tribological properties of SAMs*	*Erosion and scratch resistant*
	SLO-2	*Bearing-Classification based on relative motion between contact surfaces*	*Surface potential measurements*	*Mild and Severe wear*	*Tailoring surfaces*	*Magnetic recording devices*
S-9	SLO-1	*Comparison of sliding and rolling contact bearing*	*Nanoindentation measurement*	*Identification of wear mechanism,*	*Modifying surface composition for application in Tribology*	*Micro components*
	SLO-2	*Solving numerical problems on above topics*	*Boundary lubrication*	*Typical test geometries*	*Modifying Structurefor application in Tribology*	*MEMS/NEMS*

Learning Resources	1. *G. Phakatkar and R.R. Ghorpade, "Tribology", Nirali publication, 2009* 2. *Bharat Bhushan, "Nanotribology and Nanomechanics", Springer Publication, Second edition,2011* 3. *Bharat Bhushan," Principles and Applications to Tribology", Wiley Publication, 2013*	4. *S. M. Sze, "Semiconductor Sensors", Wiley-Interscience,1994* 5. *C. Mathew Mate, "Tribology on the Small Scale" Oxford University Press, 2008* 6. *Nicholas D. Spencer, "Tailoring surfaces", World Scientific IISC Press, 2011*

Learning Assessment

	Bloom's Level of Thinking	Continuous Learning Assessment (50% weightage)								Final Examination (50% weightage)	
		CLA – 1 (10%)		CLA – 2 (15%)		CLA – 3 (15%)		CLA – 4 (10%)#			
		Theory	Practice	Theory	Practice	Theory	Practice	Theory	Practice	Theory	Practice
Level 1	Remember Understand	30 %	-	30 %	-	30 %	-	30 %	-	30%	-
Level 2	Apply Analyze	40 %	-	40 %	-	40 %	-	40 %	-	40%	-
Level 3	Evaluate Create	30 %	-	30 %	-	30 %	-	30 %	-	30%	-
	Total	100 %		100 %		100 %		100 %		100 %	

CLA – 4 can be from any combination of these: Assignments, Seminars, Tech Talks, Mini-Projects, Case-Studies, Self-Study, MOOCs, Certifications, Conf. Paper etc.,

Course Designers

Experts from Industry	Experts from Higher Technical Institutions	Internal Experts
1. Dr. Shinji Yamada, Kao Corporation, Tokyo, Japan, Yamada.s@kao.co.jp	*1. Dr. M. Balasubramanian, IIT Madras, mbala@iitm.ac.in*	*1. Dr. S. Yuvaraj, SRMIST*
2. Dr.Sridhar M. R, Senior Engineer, GE Global Research, Bangalore, India.	*2. Dr. M. S. Ramachandra Rao, IIT Madras, msrrao@iitm.ac.in*	*2. Dr. Kiran Mangalampalli, SRMIST*

Course Code	18NTE305T	Course Name	NANOTECHNOLOGY LEGAL ASPECTS	Course Category	E	Professional Elective Course	L	T	P	C
							3	0	0	3

Pre-requisite Courses	Nil	Co-requisite Courses	Nil	Progressive Courses	Nil
Course Offering Department	Nanotechnology	Data Book / Codes/Standards	Nil		

Course Learning Rationale (CLR):	*The purpose of learning this course is to:*
CLR-1 :	*Familiarize with the concept of patent and copyright laws*
CLR-2 :	*Understand the concept of trade mark, trade secret and IP infringement*
CLR-3 :	*Understand the government policies and rules related to nanotechnology*
CLR-4 :	*Gain knowledge on environmental degradation and current regulations*
CLR-5 :	*Learn the social and ethical impact of nanotechnology*
CLR-6 :	*Understand the concept of taxation, trade, security, privacy, export import of nanomaterials*

Course Learning Outcomes (CLO):	*At the end of this course, learners will be able to:*	Learning			Program Learning Outcomes (PLO)														
		1	2	3	1	2	3	4	5	6	7	8	9	10	11	12	13	14	15
		Level of Thinking (Bloom)	Expected Proficiency (%)	Expected Attainment (%)	Engineering Knowledge	Problem Analysis	Design & Development	Analysis, Design, Research	Modern Tool Usage	Society & Culture	Environment & Sustainability	Ethics	Individual & Team Work	Communication	Project Mgt. & Finance	Life Long Learning	PSO - 1	PSO - 2	PSO - 3
CLO-1 :	*Acquire the concepts of patent and copyright laws*	*2*	*80*	*75*	*H*	*M*	*H*	*M*	*H*	*M*	*M*	*H*	*H*	*H*	*M*	*H*	*H*	*H*	*H*
CLO-2 :	*Apply the knowledge of trade mark, trade secret and IP infringement*	*2*	*75*	*70*	*M*	*M*	*M*	*M*	*M*	*M*	*M*	*H*	*M*	*H*	*M*	*H*	*M*	*M*	*M*
CLO-3 :	*Get familiarize with the government policies and rules related to nanotechnology*	*2*	*75*	*70*	*M*	*M*	*H*	*H*	*H*	*H*	*H*	*M*	*H*	*H*	*H*	*H*	*M*	*H*	*H*
CLO-4 :	*Acquire the knowledge on environmental degradation and current regulations*	*2*	*80*	*75*	*M*	*H*	*M*	*M*	*H*	*H*	*H*	*H*	*H*	*H*	*M*	*H*	*M*	*M*	*H*
CLO-5 :	*Get familiarize with the current social and ethical impact of nanotechnology*	*2*	*80*	*75*	*M*	*M*	*M*	*M*	*H*	*M*	*M*	*H*	*M*	*H*	*M*	*H*	*H*	*M*	*H*
CLO-6 :	*Apply the knowledgeof taxation, trade, security, privacy, export import of nanomaterials*	*2*	*80*	*75*	*H*	*M*	*M*	*H*	*H*	*M*	*M*	*H*	*H*	*H*	*M*	*H*	*H*	*M*	*H*

Duration (hour)		9	9	9	9	9
S-1	SLO-1	*Introduction*	*Government policies and rules*	*Environmental degradation*	*Social impact of nanotechnology*	*Trade and business in nanotechnology*
	SLO-2	*Patents*	*Quality of information*	*Current environmental regulations*	*Economic impact of nanotechnology*	*Trade restrictions*
S-2	SLO-1	*Patentability requirements – structure of patent*	*Food and drugs evaluation method*	*Classification*	*Implications of nanotechnology*	*Taxation system*
	SLO-2	*Utility patent*	*Food and drugs research*	*Sources of pollutants*	*Effect on the quality of life*	*Taxation of goods too small to be seen*
S-3	SLO-1	*Design patent, monopoly powers*	*Classification of medical products*	*Pollution – air*	*Short term implications*	*Laws for genetic research*
	SLO-2	*licensing strategies and arrangements*	*Safe workplace*	*Pollution – water*	*Long term implications*	*Rights of new life form*
S-4	SLO-1	*Classification of patent applications*	*Self-regulation*	*Industrial waste water*	*Ethical issues in nanotechnology*	*Government surveillance*
	SLO-2	*Willful infringement issues, claim scope*	*Liability – responsibility of a scientist*	*Control and quality check*	*Social and environmental issues in nanotechnology*	*Privacy violations*
S-5	SLO-1	*Reexamination of patents*	*Civil laws*	*Dispersion methods*	*Artificial intellects*	*Security and monitoring*
	SLO-2	*Patent treaties*	*Criminal laws in nanotechnology*	*Monitoring*	*Ethics for artificial intellects*	*Eavesdropping*
S-6	SLO-1	*Copyright laws – fixation*	*Negligence to nanotechnology – breach of duty causation*	*Solid waste – homes*	*Nanotechnology and life extension*	*R&D in Nanotechnology*

	SLO-2	*Originality, creativity*	*Negligence to nanotechnology – damage and defense*	*Solid waste – industrial*	*Nanotechnology for national security*	*R&D regulation*
S-7	SLO-1	*Integrated circuit topographies*	*Risk associated with nanoparticles*	*Hospital waste*	*Nanotechnology for space exploration*	*Current industrial design laws*
	SLO-2	*Industrial designs, artistic work – arrangement of atoms*	*Nanoparticles use and effects on health*	*Hazardous chemical waste*	*Nanotechnology for medical applications*	*Change in industrial design laws*
S-8	SLO-1	*Technology transfer*	*Liability for nanoparticles side effects*	*Toxicity, health issues*	*Moral issues of Nanotechnology applications*	*Export – import regulations*
	SLO-2	*Trademarks*	*Role and responsibilities*	*Safety issues*	*Public perception of Nano-technological risk*	*Crimes using Nanoparticles*
S-9	SLO-1	*Trade secrets*	*Class action*	*Risk assessment and analysis*	*Education of public about Nanotechnology*	*Corporate criminal liability,*
	SLO-2	*Ownership of IP*	*Certification*	*Responsibility and rules*	*Training of public about Nanomaterials*	*prevention and detention*

Learning Resources	1. *Patrick M. Boucher, "Nanotechnology: Legal aspects" CRC press, 2008* 2. *Fritz Allhoff, Patrick Lin, James Moor, John Weckert, "NanoEthics: The ethical and social implications of nanotechnology" Wiley publication, 2007*	3. *Louis Theodore, Robert G. Kunz, "Nanotechnology: Environmental implications and solutions" Wiley Publication, 2005*

Learning Assessment

	Bloom's Level of Thinking	Continuous Learning Assessment (50% weightage)								Final Examination (50% weightage)	
		CLA – 1 (10%)		CLA – 2 (15%)		CLA – 3 (15%)		CLA – 4 (10%)#			
		Theory	Practice	Theory	Practice	Theory	Practice	Theory	Practice	Theory	Practice
Level 1	Remember Understand	30 %	-	30 %	-	30 %	-	30 %	-	30%	-
Level 2	Apply Analyze	40 %	-	40 %	-	40 %	-	40 %	-	40%	-
Level 3	Evaluate Create	30 %	-	30 %	-	30 %	-	30 %	-	30%	-
	Total	100 %		100 %		100 %		100 %		100 %	

CLA – 4 can be from any combination of these: Assignments, Seminars, Tech Talks, Mini-Projects, Case-Studies, Self-Study, MOOCs, Certifications, Conf. Paper etc.,

Course Designers

Experts from Industry	Experts from Higher Technical Institutions	Internal Experts
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2. Dr. Krishna Surendra Muvvala, Saint Gobain Research India, India, Krishna.muvvala@saintgobain.com	*2. Prof. D. Arivuoli, Anna University, arivuoli@annauniv.edu*	*2. Dr. A. Karthigeyan, SRMIST*

Course Code	18NTE306T	Course Name	LITHOGRAPHIC TECHNIQUES AND FABRICATION	Course Category	E	Professional Elective Course	L	T	P	C
							3	0	0	3

Pre-requisite Courses	Nil	Co-requisite Courses	Micro and Nanofabrication	Progressive Courses	Nil
Course Offering Department	Nanotechnology	Data Book / Codes/Standards	Nil		

Course Learning Rationale (CLR):	*The purpose of learning this course is to:*
CLR-1 :	*Understand the physical significance of lithography tools in micro/nano structures creation*
CLR-2 :	*Acquire knowledge on masked lithography, uv and deep uv lithography, its merits and demerits*
CLR-3 :	*Understand the concept of direct lithography, its advantages; electron beam for lithography and their applications*
CLR-4 :	*Acquiring comparative knowledge of different lithography tools*
CLR-5 :	*Acquire knowledge on the replication tools such as nano imprint lithography, injection molding and others.*
CLR-6 :	*Make aware of VLSI technology*

Course Learning Outcomes (CLO):	*At the end of this course, learners will be able to:*	Learning 1: Level of Thinking (Bloom)	Learning 2: Expected Proficiency (%)	Learning 3: Expected Attainment (%)	PLO 1: Engineering Knowledge	2: Problem Analysis	3: Design & Development	4: Analysis, Design, Research	5: Modern Tool Usage	6: Society & Culture	7: Environment & Sustainability	8: Ethics	9: Individual & Team Work	10: Communication	11: Project Mgt. & Finance	12: Life Long Learning	13: PSO - 1	14: PSO - 2	15: PSO - 3
CLO-1 :	*Make use of top-down approach for micro/nano fabrication*	2	80	75	H	M	H	H	H	M	M	H	H	H	M	M	H	H	H
CLO-2 :	*Analyze the limitation of masked lithography with respect to incident radiation*	2	80	70	H	M	M	H	M	M	M	H	M	H	M	H	M	M	M
CLO-3 :	*Using electron beams for the creation of nano structures*	2	75	70	H	M	H	H	H	H	H	M	H	H	H	M	H	H	H
CLO-4 :	*Know the other techniques of nano fabrication using light and heavy ion beams*	2	80	75	M	H	H	M	H	H	H	H	H	H	M	M	H	H	H
CLO-5 :	*Apply knowledge of mass production replication tools*	2	80	70	H	M	H	H	H	M	M	H	M	H	M	M	H	H	H
CLO-6 :	*Imagine importance of nanoscale devices*	2	80	75	H	M	M	H	H	M	M	H	H	H	M	H	H	M	H

Duration (hour)		9	9	9	9	9
S-1	SLO-1	*Micro/nano fabrication*	*Optical(photo) lithography*	*Introduction-maskless/direct lithography tools*	*Ion beam lithography (IBL) types*	*Micro/ Nano replication tools*
	SLO-2	*Top-down & bottom-up approach*	*Process steps*	*Difference between masked and maskless lithography*	*Heavy and light ions for lithography*	*Necessity for replication*
S-2	SLO-1	*Necessity for clean room, types of clean room*	*Optical lithography mask*	*Advantages and disadvantages of maskless lithography*	*Focused ion beam properties*	*Application areas-MEMS/NEMS, micro/nanofluidics*
	SLO-2	*Construction and maintenance of clean room,*	*Mask definition, and different materials*	*Principles of electron beam lithography (EBL) system*	*Beam scanning*	*Soft lithography*
S-3	SLO-1	*Clean room standards, protocols*	*Different light sources*	*Electron properties for lithography*	*Resists for ion beam lithography*	*PDMS Casting*
	SLO-2	*Lithography- process steps*	*Contact and proximity exposures*	*Design of electron beam lithography system*	*Electron lithography process flow*	*Mold fabrication for soft lithography*
S-4	SLO-1	*Photo resists materials, types and characteristics*	*Diffraction limit and resolutions enhancement methods*	*Operation of electron beam lithography system*	*Focused ion beam lithography- Incident ion properties*	*Micro injection molding*
	SLO-2	*Spin coating methods*	*Projection lithography*	*E-beam resists*	*Principle, design and operation*	*Hot embossing*
S-5	SLO-1	*Exposure dose*	*Extreme UV (EUV) lithography*	*E-beam resist properties*	*Masked ion beam structuring: Broad beam patterning*	*Nano imprint lithography NIL principles*
	SLO-2	*chemical development, optimization*	*EUV: Scope and demerits*	*Comparison with optical lithography resists*	*Atom lithography*	*Mold fabrication for hot embossing and NIL*
S-6	SLO-1	*Etching methods, resist and other materials*	*Interferometric and holographic tools*	*Dose calculation*	*Proton beam lithography*	*Mold fabrication for injection molding*

	SLO-2	*Dry and wet methods*	*Lithography masks*	*Significance of beam blanking*	*Comparison of electron, proton and gallium for resist patterning*	*Process flow and requirements*
S-7	SLO-1	*Wet etching chemicals, Si etching*	*Laser writer: near UV and Deep UV masks*	*Patterning resolution comparison with other methods*	*Limitation and suitability of each technique in comparison with one another*	*Polymers for imprinting*
	SLO-2	*Wet etching examples*	*Synchrotron radiation for lithography processes*	*EBL for mask preparation*	*IBL resists, dose calculation and process optimization*	*Polymer characteristics and performance*
S-8	SLO-1	*Reactive ion etching*	*X-ray lithography mask*	*Nanofabrication with EBL – MEMS*	*Nanofabrication with IBL – MEMS*	*Master mold preparation for replication tools, comparison*
	SLO-2	*Isotropic and non isotropic etching*	*X-ray lithography, merits and demerits*	*Nanofabrication with EBL – NEMS*	*Nanofabrication with IBL – NEMS*	*Application-microfluidics*
S-9	SLO-1	*Types of lithography : classification*	*Comparison of all masked lithography tools*	*Nanofabrication with EBL –microfluidics applications*	*Nanofabrication with IBL –microfluidics applications*	*Application-nano fluidics*
	SLO-2	*Introduction to next generation lithography tools*	*Specific applications of different lithography tools.*	*Nanofabrication with EBL – Nanofluidics applications*	*Nanofabrication with IBL – Nanofluidics applications*	*Industrial applications*

Learning Resources	1. *Chris A. Mack, Fundamental Principles of Optical Lithography: The Science of Microfabrication, John Wiley & Sons, London 2007* 2. *Stefan Landis, "Lithography and nanolithography", Published by Wiley - ISTE, 2010*	

Learning Assessment											
	Bloom's Level of Thinking	Continuous Learning Assessment (50% weightage)								Final Examination (50% weightage)	
		CLA – 1 (10%)		CLA – 2 (15%)		CLA – 3 (15%)		CLA – 4 (10%)#			
		Theory	Practice	Theory	Practice	Theory	Practice	Theory	Practice	Theory	Practice
Level 1	Remember Understand	30 %	-	30 %	-	30 %	-	30 %	-	30%	-
Level 2	Apply Analyze	40 %	-	40 %	-	40 %	-	40 %	-	40%	-
Level 3	Evaluate Create	30 %	-	30 %	-	30 %	-	30 %	-	30%	-
	Total	100 %		100 %		100 %		100 %		100 %	

CLA – 4 can be from any combination of these: Assignments, Seminars, Tech Talks, Mini-Projects, Case-Studies, Self-Study, MOOCs, Certifications, Conf. Paper etc.,

Course Designers		
Experts from Industry	Experts from Higher Technical Institutions	Internal Experts
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2. Dr. Krishna Surendra Muvvala, Saint Gobain Research India, India, Krishna.muvvala@saintgobain.com	*2. Dr.N. N. Murthy, IIT Tirupati, nnmurty@iittp.ac.in*	*2. Dr. P. Malar, SRMIST*

Course Code	18NTE307T	Course Name	SENSORS AND TRANSDUCERS	Course Category	E	Professional Elective Course	L	T	P	C
							3	0	0	3

Pre-requisite Courses	Nil	Co-requisite Courses	Nil	Progressive Courses	Nil
Course Offering Department	Nanotechnology	Data Book / Codes/Standards	Nil		

Course Learning Rationale (CLR):	*The purpose of learning this course is to:*
CLR-1 :	*Understand basic principles and characteristics of sensors and transducers*
CLR-2 :	*Gain knowledge on mechanical and electromechanical sensors*
CLR-3 :	*Get acquainted with thermal sensors and its types*
CLR-4 :	*Know about magnetic sensors and radiation sensors*
CLR-5 :	*Gain knowledge on electrochemical sensors*
CLR-6 :	*Apprehend knowledge on recent trends in sensor technologies and applications*

Course Learning Outcomes (CLO):	*At the end of this course, learners will be able to:*	Learning 1 Level of Thinking (Bloom)	2 Expected Proficiency (%)	3 Expected Attainment (%)	Program Learning Outcomes (PLO) 1 Engineering Knowledge	2 Problem Analysis	3 Design & Development	4 Analysis, Design, Research	5 Modern Tool Usage	6 Society & Culture	7 Environment & Sustainability	8 Ethics	9 Individual & Team Work	10 Communication	11 Project Mgt. & Finance	12 Life Long Learning	13 PSO - 1	14 PSO - 2	15 PSO - 3
CLO-1 :	*Analyze calibration techniques and signal types of sensors*	2	80	75	H	M	H	H	H	M	M	H	H	H	M	M	H	H	H
CLO-2 :	*Expertise in various types of Sensors & Transducers and their working principles*	2	80	70	H	M	M	H	M	M	M	H	M	H	M	M	M	M	M
CLO-3 :	*Evaluate performance characteristics of different sensors and transducers*	2	75	70	H	M	H	H	H	H	H	M	H	H	H	M	H	H	H
CLO-4 :	*Predict exactly the expected performance of various sensors*	2	80	75	M	H	H	M	H	H	H	H	H	H	M	H	H	H	H
CLO-5 :	*Develop advance techniques in sensor technology*	2	80	70	H	M	H	H	H	M	M	H	M	H	M	H	H	H	H
CLO-6 :	*Devise smart sensors for real time applications*	2	80	75	H	M	M	H	H	M	M	H	H	H	M	H	H	M	H

Duration (hour)		9	9	9	9	9
S-1	SLO-1	*Measurements-Basic method of measurement*	*Mechanical and electromechanical sensors Resistive potentiometer*	*Thermal sensors- Gas thermometric sensors*	*Magnetic sensors-Introduction*	*Electroanalytical sensors-introduction*
	SLO-2	*Errors*	*Strain gauge*	*Thermal expansion type thermometric sensors*	*Principles behind*	*Electrochemical cell*
S-2	SLO-1	*Classification of errors*	*Inductive sensors*	*Acoustic temperature sensor*	*Yoke coil sensors*	*Sensor electrodes-Molecular selective electrodes*
	SLO-2	*Error analysis*	*Sensitivity and linearity of sensor*	*Dielectric constant and refractive index of thermosensors*	*Coaxial type sensors-Force and displacement sensors*	*ChemFET*
S-3	SLO-1	*Statistical methods*	*Ferromagnetic plunger type transducers*	*Helium low temperature thermometer-Nuclear thermometer*	*Magnetoresistive sensors- Anisotropic magnetoresistive sensing*	*Recent trends in sensor technologies*
	SLO-2	*Sensors/Transducers-Introduction*	*Electromagnetic transducer*	*Magnetic thermometer*	*Semiconductor magnetoresistors*	*Film sensors- Thick and thin film sensors*
S-4	SLO-1	*Principles of Sensors/Transducers*	*Magnetostrictive transducer*	*Resistance change type thermometric sensors*	*Active semiconductor magnetic sensors*	*Semiconductor IC technology*
	SLO-2	*Classification of Sensors/Transducers*	*Capacitive sensors*	*Metal resistance thermometric sensors*	*Hall effect sensor-sensor geometry and fabrication*	*Micro electro mechanical system (MEMS)-micromachining*
S-5	SLO-1	*Static Characteristics of Sensors/Transducers*	*Parallel plate capacitive sensor*	*Thermistors*	*Variable inductance sensors*	*Some application examples*
	SLO-2	*Accuracy-Precision-Resolution-Minimum detectable signal*	*Serrated plate capacitive sensor*	*Thermo emf sensors*	*Eddy current sensors*	*Nanosensors*
S-6	SLO-1	*Threshold-Sensitivity-Selectivity and specificity-Non-linearity*	*Variable thickness dielectric capacitive sensor*	*Materials for thermo emf sensors*	*Radiation sensors-Introduction-basic characteristics*	*Onboard automobile sensors-flow rate sensors-pressure sensors*
	SLO-2	*Hysteresis-Output impedance-isolation and grounding*	*Stretched diaphragm variable capacitance transducer*	*E (emf)-T(Temperature) relations*	*Types of photoresistors/photodetectors*	*Temperature sensors-oxygen sensors*

S-7	SLO-1	*Dynamic Characteristics*	*Electrostatic transducer*	*Thermosensors using semiconductor devices*	*Photoemissive cell and photomutliplier*	*Torque and position sensors*
	SLO-2	*Zero order and First order sensors*	*Piezoelectric elements*	*Thermal radiation sensors*	*Photoconductive cell-LDR*	*Home appliance sensors*
S-8	SLO-1	*Second order sensors*	*Piezoelectric materials*	*Detectors*	*Photocurrent*	*Aerospace sensors-Fluid velocity sensors*
	SLO-2	*Electrical characterization*	*Deformation modes and multimorphs*	*Pyroelectric thermal sensors*	*Photoresistors and photoFETs and other devices*	*Sensing direction of air flow- Monitoring strain, force, thrust and acceleration*
S-9	SLO-1	*Mechanical and thermal characterization*	*Lead zirconatetitanate (PZT) family*	*Quartz crystal thermoelectric sensors*	*Fibre optic sensors*	*Medical diagnostic sensors*
	SLO-2	*Optical characterization-Chemical/biological characterization*	*Force/stress sensors using quartz resonators*	*Heat flux sensors*	*Temperature sensors-microbend sensors*	*Sensors for environmental monitoring*

Learning Resources	1. *Ernest O Doebelin, "Measurement Systems – Applications and Design", 4th ed., Tata McGraw-Hill, 2009* 2. *John P. Bentley, "Principles of Measurement Systems", 4th ed., Pearson Education, 2000.*	3. *D. Patranabis, Sensors and Transducers, 2nd ed., Prentice Hall of India, 2010* 4. *D.V.S Murthy, Transducers and Instrumentation, 2nd ed., Prentice Hall of India, 2001.*

Learning Assessment

	Bloom's Level of Thinking	Continuous Learning Assessment (50% weightage)								Final Examination (50% weightage)	
		CLA – 1 (10%)		CLA – 2 (15%)		CLA – 3 (15%)		CLA – 4 (10%)#			
		Theory	Practice	Theory	Practice	Theory	Practice	Theory	Practice	Theory	Practice
Level 1	Remember Understand	30 %	-	30 %	-	30 %	-	30 %	-	30%	-
Level 2	Apply Analyze	40 %	-	40 %	-	40 %	-	40 %	-	40%	-
Level 3	Evaluate Create	30 %	-	30 %	-	30 %	-	30 %	-	30%	-
	Total	100 %		100 %		100 %		100 %		100 %	

CLA – 4 can be from any combination of these: Assignments, Seminars, Tech Talks, Mini-Projects, Case-Studies, Self-Study, MOOCs, Certifications, Conf. Paper etc.,

Course Designers

Experts from Industry	Experts from Higher Technical Institutions	Internal Experts
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Course Code	18NTE308T	Course Name	2-D LAYERED NANOMATERIALS	Course Category	E	Professional Elective Course	L	T	P	C
							3	0	0	3

Pre-requisite Courses	Nil	Co-requisite Courses	Nil	Progressive Courses	Nil
Course Offering Department	Nanotechnology	Data Book / Codes/Standards	Nil		

Course Learning Rationale (CLR):	*The purpose of learning this course is to:*
CLR-1 :	*Understanding the electronic properties of 2D materials, especially Graphene*
CLR-2 :	*Acquire knowledge on the different synthesis methods*
CLR-3 :	*Describe the difference in various properties of 2D-layered structure*
CLR-4 :	*Classification of 2D layered Nanomaterials*
CLR-5 :	*Gain knowledge on application of layered Nanomaterials*
CLR-6:	*Understand the principles of various characterization tools to study the properties of 2D materials*

Course Learning Outcomes (CLO):	*At the end of this course, learners will be able to:*	Learning 1: Level of Thinking (Bloom)	2: Expected Proficiency (%)	3: Expected Attainment (%)	PLO 1: Engineering Knowledge	2: Problem Analysis	3: Design & Development	4: Analysis, Design, Research	5: Modern Tool Usage	6: Society & Culture	7: Environment & Sustainability	8: Ethics	9: Individual & Team Work	10: Communication	11: Project Mgt. & Finance	12: Life Long Learning	13: PSO - 1	14: PSO - 2	15: PSO - 3
CLO-1 :	*Apply the concept of atomic and electronic structure to understand the physical and chemical properties of graphene*	2	80	75	M	H	H	H	H	M	M	H	H	H	M	H	H	H	H
CLO-2 :	*Utilize the procedure to synthesize layered materials and the concept of Raman spectra over synthesized materials*	2	80	70	M	H	M	H	M	M	M	H	M	H	M	H	M	M	M
CLO-3 :	*Utilize the spectroscopic concepts to analyze the properties of layered materials*	2	75	70	M	H	H	H	H	H	H	M	H	H	H	H	H	H	H
CLO-4 :	*Apply the concept and the uses of semiconducting and metal dichalcogenides based materials*	2	80	75	M	H	H	M	H	H	H	H	H	H	M	H	H	H	H
CLO-5 :	*Utilize the application of layered materials in various fields.*	2	80	70	H	H	H	H	H	M	M	H	M	H	M	H	H	H	H
CLO-6:	*Utilize the concept of sensor to analyze the material nature.*	2	80	75	M	H	M	H	H	M	M	H	H	H	M	H	H	M	H

Duration (hour)		9	9	9	9	9
S-1	SLO-1	*Introduction of graphene*	*Introduction to Scotch-tape method (micromechanical cleavage)*	*Introduction to X-ray photoemission spectroscopy*	*Graphene and its properties*	*Introduction to Gas sensors*
	SLO-2	*Vander Walls force*	*Preparation of graphene using Scotch-tape method*	*Limitation and application of XPS*	*Penta-graphene and its properties*	*Gas sensing mechanism and types of sensor*
S-2	SLO-1	*Covalent bond*	*Introduction and principle of Chemical vapor deposition*	*Introduction to X-ray diffraction study*	*h-BN structure, synthesis and properties*	*Chemical sensors*
	SLO-2	*Dimension of carbon allotrope*	*Preparation of graphene by CVD*	*Limitation and application of XRD*	*Application of h-BN*	*Uses smart materials in sensors*
S-3	SLO-1	*Transition of metal dichalcogenides*	*Introduction to Solution-exfoliation*	*Introduction to Optical absorption spectroscopy*	*SiC structure, synthesis and properties*	*2D materials based membranes*
	SLO-2	*Manipulation of quantum degree of freedom*	*Preparation of graphene using solution-exfoliation*	*Limitation and application of optical absorption spectroscopy*	*Application of SiC*	*Application of membrance*
S-4	SLO-1	*Crystal plane of 2D graphene*	*Introduction to Solution-exfoliation*	*Introduction and limitations of Scanning Tunneling Microscopy*	*Si structure, synthesis and properties*	*Oxygen reduction reaction*
	SLO-2	*Free standing model*	*Preparation of 2D layered material by solution exfoliation*	*Measuring mechanical properties*	*Application of Silicon*	*Uses of 2D materials in enhance the activity*
S-5	SLO-1	*Electronic structure of graphene*	*Decomposition*	*Introduction and limitations to BET analysis*	*Ge structure, synthesis and properties*	*Hydrogen production, types of hydrogen production*
	SLO-2	*Band structure*	*Decomposition of silicon carbide*	*Adsorption properties*	*Application of Ge*	*Uses of 2D materials in hydrogen production*
S-6	SLO-1	*Fermi levels in graphene*	*Principles of Raman spectroscopy*	*Introduction and limitations to VSM analysis*	*Types of oxide materials*	*Electronic devices*
	SLO-2	*Carrier density*	*Limitations of Raman spectroscopy*	*Magnetic properties*	*Properties of oxide materials*	*Difference between electronic and electric device*

S-7	SLO-1	*Role of defect and dopant*	*Raman spectrum of graphene*	*Types of interactions*	*Introduction and types of transition metal dichalcogenides*	*Optical materials*
	SLO-2	*Electronic structure of graphene*	*Analysis of D band Raman spectra*	*Catalytic properties*	*Introduction and application of* MoS_2	*Solar absorber materials*
S-8	SLO-1	*Tensile strength*	*Analysis of G band Raman spectra*	*Metal support interactions*	*Introduction and application of* VS_2	*Magnetic devices*
	SLO-2	*Physical properties of graphene*	*Raman shift dependence on number of layer*	*Changes in the properties due to metal support interaction*	*Introduction and application of* WS_2	*Materials used*
S-9	SLO-1	*Functional properties of graphene*	*Raman shift dependence on defect*	*Non-metal support interactions*	*Introduction of Si2BN and its application*	*Types of magnetic devices*
	SLO-2	*Chemical properties of graphene*	*Raman shift dependence on doping concentration*	*Difference in properties due to non-metal support interactions*	*Introduction of BCN and its applications*	*Applications of magnetic devices*

Learning Resources	1. *Houssa, Michel, Athanasios Dimoulas, and Alessandro Molle, "2D Materials for Nanoelectronics"- CRC Press, 2016.* 2. *Banks, Craig E., and Dale AC Brownson, eds. "2D Materials: Characterization, Production and Applications"- CRC Press, 2018.*	3. *Tiwari, Ashutosh, and Mikael Syväjärvi, eds. "Advanced 2D Materials" - John Wiley & Sons, 2016.* 4. *Dragoman, Mircea, and Daniela Dragoman,"2D Nanoelectronics: Physics and Devices of Atomically Thin Materials"- Springer, 2016.*

Learning Assessment

	Bloom's Level of Thinking	Continuous Learning Assessment (50% weightage)								Final Examination (50% weightage)	
		CLA – 1 (10%)		CLA – 2 (15%)		CLA – 3 (15%)		CLA – 4 (10%)#			
		Theory	Practice	Theory	Practice	Theory	Practice	Theory	Practice	Theory	Practice
Level 1	Remember Understand	30 %	-	30 %	-	30 %	-	30 %	-	30%	-
Level 2	Apply Analyze	40 %	-	40 %	-	40 %	-	40 %	-	40%	-
Level 3	Evaluate Create	30 %	-	30 %	-	30 %	-	30 %	-	30%	-
	Total	100 %		100 %		100 %		100 %		100 %	

CLA – 4 can be from any combination of these: Assignments, Seminars, Tech Talks, Mini-Projects, Case-Studies, Self-Study, MOOCs, Certifications, Conf. Paper etc.,

Course Designers

Experts from Industry	Experts from Higher Technical Institutions	Internal Experts
1. Dr. Hemant Dixit, Global Foundaries, USA, aplahemant@gmail.com	*Prof. K. Sethupathi. IIT Madras, ksethu@iitm.ac.in*	*Dr. J. Archana, SRMIST*
2. Dr. Krishna Surendra Muvvala, Saint Gobain Research India, India, Krishna.muvvala@saintgobain.com	*Dr. S. Balakumar. University of Madras, Madras, balakumar@iunom.ac.in*	*Dr. S. Harish, SRMIST*

Course Code	18NTE309T	Course Name	SUPRAMOLECULAR SYSTEMS	Course Category	E	Professional Elective Course	L	T	P	C
							3	0	0	3

Pre-requisite Courses	Nil	Co-requisite Courses	Nil	Progressive Courses	Nil
Course Offering Department	Nanotechnology	Data Book / Codes/Standards	Nil		

Course Learning Rationale (CLR):	*The purpose of learning this course is to:*
CLR-1 :	*Acquire the concepts of supramolecular chemistry*
CLR-2 :	*Utilize designing new materials of metal-organic frame works*
CLR-3 :	*Describe the concept of nanostructured objects*
CLR-4 :	*Understand the principles of supramolecular chirality*
CLR-5 :	*Gain knowledge on host-guest complexes*
CLR-6 :	*Understand the principles sophisticated molecular devices and infinite multicomponent systems*

Course Learning Outcomes (CLO):	*At the end of this course, learners will be able to:*	Learning 1: Level of Thinking (Bloom)	Learning 2: Expected Proficiency (%)	Learning 3: Expected Attainment (%)	PLO 1: Engineering Knowledge	PLO 2: Problem Analysis	PLO 3: Design & Development	PLO 4: Analysis, Design, Research	PLO 5: Modern Tool Usage	PLO 6: Society & Culture	PLO 7: Environment & Sustainability	PLO 8: Ethics	PLO 9: Individual & Team Work	PLO 10: Communication	PLO 11: Project Mgt. & Finance	PLO 12: Life Long Learning	PLO 13: PSO - 1	PLO 14: PSO - 2	PLO 15: PSO - 3
CLO-1 :	*Recognize the main types of supramolecular assemblies*	2	80	75	H	M	H	H	H	M	M	H	H	H	M	H	H	H	H
CLO-2 :	*Apply the importance of the bottom-up approach to prepare complex (nanoscale) systems*	2	80	70	H	M	M	M	M	M	M	H	M	M	M	H	M	M	M
CLO-3 :	*Identify the main supramolecular forces involved in such systems*	2	75	70	H	M	H	H	H	H	H	M	H	H	H	M	H	H	H
CLO-4 :	*Analyze and understand the intermolecular forces to rationalize the formation of complex nanomaterials.*	2	80	75	M	H	H	M	H	H	H	H	H	H	M	H	H	H	H
CLO-5 :	*Evaluate the needs of sustainable future, develop the supramolecular molecular materials for biological systems*	2	80	70	H	M	H	H	H	M	M	H	M	M	M	M	H	H	H
CLO-6 :	*Apply through feasible approaches, and assemble with the prior knowledge to fabricate novel designs/architectures*	2	80	75	H	M	M	H	M	M	M	H	H	H	M	H	H	M	M

Duration (hour)		9	9	9	9	9
S-1	SLO-1	*Basic concepts and principles of supramolecular chemistry*	*Introduction to coordination chemistry*	*Biological inspiration for supramolecular chemistry*	*Supramolecular Chirality*	*Special Class Materials*
	SLO-2	*Classification of supramolecular compounds*	*Hosts for cation binding*	*Alkali metal cations in biochemistry*	*Chirality in Self-Assembled Systems*	*Birth of a new macromolecular chemistry concept*
S-2	SLO-1	*Host-guest compounds*	*Cation receptors*	*Co-ordination Polymers*	*Chirality of Host-Guest Compounds*	*Rational Design*
	SLO-2	*Receptors, coordination compounds*	*Crown ethers*	*Clathrates*	*Chirality of Interlocked Systems*	*Molecular Paneling*
S-3	SLO-1	*Lock and key analogy*	*Cryptands*	*Cavitands*	*Metal Organic Frameworks (MOFs)*	*Artifical Self Replicating Systems*
	SLO-2	*Binding constants*	*Spherands*	*Binding by cavitands*	*Covalent Organic Frameworks*	*Supramolecular reactivity and catalysis*
S-4	SLO-1	*Cooperative effect*	*Calixarens*	*Cyclodextrins*	*Polymorphism*	*The past, present and future of dendrimers and dendrons*
	SLO-2	*Chelate effect*	*Selectivity of cation complex*	*Cucurbituril*	*Solvates*	*Supramolecular assembly of dendrons and dendrimers*
S-5	SLO-1	*Thermodynamic selectivity*	*Macrocyclic effects*	*Porphyrins and tetrapyrrole macrocyles*	*Co-Crystals*	*Synthesis of dendritic polymers*
	SLO-2	*Kinetic selectivity and discriminations*	*Template effects*	*Transport processes*	*Principles of supramolecular Extraction*	*Characterization of dendritic architectural structures*
S-6	SLO-1	*Nature of supramolecular interactions*	*Host for anion binding*	*Dynamic Combinatorial chemistry*	*Extraction technique, the extraction equilibrium*	*Nanomedical and advanced materials*
	SLO-2	*Solvation effects*	*Concepts in anion host design*	*Supramolecular features of plant photosynthesis*	*Examples of supramolecular extraction*	*Diagnostics and advanced imaging*

S-7	SLO-1	*Hydrophobic effects*	*Anion receptors*	*Uptake and transport of oxygen by haemoglobin*	*Binding Constant*	*Characterization of dendritic architectural structures*
	SLO-2	*Supramolecular concepts and design*	*Shape and selectivity*	*Enzymes and coenzymes*	*Binding constant determination by UV/Vis spectroscopy*	*Nanoscience applications*
S-8	SLO-1	*Hydrogen bonding and supramolecular interactions*	*Neutral receptors*	*Neurotransmitters and hormones*	*Instrumentation of mass spectrometry, Limitations of mass spectrometry*	*Molecular and Supramolecular devices*
	SLO-2	*Secondary Electrostatic Interactions in Hydrogen Bonding*	*From cation host to anion host – a simple change in pH*	*Enzymes, Metallobiosites*	*Scanning probe microscopes: - scanning electron microscopy*	*Molecular Electronic Devices*
S-9	SLO-1	*Molecular recognition*	*Hosts for binding of neutral guests*	*Heme analogues*	*Transmission electron microscopy*	*Switches*
	SLO-2	*Types of recognition*	*Inert metal- containing receptors*	*Semiochemistry in natural world, Biochemical self-assembly*	*Confocal laser scanning microscopy*	*Molecular Machines*

Learning Resources	*1. Jonathan W. Steed and Jerry L. Atwood, "Supramolecular Chemistry"J. Wiley and Sons; 1st Ed. 2000* *2. J.M. Lehn, Supramolecular Chemistry, VCH, Wiley and Sons, 1st Ed. Weinheim, 1995*	*3. Donald A. Tomalia, Jørn B. Christensen, Ulrik Boas, "Dendrimers, Dendrons, and Dendritic Polymers: Discovery, Applications and the Future", MPG books group, UK, 2012*

Learning Assessment											
	Bloom's Level of Thinking	Continuous Learning Assessment (50% weightage)								Final Examination (50% weightage)	
		CLA – 1 (10%)		CLA – 2 (15%)		CLA – 3 (15%)		CLA – 4 (10%)#			
		Theory	Practice	Theory	Practice	Theory	Practice	Theory	Practice	Theory	Practice
Level 1	Remember Understand	30 %	-	30 %	-	30 %	-	30 %	-	30%	-
Level 2	Apply Analyze	40 %	-	40 %	-	40 %	-	40 %	-	40%	-
Level 3	Evaluate Create	30 %	-	30 %	-	30 %	-	30 %	-	30%	-
	Total	100 %		100 %		100 %		100 %		100 %	

CLA – 4 can be from any combination of these: Assignments, Seminars, Tech Talks, Mini-Projects, Case-Studies, Self-Study, MOOCs, Certifications, Conf. Paper etc.,

Course Designers		
Experts from Industry	Experts from Higher Technical Institutions	Internal Experts
1. Dr. P. Sudhakara, CLRI – CSIR, Jalandhar, sudhakarp@clri.res.in	*1. Dr. Kothandaraman Ramanujam, IITM Chennai, rkraman@iitm.ac.in*	*1. Dr. Angeline Little Flower, SRMIST*
2. Dr. Sudhakar selvakumar, CSIR-Central Electrochemical Research Institute, ssudhakar79@gmail.com	*2. Dr.Arthanreeswaran, NIT, Trichy,arthanareeg@nitt.edu*	*2. Dr. S. HariniPriya, SRMIST*

Course Code	18NTE310T	Course Name	MEMS and NEMS	Course Category	E	Professional Elective	L	T	P	C
							3	0	0	3

Pre-requisite Courses	Nil	Co-requisite Courses	Nil	Progressive Courses	Nil
Course Offering Department	Nanotechnology	Data Book / Codes/Standards	Nil		

Course Learning Rationale (CLR):	*The purpose of learning this course is to:*
CLR-1 :	*Learn what are MEMS? and where they are useful?*
CLR-2 :	*Understand the basics of fabrication of electromechanical systems at micro and nanoscale and modeling*
CLR-3 :	*Understand the principles of sensing and actuation in electromechanical systems*
CLR-4 :	*Explore magnetic materials for suitable for magnetic MEMS*
CLR-5 :	*Gain knowledge on thermal, micro-opto-MEMS materials*
CLR-6 :	*Acquire knowledge on the fabrication, characterization and applications of RF, optical, MEMS Understand the*

Course Learning Outcomes (CLO):	*At the end of this course, learners will be able to:*	Learning 1: Level of Thinking (Bloom)	2: Expected Proficiency (%)	3: Expected Attainment (%)	PLO 1: Engineering Knowledge	2: Problem Analysis	3: Design & Development	4: Analysis, Design, Research	5: Modern Tool Usage	6: Society & Culture	7: Environment & Sustainability	8: Ethics	9: Individual & Team Work	10: Communication	11: Project Mgt. & Finance	12: Life Long Learning	13: PSO - 1	14: PSO - 2	15: PSO - 3
CLO-1 :	*Utilize mechanics principles to analyze the mechanical performance of microsystems.*	2	80	75	H	M	H	H	H	M	M	H	H	H	M	H	H	H	H
CLO-2 :	*Utilize optics, electrical and mechanical principles to analyze optoelectro mechanical performance of MOEMS*	2	80	70	H	M	M	H	M	M	M	H	M	H	M	H	M	M	M
CLO-3 :	*Use the radio frequency and thermal principles to analyze the performance of RF and thermal MEMS*	2	75	70	H	M	H	H	H	H	H	M	H	H	H	M	H	H	H
CLO-4 :	*Use magnetic and fluid principles to analyze the performance of magnetic MEMS and microfluidic devices*	2	80	75	M	H	H	M	H	H	H	H	H	H	M	M	H	H	H
CLO-5 :	*Analyze the tools and processes used in micromaching of MEMS*	2	80	70	H	M	H	H	H	M	M	H	M	H	M	H	H	H	H
CLO-6 :	*Apply the principles of physics to analyze and design MEMS, including sensors and actuators.*	2	80	75	H	M	M	H	H	M	M	H	H	H	M	M	H	M	H

Duration (hour)		9	9	9	9	9
S-1	SLO-1	*Micro and nanoelectro mechanical systems (MEMS and NEMS)*	*Photolithography*	*Principles of sensing and actuation*	*Magnetic materials: properties,*	*Principles of MOEMS technology, Applications*
	SLO-2	*Importance of MEMS in daily life*	*Surface machining, bulk machining, etching*	*Role of microsensors and microactuator with examples*	*Magnetoresistive materials, magnetostrictive materials,*	*Hybrid systems, application, advantages*
S-2	SLO-1	*MEMS and NEMS - Scaling Laws*	*Structural materials*	*Components of mechanical MEMS*	*hard magnetic materials, design considerations in magnetic materials*	*MOEMS components*
	SLO-2	*Conventional electromechanical systems*	*Sacrificial materials*	*Beam, cantilever, microplates*	*Magnetic sensing and design*	*Light modulators, beam splitters, Micro lens,*
S-3	SLO-1	*Mathematical Modeling*	*Thin film deposition, Impurity doping, etching*	*diaphragm structures theory, corrugated diaphragms*	*Presence and direction detection of large object – an example*	*micro mirror, digital micromirror device*
	SLO-2	*Important steps for analysis and design of engineering steps*	*Bulk and surface micromachining*	*Components in sensors*	*Magneto resistive sensor*	*MOEMS devices*
S-4	SLO-1	*Microsensors and microactuators*	*Physical and chemical vapor deposition methods,*	*Capacitive effects, piezo element, piezo mechanics,*	*Principle of magnetoresistive sensor, hall effect, magntrotransitor*	*Optical switch, wave guide and tuning,*
	SLO-2	*Principle of sensing and actuation, capacitive sensors, pressure sensors*	*P and N-type doping in semiconductors, surface machining at macro and microscales.*	*Measurement methods*	*MEMS magnetic sensors and actuators*	*shear stress measurement*
S-5	SLO-1	*Mechanical MEMS, Thermal MEMS*	*Wafer bonding and LIGA, MEMS Assembling and Packaging*	*Strain measurement, pressure measurement*	*Construction of a MEMS magnetic sensor, principle of operation, sensitivity of the sensor*	*Lab-on-a-chip, Important considerations on microscale fluid*
	SLO-2	*Strain measurement*	*Anodic bonding, fusion bonding, Lithography, electroforming and molding.*	*Flow measurement using integrated paddle-cantilever structure*	*Review of RF based Communication syste-I*	*Properties of fluids, density, viscosity, nature of flow, surface tension*
S-6	SLO-1	*MEMS gyroscope, Inchworm technology*	*Basic Modeling elements in mechanical and electrical systems*	*MEMS Gyroscopes*	*Tuners, resonators, switches,*	*Fluid actuation methods,*

	SLO-2	*Thermistors, thermal flow sensors, shape memory alloys*	*Ampler element, mass/inertia element, capacitor, resistor and inductor*	*Shear mode MEMS, principle*	*phase shifters, RF MEMS application area, advantages*	*Dilectrophoresis, electrowetting*
S-7	SLO-1	*MOEMS, Magnetic MEMS, NEMS Architectures*	*Basic Modeling elements in fluid systems*	*Compensation in gyroscope, gripping piezoactuator, design and working principle,*	*Review of RF based Communication system-II*	*Electrothermal flow*
	SLO-2	*Properties of light and their exploitation with respective to MOEMS*	*Inertance, fluid resistance, fluid capacitor*	*Inchworm technology, principle, controlling signal*	*Design scenarios, planer inductor*	*Thermo capillary effect*
S-8	SLO-1	*optical switching, beam splitters and microlenses*	*Thermal systems modeling*	*Thermal sensors and actuators*	*RF MEMS, varactors, tuner/filter*	*Electroosmosis flow*
	SLO-2	*Introduction to RF Communication systems and applications.*	*Thermal capacitance, thermal resistance*	*Thermal energy basics and heat transfer processes,*	*Fabrication process, varactors,*	*Optoelectrowetting*
S-9	SLO-1	*Varactors, RF tuners, filters, switches, phase shifters*	*Translational and rotational pure mechanical systems with spring*	*thermistors, thermocouple, Thermal actuators*	*Tuner/filter, resonator, Resonators*	*Micropumps: design consideration, Microneedle,*
	SLO-2	*Microfluidic systems, Concept of lab-on-a-chip, properties of fluids*	*damper and mass*	*Thermodevices, micromachine thermocouple probe, thermal flow sensors*	*Switches, Phase shifter*	*Construction of a micropump, modeling, working principle*

Learning Resources	1. *Mahalik N P, "MEMS", Tata McGraw-Hill Education, 2008* 2. *Sergey Edward Lyshevski, "Micro-Electro Mechanical and Nano-Electro Mechanical Systems, Fundamental of Nano-and Micro-Engineering", CRC Press, 2005*	3. *C. T. Leondes, MEMS/NEMS Handbook Techniques and Applications, Vol. 1, Sringer, 2006.* 4. *Mohamed Gad-el-Hak, MEMS- Introduction and Fundamentals, 2nd Edition, Taylor and Francis Group, LLC, 2006.*

Learning Assessment

	Bloom's Level of Thinking	Continuous Learning Assessment (50% weightage)								Final Examination (50% weightage)	
		CLA – 1 (10%)		CLA – 2 (15%)		CLA – 3 (15%)		CLA – 4 (10%)#			
		Theory	Practice	Theory	Practice	Theory	Practice	Theory	Practice	Theory	Practice
Level 1	Remember Understand	30 %	-	30 %	-	30 %	-	30 %	-	30%	-
Level 2	Apply Analyze	40 %	-	40 %	-	40 %	-	40 %	-	40%	-
Level 3	Evaluate Create	30 %	-	30 %	-	30 %	-	30 %	-	30%	-
	Total	100 %		100 %		100 %		100 %		100 %	

CLA – 4 can be from any combination of these: Assignments, Seminars, Tech Talks, Mini-Projects, Case-Studies, Self-Study, MOOCs, Certifications, Conf. Paper etc.,

Course Designers

Experts from Industry	Experts from Higher Technical Institutions	Internal Experts
1. Dr. Hemant Dixit, GlobalFoundaries,USA, aplahemant@gmail.com	*1. Prof. V. Subramaniam, IITM, Chennai, manianvs@iitm.ac.in*	*1. Dr. M. Kiran, SRMIST*
2. Dr. Krishna Surendra Muvvala, Saint Gobain Research India, India, Krishna.muvvala@saintgobain.com	*2. Prof. M. Ghanashyam Krishna, UOHYD, mgksp@uohyd.ernet.in*	*2. Dr. A. Karthigeyan, SRMIST*

Course Code	18NTE311T	Course Name	SURFACE AND INTERFACES	Course Category	E	Professional Elective	L	T	P	C
							3	0	0	3

Pre-requisite Courses	Nil	Co-requisite Courses	Nil	Progressive Courses	Nil
Course Offering Department	Nanotechnology	Data Book / Codes/Standards	Nil		

Course Learning Rationale (CLR):	The purpose of learning this course is to:
CLR-1 :	*Understand why/how surfaces are important in nanotechnology*
CLR-2 :	*Explain various mechanisms involved in surfaces/interfaces and fundamentals of various types of bonding at surfaces/interfaces*
CLR-3 :	*Describe strategies for manipulating the surfaces and how those strategies help them depending upon the application of such modified surface*
CLR-4 :	*Be familiar with property equations and thermodynamic properties of gas-surface interactions along with the concepts of phase equilibrium of multi component systems*
CLR-5 :	*Acquire the knowledge in Adsorption and desorption kinetics*
CLR-6 :	*Equip with surface-analytical tools such as photoemission spectroscopy, Kelvin probe microscopy, spectroscopy ellipsometry and its significances*

		Learning			Program Learning Outcomes (PLO)														
		1	2	3	1	2	3	4	5	6	7	8	9	10	11	12	13	14	15
Course Learning Outcomes (CLO):	*At the end of this course, learners will be able to:*	Level of Thinking (Bloom)	Expected Proficiency (%)	Expected Attainment (%)	Engineering Knowledge	Problem Analysis	Design & Development	Analysis, Design, Research	Modern Tool Usage	Society & Culture	Environment & Sustainability	Ethics	Individual & Team Work	Communication	Project Mgt. & Finance	Life Long Learning	PSO - 1	PSO - 2	PSO - 3
CLO-1 :	*Apply the knowledge in surfaces; their structure and physical-chemical properties, and interfaces between solids*	*2*	*85*	*70*	*H*	*M*	*M*	*M*	*M*	*M*	*M*	*H*	*M*	*H*	*M*	*M*	*H*	*H*	*H*
CLO-2 :	*Analyze a surface reconstruction & anticipate the stability of a given interface.*	*2*	*80*	*70*	*H*	*M*	*H*	*H*	*M*	*M*	*M*	*H*	*M*	*H*	*M*	*H*	*M*	*M*	*H*
CLO-3 :	*Decide what the necessary (statistical) thermodynamics concepts to describe an interface are.*	*2*	*70*	*70*	*H*	*M*	*H*	*H*	*H*	*H*	*H*	*H*	*M*	*H*	*M*	*H*	*H*	*H*	*M*
CLO-4 :	*Develop qualitative understanding of theories involved and general concepts*	*2*	*75*	*75*	*H*	*M*	*M*	*M*	*M*	*M*	*M*	*M*	*M*	*H*	*M*	*M*	*L*	*H*	*M*
CLO-5 :	*Validate sound understanding in collective phenomena at the surfaces/interfaces*	*2*	*75*	*70*	*H*	*M*	*M*	*M*	*M*	*M*	*M*	*M*	*M*	*H*	*M*	*H*	*M*	*H*	*M*
CLO-6 :	*Compare different surface characterization techniques in terms of their performance, sample introduction of methods and sensitivity*	*2*	*80*	*75*	*H*	*M*	*M*	*M*	*M*	*M*	*H*	*H*	*M*	*H*	*M*	*H*	*M*	*H*	*M*

Duration (hour)		9	9	9	9	9
S-1	SLO-1	*Definition of a Surface and an Interface - its importance/significance*	*The Hierarchy of Equilibrium*	*Adsorption and Desorption Kinetics*	*Structure of Surfaces*	*Electronic Properties at the surfaces*
	SLO-2	*Liquids and Liquid Surfaces*	*Thermodynamics of Flat Surfaces and Interfaces*	*Physiosorption and Chemisorption*	*Surface Crystallography*	*Beyond the Surface Selection Rule*
S-2	SLO-1	*Surface Area to Volume Ratio*	*The Interface Free Energy*	*General Issues of Isotherms*	*Surface stress, Surface energy*	*Correlation between Propagation Length and Surface Roughness*
	SLO-2	*Solids and Solid Surface Roughness*	*Surface Excesses*	*Isosters, and Isobars*	*Relaxation, Reconstruction - Defects*	*Many Body effects*
S-3	SLO-1	*Chemical Heterogeneity of Solid Surfaces - Molecular Interactions*	*Charged Surfaces at Constant Potential*	*The Langmuir Isotherm*	*General Aspects of Surface Lattice Dynamics*	*Surface Plasmons*
	SLO-2	*General concepts of Internal Energy and Free Energy*	*Charged Surfaces at Driven potential*	*Lattice Gas with Mean Field Interaction*	*Diffraction at Surfaces - Surface Superlattices*	*Surface Plasmon/phonon Dispersion and Multipole Excitations*
S-4	SLO-1	*Intramolecular Forces: Formation of a Molecule by Chemical Bonding*	*Maxwell Relations*	*The Fowler-Frumkin Isotherm*	*Defects at surfaces/interfaces – line & point defects*	*Electromagnetic Field Enhancement – Conservation laws for atomic collisions*
	SLO-2	*Interatomic forces, bonds - Molecular geometry*	*Their Applications*	*Reduction to the Langmuir Isotherm*	*Vibrational Excitations at Surfaces - Surface Phonons of Solids*	*Empty and image – potential surface states*
S-5	SLO-1	*Dipole moments*	*Solid and Solid interfaces*	*Experimental Determination of the Heat of Adsorption*	*Surface Stress and the Nearest Neighbor Central Force Model*	*Scattering of Light at Rough Surfaces- From Nanowires to Quantum Conduction*
	SLO-2	*Intermolecular Forces and Potential Energies*	*Solid-Liquid Interfaces*	*Underpotential Deposition*	*Surface Phonons in the Acoustic Limits*	*Classical limit of particle scattering*

S-6	SLO-1	*Coulomb Interactions*	*Step Line Tension*	*Symmetry of Adsorption Sites -*	*Diffusion at Surfaces*	*Linear Optical Techniques at Surfaces and Interfaces*
	SLO-2	*Polar Interactions*	*Stiffness at its interfaces*	*Vibrational Frequencies of Isolated Adsorbates*	*Observation of Single Atom Diffusion Events-Statistics of Random Walk*	*Spectroscopic Ellipsometry (SE)*
S-7	SLO-1	*van der Waals Interactions*	*Equilibrium Fluctuations of Line Defects and Surfaces*	*Desorption - Desorption Spectroscopy*	*Absolute Rate Theory*	*Reflection Difference Techniques (Surface Differential Reflectivity (SDR)*
	SLO-2	*Induction effects*	*The Terrace-Step-Kink Model - Basic Assumptions and Properties*	*Theory of Desorption Rates*	*Calculation of the Pre-factor*	*Reflection Anisotropy Spectroscopy (RAS))*
S-8	SLO-1	*Collective phenomena at interfaces – Superconductivity*	*Step-Step Interactions on Vicinal Surfaces*	*Specific Adsorption of Ions*	*The Ehrlich-Schwoebel Barrier- The Concept of the Ehrlich-Schwoebel Barrier*	*Probing occupied and unoccupied states - Photoemission spectroscopy, surface states*
	SLO-2	*Superconductivity at interfaces – A simple model for transport through normal-superconductor interface*	*The Ising-Model*	*Specific Adsorption of molecules*	*Mass Transport on Stepped Surfaces*	*General Aspects of inverse photoemission*
S-9	SLO-1	*Collective phenomena at interfaces - Ferromagnetism*	*Application to the Equilibrium Shape of Islands*	*The Chemical Bond of Adsorbates of Hydrogen, Oxygen molecules*	*The Kink Ehrlich-Schwoebel Barrier*	*Work Function changes induced by the adsorbates – 2D phase transition*
	SLO-2	*Ferromagnetism at interfaces- Magnetic layer coupling*	*Simple Solutions for the Problem of Interacting Steps*	*The Chemical Bond of Adsorbates of Water, Hydrocarbons*	*The Atomistic Picture of the Ehrlich-Schwoebel Barrier*	*Kelvin Probe measurements for the study of work-function changes*

Learning Resources	*1. G. Bordo Vladimir and Horst-Günter Rubahn, Optics and Spectroscopy at Surfaces and Interfaces, WILEY-VCH Verlag GmbH & Co. KGaA, Weinheim 2005* *2. Harald Ibach, Physics of Surfaces and Interfaces, Springer-Verlag Berlin Heidelberg 2006* *3. H. Yıldırım Erbil, Surface Chemistry Of Solid and Liquid Interfaces, First published in 2006 by Blackwell Publishing Ltd, Oxford, UK*	*4. John C. Riviere, Sverre Myhra, Handbook of Surface and Interface Analysis: Methods for Problem-Solving, 2nd Edition, CRC Press Taylor & Francis Group 2009* *5. Klaus Wandelt, Surface and Interface Science, Volume 6: Solid-Gas Interfaces II, Wiley VCH Verlag, Weinheim, Germany 2015*

Learning Assessment

	Bloom's Level of Thinking	Continuous Learning Assessment (50% weightage)								Final Examination (50% weightage)	
		CLA – 1 (10%)		CLA – 2 (15%)		CLA – 3 (15%)		CLA – 4 (10%)#			
		Theory	Practice	Theory	Practice	Theory	Practice	Theory	Practice	Theory	Practice
Level 1	Remember Understand	30 %	-	30 %	-	30 %	-	30 %	-	30%	-
Level 2	Apply Analyze	40 %	-	40 %	-	40 %	-	40 %	-	40%	-
Level 3	Evaluate Create	30 %	-	30 %	-	30 %	-	30 %	-	30%	-
	Total	100 %		100 %		100 %		100 %		100 %	

CLA – 4 can be from any combination of these: Assignments, Seminars, Tech Talks, Mini-Projects, Case-Studies, Self-Study, MOOCs, Certifications, Conf. Paper etc.,

Course Designers

Experts from Industry	Experts from Higher Technical Institutions	Internal Experts
1. Dr. D.K. Aswal,National Physical Laboratory, dkaswal@nplindia.org	*1. Prof. V. Subramaniam, Physics Department, IITM, Chennai, manianvs@iitm.ac.in*	*1. Dr. A. A. Alagiriswamy, SRMIST*
2. Dr. Krishna Surendra Muvvala, Saint Gobain Research India, India, Krishna.muvvala@saintgobain.com	*2. Prof. Gridhar U. Kulkarni, Director at CeNS, Bangalore, guk@cens.res.in*	*2. Dr. E. Senthil Kumar, SRMIST*

Course Code	18NTE312T	Course Name	NANOTECHNOLOGY IN FOOD PRODUCTION	Course Category	E	Professional Elective	L	T	P	C
							3	0	0	3

Pre-requisite Courses	Nil	Co-requisite Courses	Nil	Progressive Courses	Nil
Course Offering Department	Nanotechnology	Data Book / Codes/Standards	Nil		

Course Learning Rationale (CLR):	The purpose of learning this course is to:
CLR-1 :	*Know the various types of interactions at molecular scale*
CLR-2 :	*Understand the effect of nanoparticles on agricultural methodology and food technology*
CLR-3 :	*Gain knowledge of the types diagnostic tools using nanotechnology*
CLR-4 :	*Acquire knowledge about the newer technologies in the food production*
CLR-5 :	*Get familiarized with the new concepts of Nano Science in the packaging industries and food production*
CLR-6 :	*Know the toxic effect of nanomaterials used in food processing and technology*

Course Learning Outcomes (CLO):	At the end of this course, learners will be able to:	Learning 1: Level of Thinking (Bloom)	2: Expected Proficiency (%)	3: Expected Attainment (%)	PLO 1: Engineering Knowledge	2: Problem Analysis	3: Design & Development	4: Analysis, Design, Research	5: Modern Tool Usage	6: Society & Culture	7: Environment & Sustainability	8: Ethics	9: Individual & Team Work	10: Communication	11: Project Mgt. & Finance	12: Life Long Learning	13: PSO - 1	14: PSO - 2	15: PSO - 3
CLO-1 :	*Apply the concept of interactions with in the supramolecular structures at molecular scale*	2	80	75	M	M	H	M	M	H	H	H	H	H	H	H	H	H	H
CLO-2 :	*Utilize the assay techniques in agricultural and food diagnostics*	2	80	70	M	H	M	M	M	H	H	H	M	H	H	H	M	M	M
CLO-3 :	*Apply the concepts of nanotechnology in food products*	2	75	70	H	M	M	M	M	H	H	M	H	H	H	H	H	H	H
CLO-4 :	*Engineer food ingredients which are capable to improve the bioavailability*	2	80	75	H	H	H	M	M	M	H	H	M	H	H	H	H	H	H
CLO-5 :	*Select the preferred packaging materials for various food products*	2	80	70	M	H	M	M	M	M	M	H	M	H	H	H	H	H	H
CLO-6 :	*Assess the toxic effects of the nanomaterials used in the food processing and technology*	2	80	75	M	H	M	M	M	M	M	H	M	H	M	H	H	M	H

Duration (hour)		9	9	9	9	9
S-1	SLO-1	*Intermolecular interactions and supermolecular structures – Introduction*	*Nanotechnology in Agriculture and Food diagnostics*	*Food products and its production – Introduction*	*Nanotechnology in Crop management - Introduction*	*Toxicology of Nanomaterials in food - Introduction*
	SLO-2	*Water - hydrophobic and hydrophilic interactions*	*Nanodiagnostic approaches in detecting microbial agents*	*Food and new ways of food production*	*Crop improvement - reasons to package food products*	*Characterization of engineered nanomaterials*
S-2	SLO-1	*dispersion interaction, electrostatic interactions*	*Biosensors, Enzyme biosensors and diagnostics*	*Need for new food processing methods*	*Physical properties of packaging materials*	*Unique issues for characterization of engineered nanomaterials for food applications*
	SLO-2	*Atoms and small molecules*	*DNA-based biosensors and diagnostics*	*Efficient fractionation of crops*	*Strength*	*Safety assessment of oral-exposure engineered nanomaterials for food application*
S-3	SLO-1	*Polymers, particles, and surfaces*	*Radiofrequency identification*	*Efficient product structuring*	*Barrier properties*	*Experimental design considerations for toxicology studies*
	SLO-2	*Introduction to Steric interactions*	*Integrated nanosensor networks: Detection and Response*	*Optimizing Nutritional value*	*light absorption*	*Life cycle of nanotechnology food products*
S-4	SLO-1	*Steric interactions involving soluble polymers*	*Electrochemical biosensors – Gold Nanoparticles*	*Nanotechnology in Food Production*	*structuring of interior surfaces*	*Environmental behavior of nanoparticles - Toxicology of nanoparticles*
	SLO-2	*Aggregation*	*Magnetic Nanoparticles in diagnostics*	*Applications of nanotechnology in foods*	*Antimicrobial functionality*	*Molecules in foods involved in triggering allergies*
S-5	SLO-1	*Depletion aggregation of particles by non-adsorbing polymers*	*Fluorescent Nanoparticles in diagnostics*	*Sensing, packaging*	*Visual indicators*	*Impact of nanoscale structures on allergenic potential of foods*
	SLO-2	*Bridging aggregation of particles by adsorbing polymers*	*Silica Nanoparticles in diagnostics*	*Encapsulation*	*Quality assessment*	*Toxicokinetics*
S-6	SLO-1	*Stabilization of dispersed particles by adsorbing polymers*	*Safety of nanotechnology in food and the impact in consumer health*	*Nano Engineering food ingredients to improve bioavailability*	*Food safety indication*	*Adme (absorption)*

	SLO-2	*Polymer brushes to prevent particle aggregation and particle deposition at surfaces*	*Transduction Principles*	*Nanocrystalline food ingredients*	*Product properties*	*Adme (distribution)*
S-7	SLO-1	*Self Assembly*	*Microfluidic Assays*	*Nano-emulsions*	*Information and Communication technology*	*Adme (metabolism)*
	SLO-2	*Organized self-assembled structures*	*Lateral flow (immuno) assay*	*Nano-engineered protein fibrils as ingredient building blocks*	*Sensors*	*Adme (excretion)*
S-8	SLO-1	*Langmuir layers*	*Nucleic acid lateral flow (immuno) assay*	*Preparation of food matrices*	*Radiofrequency identification technology*	*Toxicodynamics*
	SLO-2	*Lipid bilayers*	*Flow-through (immuno) assays*	*Risks of Nanotechnology*	*Health Risks*	*In vivo toxicity*
S-9	SLO-1	*Solid-supported lipid bilayers*	*Antibody microarrays*	*Concerns about using nanotechnology in food production*	*Environmental Risks*	*In vitro toxicity*
	SLO-2	*Micelles, Vesicles*	*Surface plasmon resonance spectroscopy*	*Rational argumentation versus Human feelings*	*Consumer and societal acceptance*	*Study Reliability*

Learning Resources	1. *Nicholas A. Kotov, "Nanoparticle Assemblies and Superstructures", CRC, 2006 (ISBN 9780367392284)* 2. *Lynn J. Frewer, Willem Norde, Arnout Fischer, and FransKampers,"Nanotechnology in the Agri-Food Sector", Wiley VCH, 2011 (ISBN:9783527330607)*	3. *David S Goodsell, "Bionanotechnology", John Wiley & Sons, 2004 (ISBN 0-471-41719-X)* 4. *Jennifer Kuzma and Peter VerHage, "Nanotechnology in agriculture and food production", Woodrow Wilson International, 2006*

Learning Assessment

	Bloom's Level of Thinking	Continuous Learning Assessment (50% weightage)								Final Examination (50% weightage)	
		CLA – 1 (10%)		CLA – 2 (15%)		CLA – 3 (15%)		CLA – 4 (10%)#			
		Theory	Practice	Theory	Practice	Theory	Practice	Theory	Practice	Theory	Practice
Level 1	Remember Understand	30 %	-	30 %	-	30 %	-	30 %	-	30%	-
Level 2	Apply Analyze	40 %	-	40 %	-	40 %	-	40 %	-	40%	-
Level 3	Evaluate Create	30 %	-	30 %	-	30 %	-	30 %	-	30%	-
	Total	100 %		100 %		100 %		100 %		100 %	

CLA – 4 can be from any combination of these: Assignments, Seminars, Tech Talks, Mini-Projects, Case-Studies, Self-Study, MOOCs, Certifications, Conf. Paper etc.,

Course Designers

Experts from Industry	Experts from Higher Technical Institutions	Internal Experts
1. Mr.Rajendra Moorthy Rajendran, Kemin Industries, Chennai, India rajendramoorthy.r@kemin.com	*1. Dr. V Geethalakshmi, TNAU, Coimbatore, directorscms@tnau.ac.in*	*1. Dr. C.Gopalakrishnan, SRMIST*
2. Mr. Saravanan Lokasundaram, Agro Crops, Chennai, India, sara@agrocrops.com	*2. Dr. A Lakshmanan,TNAU, Coimbatore, microlaxman@yahoo.com*	*2. Dr. E.Senthilkumar, SRMIST*

Course Code	18NTE313T	Course Name	ADVANCED DRUG DELIVERY SYSTEMS	Course Category	E	Professional Elective	L	T	P	C
							3	0	0	3

Pre-requisite Courses	NIL	Co-requisite Courses	NIL	Progressive Courses	NIL
Course Offering Department	Physics and Nanotechnology	Data Book / Codes/Standards	NIL		

Course Learning Rationale (CLR):	*The purpose of learning this course is to:*
CLR-1 :	*Understand the concept of drug delivery*
CLR-2 :	*Acquire knowledge on controlled drug delivery*
CLR-3 :	*Learn the concept of targeted drug delivery*
CLR-4 :	*Know about the methods of drug delivery*
CLR-5 :	*Learn about various nanocarriers*

Course Learning Outcomes (CLO):	*At the end of this course, learners will be able to:*	Learning 1: Level of Thinking (Bloom)	2: Expected Proficiency (%)	3: Expected Attainment (%)	PLO 1: Engineering Knowledge	2: Problem Analysis	3: Design & Development	4: Analysis, Design, Research	5: Modern Tool Usage	6: Society & Culture	7: Environment & Sustainability	8: Ethics	9: Individual & Team Work	10: Communication	11: Project Mgt. & Finance	12: Life Long Learning	13: PSO - 1	14: PSO - 2	15: PSO - 3
CLO-1 :	*Explain various drug delivery systems*	*2*	*80*	*75*	*H*	*M*	*H*	*H*	*H*	*H*	*H*	*H*	*M*	*H*	*L*	*H*	*H*	*H*	*H*
CLO-2 :	*Analyse a controlled drug release profile*	*2*	*80*	*70*	*H*	*M*	*H*	*H*	*M*	*M*	*M*	*H*	*M*	*H*	*L*	*H*	*M*	*M*	*M*
CLO-3 :	*Formulate different drug delivery systems*	*2*	*75*	*70*	*H*	*L*	*H*	*H*	*H*	*H*	*H*	*H*	*M*	*H*	*L*	*H*	*H*	*H*	*H*
CLO-4 :	*Apply the concept of drug targeting*	*2*	*80*	*75*	*H*	*M*	*H*	*H*	*H*	*H*	*H*	*H*	*M*	*H*	*L*	*H*	*H*	*H*	*H*
CLO-5 :	*Differentiate among various nanocarriers*	*2*	*80*	*70*	*H*	*M*	*H*	*H*	*H*	*H*	*H*	*H*	*M*	*H*	*L*	*H*	*H*	*H*	*H*

Duration (hour)		9	9	9	9	9
S-1	SLO-1	*Drug delivery systems*	*Targeted drug delivery system*	*Metal nanoparticles for drug delivery*	*Cancer therapy*	*Theranostic metal nanoshells*
	SLO-2	*Traditional drug delivery*	*Site specific drug release*	*Gold based drug delivery systems*	*Drug delivery to cancer*	*Photothermally-modulated drug delivery using nanoshell*
S-2	SLO-1	*Advantages and disadvantages of various traditional drug delivery systems*	*Types of drug targeting*	*Multifunctional nanoparticles*	*Targeted drug delivery to cancer*	*Hydrogels*
	SLO-2	*Modes of drug delivery*	*Active targeting*	*Multifunctional gold nanoparticles for drug delivery and imaging*	*Enhanced permeability and retention*	*Nanoporous systems for drug delivery*
S-3	SLO-1	*Routes of administration*	*Passive targeting*	*Virus based drug delivery system*	*Cancer markers*	*Molecularly-derived therapeutics*
	SLO-2	*Novel drug delivery system*	*Barriers for drug targeting*	*Polymeric nanoparticles*	*Folate receptor*	*transdermal drug delivery*
S-4	SLO-1	*Pharmacokinetics*	*Strategies for site specific drug delivery*	*Classifications of polymers*	*Angiogenesis*	*low-frequency sonophoresis*
	SLO-2	*ADME studies*	*Receptors*	*Polymer micelles*	*Leaky vasculature*	*implants for controlled drug delivery*
S-5	SLO-1	*Kinetics of drug delivery*	*Ligands*	*Synthesis of polymeric nanoparticles for drug delivery*	*Cancer specific targeting*	*Responsive release system*
	SLO-2	*Zero order kinetics*	*Antibodies based drug delivery*	*Dentrimers*	*Combinational therapy*	*Fabrication and Applications of Microneedles*

S-6	SLO-1	*First order kinetics*	*Metabolism based drug delivery*	*Magnetic nanoparticles for drug delivery*	*Neutron capture therapy*	*Micropumps*
	SLO-2	*Mixed order kinetics*	*Surface modification of nanoparticles*	*Nanoscaffolds*	*Targeting tumor vasculature for imaging*	*microvalves*
S-7	SLO-1	*Controlled drug delivery*	*Bioconjugation of nanoparticles*	*CNT in drug delivery*	*Anticancer drugs*	*Implantable microchips*
	SLO-2	*Mechanism of controlled drug release*	*PEGylation of nanoparticles*	*Liposomes*	*Pharmacodynamics*	*Quantum Dot Probes*
S-8	SLO-1	*Therapeutic index*	*reticuloendothelial system*	*Protein drug delivery*	*Photothermal therapy*	*Applications Nano biotechnologies for Single-Molecule Detection*
	SLO-2	*Drug release profile*	*Opsonaization*	*Gene delivery*	*Cancer imaging*	*Nanorobots*
S-9	SLO-1	*Rate controlled drug delivery*	*Renal clearance*	*Gene transfection*	*Nanoparticle–Aptamer Conjugates for Cancer Cell Targeting and Detection.*	*Drug delivery to Central Nervous systems*
	SLO-2	*Time controlled drug delivery*	*Steric repulsion*	*Methods of gene transfection*	*Fluorescent Silica Nanoparticles for Tumor Imaging-*	*Drug delivery across Blood brain barrier*

Learning Resources	1. Drug Delivery: Engineering Principles for Drug Therapy, M. Salzman, Oxford University Press, 2001. 2. Drug Delivery and Targeting, A.M. Hillery, CRC Press, 2002.	3. Drug Delivery: Principles and Applications, B. Wang, Wiley Intersceince, 2005. 4. Nanoparticle Technology for Drug Delivery, Ram B. Gupta, Uday B. Kompella Taylor & Francis, 2006

Learning Assessment

	Bloom's Level of Thinking	Continuous Learning Assessment (50% weightage)								Final Examination (50% weightage)	
		CLA – 1 (10%)		CLA – 2 (15%)		CLA – 3 (15%)		CLA – 4 (10%)#			
		Theory	Practice	Theory	Practice	Theory	Practice	Theory	Practice	Theory	Practice
Level 1	Remember Understand	30 %	-	30 %	-	30 %	-	30 %	-	30%	-
Level 2	Apply Analyze	40 %	-	40 %	-	40 %	-	40 %	-	40%	-
Level 3	Evaluate Create	30 %	-	30 %	-	30 %	-	30 %	-	30%	-
	Total	100 %		100 %		100 %		100 %		100 %	

CLA – 4 can be from any combination of these: Assignments, Seminars, Tech Talks, Mini-Projects, Case-Studies, Self-Study, MOOCs, Certifications, Conf. Paper etc.,

Course Designers

Experts from Industry	Experts from Higher Technical Institutions	Internal Experts
1. Mr. K. ChandruTrivitron Healthcare Pvt. Ltd. Chennai, chandru.k@trivitron.com	*1. Dr. AsifkhanShanavas, INST Mohali, asifkhan@inst.ac.in*	*1. Dr. G. Devanand Venkatasubbu, SRMIST*
2. Dr. AchuthPadmanaban, Baylor College of Medicine, USA, achuthz@gmail.com	*2. Dr.MukeshDoble, IIT M, mukeshd@iitm.ac*	*2. Dr. Selvamurugan, SRMIST*

Course Code	18NTE314T	Course Name	NANOMEDICINES	Course Category	E	Professional Elective	L	T	P	C
							3	0	0	3

Pre-requisite Courses	Nil	Co-requisite Courses	Nil	Progressive Courses	Nil
Course Offering Department	Nanotechnology	Data Book / Codes/Standards	Nil		

Course Learning Rationale (CLR):	*The purpose of learning this course is to:*
CLR-1 :	*Understanding the basis of medicine*
CLR-2 :	*Know the various classification of nanomedicine*
CLR-3 :	*Getting knowledge about interaction of nanomaterials with biological environment*
CLR-4 :	*Gain a broad understanding about the nanosystems for the diagnosis and therapy*
CLR-5 :	*Get acquainted with future aspects of nanoimprinted biosensor*
CLR-6:	*Comprehend the principles behind nanomedicine*

Course Learning Outcomes (CLO):	*At the end of this course, learners will be able to:*	Learning 1: Level of Thinking (Bloom)	2: Expected Proficiency (%)	3: Expected Attainment (%)	PLO 1: Engineering Knowledge	2: Problem Analysis	3: Design & Development	4: Analysis, Design, Research	5: Modern Tool Usage	6: Society & Culture	7: Environment & Sustainability	8: Ethics	9: Individual & Team Work	10: Communication	11: Project Mgt. & Finance	12: Life Long Learning	13: PSO - 1	14: PSO - 2	15: PSO - 3
CLO-1 :	*Apply the principles of medicine in nanomedicine*	*2*	*80*	*75*	*H*	*M*	*H*	*H*	*H*	*M*	*M*	*H*	*H*	*H*	*M*	*H*	*H*	*H*	*H*
CLO-2 :	*Analyze the shortcomings of conventional medicine*	*2*	*80*	*70*	*H*	*M*	*M*	*H*	*M*	*M*	*M*	*H*	*M*	*H*	*M*	*H*	*M*	*M*	*M*
CLO-3 :	*Apply concepts of nanomedicine to a focused clinical area of their choice*	*2*	*75*	*70*	*H*	*M*	*H*	*H*	*H*	*H*	*H*	*M*	*H*	*H*	*H*	*H*	*H*	*H*	*H*
CLO-4 :	*Apply these nanosystems for the diagnosis and therapy*	*2*	*80*	*75*	*M*	*H*	*H*	*M*	*H*	*H*	*H*	*H*	*H*	*H*	*M*	*H*	*H*	*H*	*H*
CLO-5 :	*Utilize the current techniques for novel applications of bioimaging*	*2*	*80*	*70*	*H*	*M*	*H*	*H*	*H*	*M*	*M*	*H*	*M*	*H*	*M*	*H*	*H*	*H*	*H*
CLO-6 :	*Apply the principles of 3D printing for future aspects of nanoimprinted biosensor*	*2*	*80*	*75*	*H*	*M*	*M*	*H*	*H*	*M*	*M*	*H*	*H*	*H*	*M*	*H*	*H*	*M*	*H*

Duration (hour)		9	9	9	9	9
S-1	SLO-1	*Carbon nanotubes for Bone regeneration*	*Biocompatibility of traditional medical implants*	*Introduction to biomedical imaging*	*Drug delivery to CNS*	*3D Bioprinting – introduction*
	SLO-2	*Carbon nanotubes for Electroporation*	*Adhesive interactions with implant surfaces*	*Types of biomedical imaging*	*Drug delivery across blood brain barrier (BBB)*	*3D Bioprinting uses*
S-2	SLO-1	*Hexagonal array of gold nanorods*	*Nanorobot immunoreactivity*	*The emergence of nanoparticles as imaging platform in biomedicine*	*EEG for monitoring brain activity*	*Types of 3D bioprinting*
	SLO-2	*Gold nanorods in sensing*	*Nanopyrexia*	*Magnetic resonant imaging- principle and techniques*	*Nanowires for monitoring brain activity*	*3D Bioprinting technologies: ink jet based*
S-3	SLO-1	*Isohelical DNA-binding oligomers*	*Mutagenicity*	*Magnetic resonant imagingworking methodology*	*Neuroregeneration*	*Pressure assisted*
	SLO-2	*Nanospearing- multifunctional glyco-nanoparticles*	*Carcinogenicity*	*Magnetic resonant imaging-Paramagnetic contrast agents*	*Neurosurgery*	*Laser assisted*
S-4	SLO-1	*Nanoarchitecures*	*Thermocompatibility*	*USPIOS for imaging*	*Nanoneurosurgery*	*Solenoid valve based*
	SLO-2	*Nanoconstructions based on spatially ordered nucleic acid molecules*	*Mechanocompatibility*	*SPIOS for imaging*	*Lipoblockers*	*Acoustic jet based*
S-5	SLO-1	*DNA self assembly*	*Cell membrane disruption*	*MPIOS for imaging*	*Nanolipoblockers - antirestenosis drugs*	*Challenges of 3D bio printing*
	SLO-2	*DNA self-assembling nanostructures induced by trivalent ions*	*Systemic nanoparticle distribution*	*Magnetic nanosensors*	*Myocardial Infraction conventional therapy*	*Future development of 3D bio printing*
S-6	SLO-1	*Assembling by polycations*	*Nanoparticle phagocytosis*	*Nanosensors- radio labeled nanoparticles*	*Cell therapy for myocardial infarction*	*Nanoparticles sensors*
	SLO-2	*Wang tiles*	*Nanomaterial volumetric intrusiveness*	*Ultrasound imaging*	*Stem cell types*	*Calorimetric sensing*

S-7	SLO-1	*Biological examples of Nanomotors and devices*	*Intusiveness of Nanobots*	*Acoustically reflective nanoparticles*	*Regeneration of the cardiovascular system*	*Vapor phase sensing*
	SLO-2	*ATPase motor*	*Nanobiotechnology in tissue engineering*	*Acoustically reflective nanoparticles: application in ultrasound imaging*	*Nanobone implants*	*Raman sensing at surfaces*
S-8	SLO-1	*Kinesine motor*	*Nanobiotechnology for organ replacement*	*Iodinated liposomes*	*Nanobone scaffolds*	*Electro analytical sensing*
	SLO-2	*Dynein motor*	*Liver and kidney transplant*	*Application of Iodinated liposomes*	*Nanoparticle drug formulations for spray inhalation - wound healing*	*Plasma sensing*
S-9	SLO-1	*Polymer-based capsules*	*Nanobiotechnology for assisted function*	*Quantum dots*	*Nanogeriatrics*	*Optical sensing*
	SLO-2	*Oral drug delivery*	*Organ assists*	*Quantum dots in optical imaging*	*Orthodontal application*	*Sensors for cancer detection*

Learning Resources	1. *Understanding Nanomedicine: An Introductory Textbook by Rob Burgess. 2012 CRC Press* 2. *Nanomedicine for Drug Delivery and Therapeutics, Editor(s): Ajay Kumar Mishra, 2013, Wiley*	3. *Medical Nanotechnology and Nanomedicine by Harry F. Tibbals. 2010 by CRC Press* 4. *Introduction to Nanomedicine and Nanobioengineering, by Paras N. Prasad. 2012, Wiley*

Learning Assessment

	Bloom's Level of Thinking	Continuous Learning Assessment (50% weightage)								Final Examination (50% weightage)	
		CLA – 1 (10%)		CLA – 2 (15%)		CLA – 3 (15%)		CLA – 4 (10%)#			
		Theory	Practice	Theory	Practice	Theory	Practice	Theory	Practice	Theory	Practice
Level 1	Remember Understand	30 %	-	30 %	-	30 %	-	30 %	-	30%	-
Level 2	Apply Analyze	40 %	-	40 %	-	40 %	-	40 %	-	40%	-
Level 3	Evaluate Create	30 %	-	30 %	-	30 %	-	30 %	-	30%	-
	Total	100 %		100 %		100 %		100 %		100 %	

CLA – 4 can be from any combination of these: Assignments, Seminars, Tech Talks, Mini-Projects, Case-Studies, Self-Study, MOOCs, Certifications, Conf. Paper etc.,

Course Designers

Experts from Industry	Experts from Higher Technical Institutions	Internal Experts
1. Mr. K. Chandru Trivitron Healthcare Pvt. Ltd. Chennai, chandru.k@trivitron.com	*1. Dr.Amit Kumar Mishra , IIT Jodhpur, amit@iitj.ac.in*	*1. Dr. Devanandh venkata subhu, SRMIST*
2. Dr.Nagesh Kini,Thermax,Pune,Maharastra,nagesh.kini@gmail.com	*2. Dr.Sampath Kumar T.S,IIT Madras, tssk@iitm.ac.in*	*2. Dr. Selvamurugan, SRMIST*

Course Code	18NTE315T	Course Name	MICROELECTRONICS AND VLSI	Course Category	E	Professional Elective	L	T	P	C
							3	0	0	3

Pre-requisite Courses	Nil	Co-requisite Courses	Nil	Progressive Courses	Nil
Offering Department	Nanotechnology	Data Book / Codes/Standards	Nil		

Learning Rationale (CLR):	*The purpose of learning this is to:*
CLR-1 :	*Acquire knowledge on importance of microelectronics*
CLR-2 :	*Understand the physical effects of semiconductor-semiconductor junction, its electrostatics, device and circuit level operation*
CLR-3 :	*Acquire knowledge on digital language of Boolean algebra, basics of logic gates for advanced memory applications*
CLR-4 :	*Learn process flow of CMOS IC fabrication, circuit formation and its operation*
CLR-5 :	*Understand intricacies of designing micro/nanoscale rules, flow of fabrication and IC testing principles*
CLR-6 :	*Acquire knowledge on power consumption and optimization of on-chip devices, its analysis on performance*

Learning Outcomes (CLO):	*At the end of this , learners will be able to:*	Learning 1: Level of Thinking (Bloom)	2: Expected Proficiency (%)	3: Expected Attainment (%)	PLO 1: Engineering Knowledge	2: Problem Analysis	3: Design & Development	4: Analysis, Design, Research	5: Modern Tool Usage	6: Society & Culture	7: Environment & Sustainability	8: Ethics	9: Individual & Team Work	10: Communication	11: Project Mgt. & Finance	12: Life Long Learning	13: PSO - 1	14: PSO - 2	15: PSO - 3
CLO-1 :	*Interpret difference between macro and micro electronics*	2	80	75	H	M	H	H	H	M	M	H	H	H	M	H	H	H	H
CLO-2 :	*Apply basic semiconductor physics which is important to understand the working of semiconductor-semiconductor junctions, device and circuit level operation*	2	80	70	H	M	M	H	M	M	M	H	M	H	M	H	M	M	M
CLO-3 :	*Analyze various number systems of Boolean algebra, operation of logic gates and memory circuits*	2	75	70	H	M	H	H	H	H	H	M	H	H	H	M	H	H	H
CLO-4 :	*Elucidate process flow of CMOS based logic devices, circuit formation and its operation*	2	80	75	M	H	H	M	H	H	H	H	H	H	M	H	H	H	H
CLO-5 :	*Designing steps in VLSI, rules, flow of fabrication and IC testing at high frequency*	2	80	70	H	M	H	H	H	M	M	H	M	H	M	H	H	H	M
CLO-6 :	*Analyze power consumption and need for optimization in on-chip devices, its effect on switching speed*	2	80	75	H	M	M	H	M	M	M	H	H	M	M	H	M	M	H

Duration (hour)		9	9	9	9	9
S-1	SLO-1	*Introduction to classification of materials*	*Number systems*	*Introduction to IC Technologies*	*Overview of VLSI design methodologies*	*Usage of power in IC*
	SLO-2	*Types of semiconductors*	*Binary and octal numbering*	*Needs of VLSI*	*Needs of designing*	*Overview of power consumption, low and high power in VLSI chips*
S-2	SLO-1	*Concept of energy band gap*	*Hexadecimal numbering*	*VLSI design styles*	*Steps in designing*	*On-chip capacitors*
	SLO-2	*Doping in semiconductors*	*Conversions between number systems*	*Layout rules*	*Cascading of process*	*Charging and discharging of capacitor*
S-3	SLO-1	*Formation of p-n junction*	*Boolean algebra*	*Introduction to Complementary Metal Oxide Semiconductor (CMOS)*	*Introduction to MOFET*	*Currents and voltages in CMOS short circuits*
	SLO-2	*Electrostatics of junction operation*	*Logic gates*	*VLSI for CMOS*	*VLSI for MOSFET*	*Leakage current, static current*
S-4	SLO-1	*Diode as circuit element*	*Truth tables for AND, OR, NOT gates*	*Positive channel MOS (PMOS) and negative channel MOS (NMOS)*	*DC operation of MOSFET*	*Gate-level- architecture*
	SLO-2	*Basics of bipolar and unipolar junction transistors*	*Truth tables for NAND, NOR gates*	*BiCMOS and applications*	*AC operation of MOSFET*	*transistor and gate sizing*
S-5	SLO-1	*Current-voltage characteristics and operation of transistors*	*Circuits with logic gates*	*CMOS inverter*	*Modelling of MOSFET*	*Power analysis*

	SLO-2	*Ebers-Moll representation of transistor for circuit element*	*combinational circuits and sequential circuits*	*CMOS logic circuits*	*Small signal model*	*Data correlation analysis*
S-6	SLO-1	*AC operation of transistor*	*Flip-flops*	*Combinatorial CMOS Logic*	*Need of high frequency operation*	*Random logic signals, signal entropy*
	SLO-2	*Small signal model*	*SR and JK flip-flops*	*pMOS and nMOS in logic operation*	*high frequency MOSFET models*	*Switching activity analysis*
S-7	SLO-1	*Small signal model for bipolar junction transistor (BJT)*	*Basics of counters*	*D-latch*	*Testing of transistor*	*Parallel architecture*
	SLO-2	*Small signal model for junction field effect transistor (JFET)*	*Asynchronous and synchronous counters*	*CMOS for D-latch*	*Need for testing*	*Digital CMOS circuits*
S-8	SLO-1	*Amplifiers*	*Overview of memory devices*	*Triggering of flip-flops*	*Testing principles*	*CMOS amplifiers*
	SLO-2	*Transistor connections in various modes*	*Logic gates for memory applications*	*Edge triggered Flip Flops*	*design for testability*	*CMOS amplifier topologies*
S-9	SLO-1	*Feedback concept*	*Read only memory*	*Transistor logic*	*Error analysis*	*Common-Source topologies*
	SLO-2	*Ideal F/B amplifiers*	*Random access memory*	*Pass transistor circuits*	*Safety in testing*	*Parallel architecture with voltage reduction*

Learning Resources	*1. Behzad Razavi, Fundamentals of Microelectronics/Edition 1, Wiley, 2008* *2. Millman and Grabel, "Microelectronics", 2nd Ed. Tata McGraw-Hill, 1999*	*3. Weste N.H., "Principles of CMOS VLSI Design", Pearson Education, India, 2002*

Learning Assessment											
	Bloom's Level of Thinking	Continuous Learning Assessment (50% weightage)								Final Examination (50% weightage)	
		CLA – 1 (10%)		CLA – 2 (15%)		CLA – 3 (15%)		CLA – 4 (10%)#			
		Theory	Practice	Theory	Practice	Theory	Practice	Theory	Practice	Theory	Practice
Level 1	Remember Understand	30 %	-	30 %	-	30 %	-	30 %	-	30%	-
Level 2	Apply Analyze	40 %	-	40 %	-	40 %	-	40 %	-	40%	-
Level 3	Evaluate Create	30 %	-	30 %	-	30 %	-	30 %	-	30%	-
	Total	100 %		100 %		100 %		100 %		100 %	

CLA – 4 can be from any combination of these: Assignments, Seminars, Tech Talks, Mini-Projects, Case-Studies, Self-Study, MOOCs, Certifications, Conf. Paper etc.,

Course Designers		
Experts from Industry	Experts from Higher Technical Institutions	Internal Experts
1. Dr. D.K. Aswal, National Physical Laboratory, dkaswal@nplindia.org	*1. Prof. K. Sethupathi, IITM Chennai, ksethu@iitm.ac.in*	*1. Dr. Abhay A Sagade, SRMIST*
2. Dr. S. Sudhakar, CSIR-CECRI, sudhakar@cecri.res.in	*2. Prof. S. Balakumar, University of Madras, balakumar@iunom.acs.in*	*2. Dr. P. Malar, SRMIST*

Course Code	18NTE316T	Name	PHYSICS OF ELECTRONIC MATERIALS	Category	E	Professional Elective	L	T	P	C
							3	0	0	3

Pre-requisite Courses	Nil	Co-requisite Courses	Nil	Progressive Courses	Nil
Offering Department	Nanotechnology	Data Book / Codes/Standards	Nil		

Learning Rationale (CLR):	The purpose of learning this is to:
CLR-1 :	*Understand the physics of electronic materials*
CLR-2 :	*Familiarize different physical properties of electronic materials*
CLR-3 :	*Know-how the various processes in electronic materials*
CLR-4 :	*Understand the physics behind the working of electronic materials based devices*
CLR-5 :	*Gain a fundamental understanding of the emerging electronic materials*
CLR-6:	*Know new materials other than Si etc and future technology roadmap*

Learning Outcomes (CLO):	At the end of this , learners will be able to:	Learning 1: Level of Thinking (Bloom)	2: Expected Proficiency (%)	3: Expected Attainment (%)	PLO 1: Engineering Knowledge	2: Problem Analysis	3: Design & Development	4: Analysis, Design, Research	5: Modern Tool Usage	6: Society & Culture	7: Environment & Sustainability	8: Ethics	9: Individual & Team Work	10: Communication	11: Project Mgt. & Finance	12: Life Long Learning	13: PSO - 1	14: PSO - 2	15: PSO - 3
CLO-1 :	*Use knowledge of physics to understand the properties of electronic materials*	2	80	75	M	M	H	H	M	H	H	M	M	H	M	H	H	H	H
CLO-2 :	*Analyze different mechanisms that determine the properties of electronic materials*	2	80	70	H	M	H	H	M	M	M	M	M	H	L	H	M	M	M
CLO-3 :	*Determine the applications of electronic materials based on their properties*	2	75	70	M	L	H	H	H	H	H	H	M	H	M	H	H	H	H
CLO-4 :	*Evaluate the material characteristics by applying laws of physics*	2	80	75	H	H	H	H	H	H	H	M	M	H	M	H	H	M	M
CLO-5 :	*Develop in depth understanding of the physical processes of electronic materials*	2	80	70	H	M	H	H	H	H	H	H	M	H	M	H	H	M	M
CLO-6 :	*Distinguish how materials are classified and their applications*				M	M	M	M	L	M	M	H	H	H	H	M	H	M	M

Duration (hour)		9	9	9	9	9
S-1	SLO-1	*Defining characteristics and classification of semiconductors*	*Concept of relative permittivity*	*Definition of magnetic dipole moment*	*Optical properties of materials*	*Thermal properties of materials*
	SLO-2	*Fundamentals of band theory of semiconductors*	*Electric dipole moment and polarizability*	*Orbital and spin magnetic moment of an electron*	*Refractive index, Refractive index-wavelength behavior*	*Atomistic theory of heat capacity*
S-2	SLO-1	*Intrinsic semiconductors*	*Polarization vector and charge density*	*Magnetization vector*	*Snell's law and total internal reflection*	*Quantum mechanical considerations*
	SLO-2	*Energy band diagram and carrier movement*	*Electric susceptibility and relative permittivity*	*Definition of magnetic susceptibility and magnetic permeability*	*Case study: fiber optics and LEDs*	*Einstein and Debye model*
S-3	SLO-1	*Conductivity of a semiconductor*	*Lorentz field in dielectrics*	*Magnetic materials classification*	*Interaction of photons with materials*	*Electronic contribution to the heat capacity*
	SLO-2	*Electron and hole concentrations*	*Clausius-Mossotti equation*	*Dia-, para-, ferro-, antiferro-, and ferrimagnetism*	*Absorption, transmittance and reflection*	*Heat capacity and specific heat*
S-4	SLO-1	*Extrinsic semiconductors*	*Electronic polarization in covalent solids*	*Origin of ferromagnetism and exchange interaction*	*Antireflection coatings on solar cells*	*Thermal expansion and thermal conductivity*
	SLO-2	*Concepts of p-type, n-type and compensation doping*	*Ionic, dipolar, interfacial and total polarization*	*Saturation magnetization and curie temperature*	*Dielectric mirrors*	*Thermal conductivity in metals, alloys, and dielectrics*
S-5	SLO-1	*Energy band diagram and electron and hole concentrations*	*Concept of dielectric loss*	*Magnetic domains and domain walls*	*Band to band absorption*	*Thermoelectricity in metals*

	SLO-2	Estimation of the position of the Fermi energy and the resistivity	Dielectric studies and the Cole-Cole plot	Magnetostriction and domain wall motion	Direct and indirect transitions	Seebeck effect and the figure-of-merit
S-6	SLO-1	The temperature dependence of carrier concentration	Dielectric strength and insulation breakdown	Magnetic domains in polycrystalline materials	Light scattering in materials, attenuation in optical fibers	Thermoelectricity in semiconductors
	SLO-2	The temperature dependence of drift mobility	Dielectric breakdown mechanisms	Understanding the M versus H hysteresis curve	Luminescence, phosphors, and white LEDs	Overview of thermoelectric devices
S-7	SLO-1	Degenerate and nondegenerate semiconductors	Capacitor dielectric materials	Demagnetization	Spontaneous and stimulated emission	Two-dimensional electronic materials
	SLO-2	Direct and indirect recombination	Typical capacitor constructions	Soft and hard magnetic materials: Examples and uses	Laser materials and laser action	The Era of graphene and related materials
S-8	SLO-1	Minority carrier life time	Piezoelectricity	Superconductivity, Type I and Type II superconductors	Concept of photoluminescence and electroluminescence	Electronic properties at 2D limit
	SLO-2	Carrier injection and diffusion	Piezoelectric spark generator and quartz crystal	Critical current density and superconducting solenoids	Examples for devices working on the principles of PL and EL	Optical properties- layer dependence
S-9	SLO-1	Optical absorption in semiconductors	Ferroelectricity and pyroelectricity	Josephson effect	Electro-optic effects and applications	2D materials based metal, semiconductor and dielectrics
	SLO-2	Direct and indirect band gap semiconductors and the E-k diagram	Practical Applications	Introduction to anisotropic and giant magnetoresistance	Magneto-optic effects and applications	Applications and future perspectives

Learning Resources	1. S O Kasap, "Principles of Electronic Materials and Devices" – McGraw Hill, Fourth Edition, 2017 2. Wei Gao, Zhengwei Li, Nigel Sammes, "An Introduction to Electronic Materials for Engineers" – World Scientific Publishing Co. Pte. Ltd, Second Edition, 2011 3. David Jiles, "Introduction to the Electronic Properties of Materials: - Nelson Thornes Ltd, Second Edition, 2001	4. David K. Ferry, Jonathan P. Bird "Electronic Materials and Devices" – Academic Press, First Edition, 2011. 5. Yuriy M Poplavko, "Electronic Materials: Principles and Applied Science" – Elsevier, First Edition, 2019 6. Rolf E. Hummel, "Electronic Properties of Materials: An Introduction for Engineers" – Springer, 1993

Learning Assessment

	Bloom's Level of Thinking	Continuous Learning Assessment (50% weightage)								Final Examination (50% weightage)	
		CLA – 1 (10%)		CLA – 2 (15%)		CLA – 3 (15%)		CLA – 4 (10%)#			
		Theory	Practice	Theory	Practice	Theory	Practice	Theory	Practice	Theory	Practice
Level 1	Remember Understand	30 %	-	30 %	-	30 %	-	30 %	-	30%	-
Level 2	Apply Analyze	40 %	-	40 %	-	40 %	-	40 %	-	40%	-
Level 3	Evaluate Create	30 %	-	30 %	-	30 %	-	30 %	-	30%	-
	Total	100 %		100 %		100 %		100 %		100 %	

CLA – 4 can be from any combination of these: Assignments, Seminars, Tech Talks, Mini-Projects, Case-Studies, Self-Study, MOOCs, Certifications, Conf. Paper etc.,

Course designers

Experts from Industry	Experts from Higher Technical Institutions	Internal Experts
1. Dr. D.K. Aswal, National Physical Laboratory, dkaswal@nplindia.org	1. Prof. K. Sethupathi, IITM Chennai, ksethu@iitm.ac.in	1. Dr. S. Chandramohan, SRMIST
2. Dr. S. Sudhakar, CSIR-CECRI, sudhakar@cecri.res.in	2. Prof. S. Balakumar, University of Madras, balakumar@iunom.acs.in	2. Dr. E. Senthil Kumar, SRMIST

Course Code	18NTE317T	Name	NANOCATALYSTS	Category	E	Professional Elective	L	T	P	C
							3	0	0	3

Pre-requisite Courses	Nil	Co-requisite Courses	Nil	Progressive Courses	Nil
Offering Department	Nanotechnology	Data Book / Codes/Standards	Nil		

Learning Rationale (CLR):	The purpose of learning this is to:
CLR-1 :	*Aquire the concepts of chemistry of nanocatalyst*
CLR-2 :	*Understand the catalytic kinetics*
CLR-3 :	*Describe the reaction kinetics of adsorption and desorption processes*
CLR-4 :	*Understand the principles behind the synthesis of nanocatalyst*
CLR-5 :	*Gain knowledge about the working mechanism of nanocatalytic materials*
CLR-6 :	*Describe catalytic processes at nano-levels*

Learning Outcomes (CLO):	At the end of this , learners will be able to:	Learning 1: Level of Thinking (Bloom)	2: Expected Proficiency (%)	3: Expected Attainment (%)	PLO 1: Engineering Knowledge	2: Problem Analysis	3: Design & Development	4: Analysis, Design, Research	5: Modern Tool Usage	6: Society & Culture	7: Environment & Sustainability	8: Ethics	9: Individual & Team Work	10: Communication	11: Project Mgt. & Finance	12: Life Long Learning	13: PSO - 1	14: PSO - 2	15: PSO - 3
CLO-1 :	*Describe the mechanisms of nanomaterials for using as catalyst*	2	80	75	H	M	H	H	H	M	M	H	H	H	M	H	H	H	H
CLO-2 :	*Apply the importance of the bottom-up approach to prepare nanomaterials*	2	80	70	H	M	M	H	M	M	M	H	M	H	L	H	M	M	M
CLO-3 :	*Identify the photocatalyst for environmental remediation*	2	75	70	H	M	H	H	M	H	H	M	H	H	H	H	H	H	H
CLO-4 :	*Analyze the working of noble metal nanocatalyst*	2	80	75	M	H	H	M	H	H	H	H	H	H	M	H	H	H	H
CLO-5 :	*Evaluate the needs and future possibilities of nanocatalyst*	2	80	70	H	M	H	H	H	M	M	H	M	H	L	H	H	H	H
CLO-6 :	*Apply isotherms for different micro and nano porous catalytic materials*	2	80	75	H	M	M	H	M	M	M	H	H	H	M	H	H	M	H

Duration (hour)		9	9	9	9	9
S-1	SLO-1	*Introduction to catalysis*	*Adsorption and Desorption Processes*	*Kinetics and photocatalytic activity*	*Catalyst in Nanoscale*	*Applications of Nano-Catalyst*
	SLO-2	*Classifications*	*Adsorption Rate*	*Introduction to photocatalyst*	*Noble metals nanocatalyst (Ru, Rh, Pd, Pt, etc)*	*Toxic Gases conversion using nanocatalyst: NOx*
S-2	SLO-1	*heterogeneous catalysis*	*Desorption Rate*	*Basics of electrochemistry*	*Polymer stabilized Rh and Ru nanoparticles*	*CO oxidation using nanocatalyst*
	SLO-2	*Reaction on the solid surfaces*	*Catalytic activity (bulk and nanoscale)*	*Photochemistry*	*Oxide supports for nano-catalysts; carbon supports for nano-catalysts*	*Hydrogenation of compounds with C≡C bonds, hydrogenation of aromatic compounds*
S-3	SLO-1	*Active sites- Activation energy*	*Catalytic activity determination for metal/metal oxide nanostructures*	*Electronic structure and photoabsorption*	*Gold nanoparticle-based catalyst*	*Green house gases: CO2 conversion*
	SLO-2	*Adsorption isotherms*	*Langmuir-Hinshelwood mechanism for nanocatalyst*	*Jablonskii diagram*	*Gold vs. Palladium catalysts for the aerobic oxidation of alcohols*	*Dissociative mechanism: oxygen reduction reaction using nanocatalyst*
S-4	SLO-1	*Physisorption and chemisorptions*	*Mass transport*	*Structure of photocatalysts*	*Oxide based catalyst*	*Associative mechanism: oxygen reduction reaction using nanocatalyst*
	SLO-2	*Brunauer-Emmett-Teller (BET) theory*	*Diffusion controlled process*	*Solar spectrum*	*Metal free catalyst (CNT, Graphene based Catalyst)*	*Hydrogen Production using oxide and dichalcogenides based catalyst*
S-5	SLO-1	*Total surface area*	*Adsorption equilibrium on uniform surfaces-Langmuir isotherms single-site (non-dissociative) adsorption*	*Fundamental understanding of semiconductor interfaces*	*Transition metal dichalcogenides based catalyst*	*Energy processing: Processes involved in crude oil refinery*
	SLO-2	*Pore volume and pore size distribution*	*Dual-site (dissociative) adsorption*	*Principles and relevance to photoelectrochemical mechanism*	*Microporous materials: Zeolites- Zeotypes*	*Gasoline production*
S-6	SLO-1	*Hg porosimetry method*	*Derivation of the Langmuir isotherm*	*Photocatalysis mechanism*	*Overall steps in zeolite crystallization*	*Cracking*

	SLO-2	*N2 adsorption-desorption method*	*Adsorption equilibrium on non-uniform surfaces-Langmuir isotherms*	*Properties of good photocatalysts*	*Zeolite synthesis via.- dry gel route*	*Fuel cell*
S-7	SLO-1	*Reaction mechanism*	*The Freundlich isotherm*	*Advantages of photocatalysts*	*Zeolite Y- determination of surface acidity-*	*Biomass gasification*
	SLO-2	*Kinetics of the heterogeneous catalytic reactions*	*The Temkin Isotherm*	*Types of photocatalysts*	*Shape-selectivity*	*Biodiesel*
S-8	SLO-1	*Activation energy (Arrhenius equation, Eyring equation)*	*Activated adsorption*	*Homogeneous and heterogeneous photocatalyst*	*Synthesis of Mesoporous Silica MCM-41*	*Photocatalyst for self cleaning*
	SLO-2	*Terminology in catalysis, TO(Turnover),TON(Turnover number), TOF(Turnover frequency)*	*Catalytic efficiency*	*Carbonaceous photocatalysts.*	*Mesoporous Carbon*	*Purification of water and air*
S-9	SLO-1	*Sequences involved in a catalysed reaction*	*Application of metal nanoparticles in organic reactions*	*Plasmonic photocatalysts.*	*Sulfated Zirconia*	*Environmental remediation*
	SLO-2	*Asymmetric synthesis using a catalyst*	*Environmental remediation*	*Application of photocatalyst*	*Ag/SiO$_2$ composite nanocatalysts*	*Future possibilities*

earning Resources	1. *M. Albert Vannice, Kinetics of Catalytic Reactions, Springer, 2008.* 2. *Nick Serpone and Ezio Pelizzetti, Photocatalysis: Fundamentals and Application, Wiley Interscience, 1st Edition, 1989*	3. *Kurt W. Kolasinaski, Surface Science: Foundations of Catalysis and Nanoscience , John Wiley & Sons, England, 2nd Edition , 2005* 4. *Nanoporous Materials: Synthesis and Applications, Edited by Qiang Xu, CRC Press, 1st Edition, 2013*

Learning Assessment											
	Bloom's Level of Thinking	Continuous Learning Assessment (50% weightage)								Final Examination (50% weightage)	
		CLA – 1 (10%)		CLA – 2 (15%)		CLA – 3 (15%)		CLA – 4 (10%)#			
		Theory	Practice	Theory	Practice	Theory	Practice	Theory	Practice	Theory	Practice
Level 1	Remember Understand	30 %	-	30 %	-	30 %	-	30 %	-	30%	-
Level 2	Apply Analyze	40 %	-	40 %	-	40 %	-	40 %	-	40%	-
Level 3	Evaluate Create	30 %	-	30 %	-	30 %	-	30 %	-	30%	-
	Total	100 %		100 %		100 %		100 %		100 %	

CLA – 4 can be from any combination of these: Assignments, Seminars, Tech Talks, Mini-Projects, Case-Studies, Self-Study, MOOCs, Certifications, Conf. Paper etc.

Course Designers		
Experts from Industry	Experts from Higher Technical Institutions	Internal Experts
1. Dr. P. Sudhakara, CLRI – CSIR, Jalandhar, sudhakarp@clri.res.in	*1. Dr.G. Arthanareeswaran, NIT Trichy, arthanareeg@gmail.com*	*1. Dr. N. Angeline Little Flower. SRMIST*
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Course Code	18NTE318T	Course Name	NANO AND MICRO EMULSIONS	Course Category	E	Professional Elective	L	T	P	C
							3	0	0	3

Pre-requisite Courses	Nil	Co-requisite Courses	Nil	Progressive Courses	Nil
Course Offering Department	Nanotechnology	Data Book / Codes/Standards	Nil		

Course Learning Rationale (CLR):	*The purpose of learning this course is to:*
CLR-1 :	*Acquire knowledge on micro and nano emulsion and its stability*
CLR-2 :	*Understand the various properties of emulsion*
CLR-3 :	*Describe the concept of Mechanism of Emulsification*
CLR-4 :	*Understand the formulation of Nano emulsion*
CLR-5 :	*Learn the applications of emulsion for various fields*
CLR-6 :	*Understand the principles of NMR and Ultrasound characterization*

Course Learning Outcomes (CLO):	*At the end of this course, learners will be able to:*	Learning 1: Level of Thinking (Bloom)	2: Expected Proficiency (%)	3: Expected Attainment (%)	PLO 1: Engineering Knowledge	2: Problem Analysis	3: Design & Development	4: Analysis, Design, Research	5: Modern Tool Usage	6: Society & Culture	7: Environment & Sustainability	8: Ethics	9: Individual &Team Work	10: Communication	11: Project Mgt. & Finance	12: Life Long Learning	13: PSO - 1	14: PSO - 2	15: PSO - 3
CLO-1 :	*Explore basic principles in chemistry of microemulsions*	2	80	75	H	M	H	H	H	M	M	H	H	H	M	M	H	H	H
CLO-2 :	*Explainproperties of emulsion by concept of phase diagram*	2	80	70	H	M	M	H	M	M	M	H	M	H	M	H	M	M	M
CLO-3 :	*Analyze the stabilization mechanism in emulsions*	2	75	70	H	M	H	H	H	H	H	M	H	M	H	H	H	H	H
CLO-4 :	*Apply the formulation of micro and nano emulsions*	2	80	75	M	H	H	M	H	H	H	H	H	H	M	M	H	H	H
CLO-5 :	*Elucidate importance of emulsions in various technological applications*	2	80	70	H	M	H	H	H	M	M	H	M	H	M	H	H	H	H
CLO-6 :	*Utilize the knowledge on formulation and characterization of microemulsions*	2	80	75	H	M	M	H	M	M	M	M	H	H	M	H	H	M	M

Duration (hour)		9	9	9	9	9
S-1	SLO-1	*Introduction to Emulsion*	*A phase diagram approach to microemulsion*	*Mechanism of Emulsification*	*Nanoparticle formation in microemulsion*	*Characterization and Application of Microemulsion*
	SLO-2	*Introduction to Micro and Nano Emulsion*	*Partial generic phase diagram*	*Surface forces*	*Concept of formation in microemulsion:*	*Introduction in basics and principles of NMR*
S-2	SLO-1	*Definition of micro emulsion*	*Microemulsion formation*	*Van der walls interactions*	*Chemical Reaction*	*NMR technique for measurement emulsion*
	SLO-2	*Definition of nano emulsion*	*Ordering and disordering*	*Electrical interactions*	*Nucleation*	*Relaxation measurements on emulsions via CPMG experiments*
S-3	SLO-1	*Theory of emulsion and methods*	*Temperature Dependence of microemulsion ordering*	*Phase inversion phenomena*	*Exchange mechanism in emulsions*	*Diffusion measurements on emulsions via PGSE andPGSTE experiments*
	SLO-2	*Theory of Micro emulsions*	*Vapor Composition from Microemulsions*	*Phase behaviorsof emulsions*	*Autocatalysis*	*Introduction and basics of ultrasound*
S-4	SLO-1	*Theory nano emulsions*	*Ekwall on the association structures*	*Standard inverse boundary*	*Mechanism of microemulsion*	*Ultrasound characterization for emulsion*
	SLO-2	*Preparation of microemulsion*	*Water–surfactant combination*	*Dynamic inversion*	*Critical Nucleus Size*	*Ultrasound characterization for microemulsion*
S-5	SLO-1	*Preparation of nano emulsion*	*Physicochemistry of W/O microemulsion formation*	*Dynamic behavior of emulsion*	*Chemical Reaction Rate*	*General features of acoustic measurement*
	SLO-2	*Winsor's classification of microemulsions*	*Stability of emulsions*	*Spontaneous emulsification*	*Nanoparticles uptake from W/O emulsion*	*Acoustic measurements on emulsions*
S-6	SLO-1	*Stability of micro emulsions*	*Droplet clustering*	*Recent development with emphasis on self emulsification,*	*W/O emulsion process*	*Physicochemical characterization and characterization techniques types*

	SLO-2	*Rheology of microemulsion drops*	*Energetics of Droplet Clustering*	*Self-emulsification process*	*Nanoparticle Uptake in Reactive Surfactant Systems*	*Pharmaceutically applicable microemulsions*
S-7	SLO-1	*Applications of emulsions*	*Phenomenon in microemulsion*	*Organic Reactions in Emulsions*	*Nanoparticle Uptake in Nonreactive Surfactant Systems*	*Places of microemulsion and emulsion in cancer therapy*
	SLO-2	*Ostwald ripening*	*Percolating phenomenon in microemulsion*	*Microemulsions*	*TiO_2 nanoparticle in micro-emulsion and photophysical properties*	*In vitro and in vivo evaluation*
S-8	SLO-1	*Flocculation*	*Scaling Laws*	*Symmetric thin liquid film with Fluid interfaces*	*Optical Absorption and Emission of TiO_2 Nanoparticles in Microemulsion*	*Biocatalysis in microemulsion*
	SLO-2	*Coalescence of drops*	*Effect of external entity-Microemulsions with mixed nonionic surfactants*	*Formation emulsified microemulsion*	*Electron Transfer Dynamics in Catechol-Sensitized TiO_2 Nanoparticles*	*Biofluidic Matrices*
S-9	SLO-1	*Applications of emulsions*	*Organ chalcogenides,Aromatic Heterocyclic Compounds*	*Microemulsion properties*	*Properties of interfacial electron transfer dynamics*	*Microemulsions as Decontamination Media for Chemical weapons*
	SLO-2	*Different application of micro and Nano emulsions*	*Properties of microemulsions with mixed nonionic surfactants*	*Characterization of emulsified microemulsion*	*Interfacial electron transfer dynamics*	*Microemulsions as toxic Industrial Chemicals*

Learning Resources	1. *Fanun, Monzer.,Microemulsions: properties and applications, CRC press, 2008.* 2. *Sjoblom, Johan., Emulsions and emulsion stability: Surfactant science series/61. CRC Press, 2005.*	3. *Berg J. C., An Introduction to Interfaces and Colloids: The Bridge to Nanoscience, World Scientific, 2010*

Learning Assessment

	Bloom's Level of Thinking	Continuous Learning Assessment (50% weightage)								Final Examination (50% weightage)	
		CLA – 1 (10%)		CLA – 2 (15%)		CLA – 3 (15%)		CLA – 4 (10%)#			
		Theory	Practice	Theory	Practice	Theory	Practice	Theory	Practice	Theory	Practice
Level 1	Remember Understand	30 %	-	30 %	-	30 %	-	30 %	-	30%	-
Level 2	Apply Analyze	40 %	-	40 %	-	40 %	-	40 %	-	40%	-
Level 3	Evaluate Create	30 %	-	30 %	-	30 %	-	30 %	-	30%	-
	Total	100 %		100 %		100 %		100 %		100 %	

CLA – 4 can be from any combination of these: Assignments, Seminars, Tech Talks, Mini-Projects, Case-Studies, Self-Study, MOOCs, Certifications, Conf. Paper etc.,

Course Designers

Experts from Industry	Experts from Higher Technical Institutions	Internal Experts
1. Dr. Krishna Surendra, SAINT GOBAIN, Krishna.muvvala@saintgobain.com	*1.. Dr. Vinu, IITM, vinu@iitm.ac.in*	*1. Dr. V. Eswaraiah, SRMIST*
2. Dr. D.K. Aswal, National Physical Laboratory, dkaswal@nplindia.org	*2. Dr. S. Ramaprabhu,IITM, ramp@iitm.ac.in*	*2. Dr. N. Venkatramaiah, SRMIST*

Course Code	18NTE401T	Course Name	NANOROBOTICS	Course Category	E	Professional Elective	L	T	P	C
							3	0	0	3

Pre-requisite Courses	Nil	Co-requisite Courses	Nil	Progressive Courses	Nil
Course Offering Department	Nanotechnology	Data Book / Codes/Standards	Nil		

Course Learning Rationale (CLR):	*The purpose of learning this course is to:*
CLR-1 :	*Provide an insight into the fundamentals of nanorobotics manipulation and assembly*
CLR-2 :	*Gain scientific understanding regarding the role of nanorobotics in the modern engineering applications*
CLR-3 :	*Understand the concept of nanomanipulation of nanostructures*
CLR-4 :	*Learn the techniques of automated manipulation of nanoobjects*
CLR-5 :	*Gain knowledge on theoretical and experimental aspects of Nanorobotics*
CLR-6 :	*Understand the principles of nanomicroscopy*

Course Learning Outcomes (CLO):	*At the end of this course, learners will be able to:*	Learning 1 Level of Thinking (Bloom)	2 Expected Proficiency (%)	3 Expected Attainment (%)	PLO 1 Engineering Knowledge	2 Problem Analysis	3 Design & Development	4 Analysis, Design, Research	5 Modern Tool Usage	6 Society & Culture	7 Environment & Sustainability	8 Ethics	9 Individual & Team Work	10 Communication	11 Project Mgt. & Finance	12 Life Long Learning	13 PSO - 1	14 PSO - 2	15 PSO - 3
CLO-1 :	*Apply the scientific concepts underlying engineering and technological applications in nanorobotics*	*2*	*80*	*75*	*H*	*M*	*H*	*H*	*H*	*M*	*M*	*H*	*H*	*M*	*M*	*H*	*H*	*H*	*H*
CLO-2 :	*Acquire the knowledge of nanorobotics manipulation*	*2*	*80*	*75*	*H*	*M*	*M*	*M*	*M*	*M*	*M*	*H*	*M*	*H*	*M*	*H*	*M*	*M*	*M*
CLO-3 :	*Apply the knowledge of fast imaging system for advance nanotechnology applications*	*2*	*75*	*70*	*H*	*M*	*H*	*H*	*H*	*H*	*H*	*M*	*H*	*H*	*H*	*M*	*H*	*H*	*H*
CLO-4 :	*Get familiarize with the new concepts of real-time nanomanipulation*	*2*	*75*	*70*	*M*	*H*	*H*	*M*	*H*	*H*	*H*	*H*	*H*	*M*	*M*	*H*	*H*	*H*	*H*
CLO-5 :	*Apply the concept of nanorobotics assembly using CAD*	*2*	*75*	*70*	*H*	*M*	*H*	*H*	*H*	*M*	*M*	*H*	*M*	*H*	*M*	*M*	*H*	*H*	*H*
CLO-6 :	*Utilize the concept of nanobots for Medical applications*	*2*	*80*	*75*	*H*	*M*	*M*	*H*	*M*	*M*	*M*	*H*	*H*	*H*	*M*	*H*	*H*	*M*	*M*

Duration (hour)		9	9	9	9	9
S-1	SLO-1	*Types of interaction forces*	*Dieelectric materials*	*Sensors-classifications*	*computer-aided design (CAD)*	*Nanorobotic- introduction*
	SLO-2	*Interaction forces in nanomanipulation*	*Dielectric polarization*	*Art of compressive sensing*	*CAD models of nanostructures*	*Nanorobotic Applications*
S-2	SLO-1	*Actuation*	*Electro rotation*	*Fast imaging system*	*Automated manipulation of micro-nano objects*	*Endoscopy imaging*
	SLO-2	*Electro kinetic based actuation*	*Theory and modelling of electro rotation*	*Compressive sensing based fast imaging system*	*Automated manipulation of nanostructures*	*Wireless capsules endoscopy imaging*
S-3	SLO-1	*Carbon nanotubes*	*Properties of fluid medium*	*SPMbasics*	*Automated manipulation of Nanorods*	*Energy harvesting*
	SLO-2	*Electro kinetic manipulation of carbon nanotubes*	*Dynamic effects of fluid medium*	*AFM based imaging*	*Automated manipulation of Nanowires*	*Energy harvesting by nanorobotic*
S-4	SLO-1	*Graphene sheets*	*Dielectrophoretic*	*Atomic manipulation in AFM*	*Automated manipulation of nanotubes*	*Gastro-intestinal tract- introduction*
	SLO-2	*Nanoparticles*	*Nanoparticles by dielectrophoretic*	*AFM based nanorobotic system*	*Automated manipulation of nanoparticles*	*Capsules robot in gastro-intestinal tract*
S-5	SLO-1	*Biological entities*	*CNT-definition*	*Augmented reality*	*Augmented reality system*	*Nanorobots - introduction*
	SLO-2	*Biological nanomaterials*	*Manipulation of CNT*	*AFM based nanorobotic system enhanced by augmented reality*	*Limitation of augmented reality system*	*Nanorobots –basic design*
S-6	SLO-1	*Laser based actuation-fundamentals*	*Scanning probes*	*Hardware setup for Sensing*	*Real time fault detection*	*Cooperative control design for nanorobots*
	SLO-2	*Laser based actuation-applications*	*Nanomanipulation by scanning probe*	*Software setup for Sensing*	*Methods of real time fault correction*	*Design and application of nanorobotics in oncology*

S-7	SLO-1	*Optical tweezers*	*Atomic scale stick-definition*	*Hardwaresetup for fast imaging system*	*Time random drift*	*Drug delivery system*
	SLO-2	*Applications of optical tweezers*	*Reducing atomic scale stick*	*Softwaresetup for fast imaging system*	*Time random drift compensation with local scan*	*Cooperative control design for nanorobots in drug delivery*
S-8	SLO-1	*Manipulation of biological entities*	*Slip motion*	*Experiments on nanomanipulation of nanoparticles-I*	*on-line fault detection*	*Medical applications of nanorobots*
	SLO-2	*Manipulation of chemical entities*	*Nanomanipulation by slip motion*	*Experiments on nanomanipulation of nanoparticles-II*	*Interpretation of on-line fault correction*	*Medical applications of nanorobots: current proposals and designs*
S-9	SLO-1	*Piezoelectricity*	*Feedback control*	*Experiments on nanomanipulation of nanoparticles-III*	*Implementation of the data to test the hypothesis*	*Therapy using nanorobots*
	SLO-2	*Piezoelectric enabled actuators*	*Slip motion by feedback control nanomanipulation*	*Experiments on nanomanipulation of nanoparticles-IV*	*Experimental results of the data to test the hypothesis*	*Cancer targeted therapy using nanorobots*

Learning Resources	*1. Ning Xi, Guangyoung Li, "Introduction to Nanorobotic Manipulation & Assembly" Artech House Press, 2012* *2. Yi Guo,"Selected Topics in Micro/Nano-robotic for Biomedical Applications", Springer, 2013*	*3. Klaus D. Sattler, "Hand Book of Nanophysics: Nano medicine & Nanorobotics", CRC Press, 2010*

Learning Assessment

	Bloom's Level of Thinking	Continuous Learning Assessment (50% weightage)								Final Examination (50% weightage)	
		CLA – 1 (10%)		CLA – 2 (15%)		CLA – 3 (15%)		CLA – 4 (10%)#			
		Theory	Practice	Theory	Practice	Theory	Practice	Theory	Practice	Theory	Practice
Level 1	Remember Understand	30 %	-	30 %	-	30 %	-	30 %	-	30%	-
Level 2	Apply Analyze	40 %	-	40 %	-	40 %	-	40 %	-	40%	-
Level 3	Evaluate Create	30 %	-	30 %	-	30 %	-	30 %	-	30%	-
	Total	100 %		100 %		100 %		100 %		100 %	

CLA – 4 can be from any combination of these: Assignments, Seminars, Tech Talks, Mini-Projects, Case-Studies, Self-Study, MOOCs, Certifications, Conf. Paper etc.,

Course Designers

Experts from Industry	Experts from Higher Technical Institutions	Internal Experts
1. Dr. Narayanasvamy Vijayan, National Physical Laboratory, nvijayan@nplindia.org	*1. Prof. V. Subramaniam, IITM, Chennai, manianvs@iitm.ac.in*	*1. Dr. S. Murali, SRMIST*
2. Dr. A. Pandikumar, Scientist, CSIR-CERL, pandikumar@cecri.res.in	*2. Prof. D. Arivuoli, Anna University, arivuoli@annauniv.edu*	*2. Dr. V. Kathirvel, SRMIST*

Course Code	18NTE402T	Course Name	MICRO AND NANOFLUIDS	Course Category	E	Professional Elective	L	T	P	C
							3	0	0	3

Pre-requisite Courses	Nil	Co-requisite Courses	Nil	Progressive Courses	Nil
Offering Department	Nanotechnology	Data Book / Codes/Standards	Nil		

Learning Rationale (CLR):	The purpose of learning this is to:
CLR-1 :	*Acquire knowledge on various physical principles related to liquid flow*
CLR-2 :	*Understand theory of fluid flow in micro and nano-size devices.*
CLR-3 :	*Describe the concept of heat and mass transfer phenomena in channel*
CLR-4 :	*Unifies thermal sciences with colloidal sciences, biological sciences*
CLR-5 :	*Gain knowledge on electrochemistry*
CLR-6 :	*Understand the applications of micro and nanofluidics*

Learning Outcomes (CLO):	At the end of this , learners will be able to:	Learning 1	2	3	Program Learning Outcomes (PLO) 1	2	3	4	5	6	7	8	9	10	11	12	13	14	15
		Level of Thinking (Bloom)	Expected Proficiency (%)	Expected Attainment (%)	Engineering Knowledge	Problem Analysis	Design & Development	Analysis, Design, Research	Modern Tool Usage	Society & Culture	Environment & Sustainability	Ethics	Individual & Team Work	Communication	Project Mgt. & Finance	Life Long Learning	PSO - 1	PSO - 2	PSO - 3
CLO-1 :	*Apply the principles of liquid flow*	2	80	75	H	M	H	H	H	M	M	H	H	H	M	H	H	H	H
CLO-2 :	*Analyze flow of fluid in micro and nano-size devices*	2	80	70	H	M	M	H	M	M	M	M	M	H	M	H	M	M	M
CLO-3 :	*Apply the knowledge of micro and nanofluidic devices, their fabrication, charecterization*	2	75	70	H	M	H	M	M	H	H	M	H	H	H	H	H	H	H
CLO-4 :	*Utilize the opportunities in the emerging field of micro and nanofluids*	2	80	75	M	H	H	M	H	H	H	H	H	H	M	H	H	H	H
CLO-5 :	*Apply the concept electrochemistry*	2	80	70	H	M	H	H	M	M	H	H	M	H	M	H	H	H	H
CLO-6 :	*Utilize the new concepts of real-time nanomanipulation & assembly*	2	80	75	H	M	M	M	H	M	M	M	H	H	M	H	H	M	H

Duration (hour)		9	9	9	9	9
S-1	SLO-1	*Microscale liquid flow - Introduction*	*Microscale viscous flow - Essentials*	*Heat transfer phenomena in channels and tubes*	*Elements of electrochemistry and the electrical double layer - introduction*	*Elements of cell biology and applications*
	SLO-2	*Micro and Nanofluidics*	*Structure of flow in a pipe or channel*	*Mass transfer phenomena in channels and tubes*	*The structure of water and ionic species*	*Nucleic acids and polysaccharides*
S-2	SLO-1	*Micro and Nanofluidics devices*	*Poiseuille flow in a pipe*	*One-dimensional temperature distributions in channel flow*	*Chemical bonds in biology and chemistry*	*Proteins : Protein function*
	SLO-2	*Design of micro and Nanofluidics devices*	*Poiseuille flow in a pipe – derivation of maximum velocity*	*Temperature distributions in channel flow (Quantitative approach)*	*Hydration of ions*	*Protein structure*
S-3	SLO-1	*Preparatory concepts*	*The velocity in slip flow - gases*	*Thermal and mass transfer entrance regions*	*Chemical potential*	*Some common proteins*
	SLO-2	*Constitutive Laws*	*The velocity in slip flow - Liquids*	*Mass transfer entrance regions*	*Chemical potential (Quantitative approach)*	*Few polypeptide chains are useful*
S-4	SLO-1	*Determination of transport properties – viscosity, diffusion coefficients*	*Flow in a thin film under gravity*	*The temperature distribution in fully developed tube flow*	*The Gibbs function*	*Protein binding*
	SLO-2	*Determination of transport properties – thermal conductivity*	*Flow in a thin film under gravity – film flow rate*	*Nusselt number*	*Chemical equilibrium*	*Cells - The cell membrane*
S-5	SLO-1	*Classification of fliud flows*	*Fully developed suction flows*	*The Graetz problem for a channel*	*Electrochemical potential*	*Membrane transport*
	SLO-2	*Continuum approximation and its limitations*	*Velocity profile – suction flow*	*The Graetz problem for a channel (Quantitative approach)*	*Acids, bases, and electrolytes*	*Ion channels*
S-6	SLO-1	*Kinematics - Surface forces*	*Developing suction flows*	*Mass transfer in thin films*	*Site-binding models of the silica surface*	*Applications - DNA transport*

	SLO-2	*Body forces*	*Darcy's law*	*A thin liquid film falling under gravity*	*Polymer surfaces*	*DNA current*
S-7	SLO-1	*Navier-Stokes equation*	*Surface tension driven flow*	*Classical Taylor–Aris dispersion*	*Qualitative description of the electrical double layer -*	*Development of an artificial kidney : Background*
	SLO-2	*Navier–Stokes equations in Cartesian coordinates*	*Surface tension driven flow (Quantitative approach)*	*Classical Taylor–Aris dispersion (Quantitative approach)*	*Qualitative description of the electrical double layer - triple layer model*	*The nanopore membrane for filtration, Hindered transport*
S-8	SLO-1	*Energy transport*	*Stokes flow past a sphere*	*The stochastic nature of diffusion*	*The electrical double layer on a cylinder*	*Biochemical sensing : Biosensor, Receptor -based classification of biosensors*
	SLO-2	*Energy transport - conduction heat transfer*	*Stokes flow past a sphere – drag calculation*	*Brownian motion*	*The electrical double layer on a sphere*	*Transducer-based classification of biosensors*
S-9	SLO-1	*Two-dimensional, Steady flow*	*Sedimentation of a solid particle*	*Unsteady mass transport in uncharged membranes*	*Electrical conductivity in an electrolyte solution.*	*Evaluation of biosensor performance*
	SLO-2	*Incompressible flow*	*Simple model for blood flow*	*Temperature and concentration boundary layers*	*Electrophoretic effect*	*Nanopores and nanopore membranes for biochemical sensing.*

Learning Resources	1. *Terrence Conlisk "Essential of Micro and nanofluidics: with applicationsto biological and chemical sciences" Cambridge University Press, 2018.* 2. *Joshua Edel "Nanofluidics" RCS publishing, 2016.*	3. *Henrik Bruus "Theoretical Microfluidics" Oxford Master Series in Physics,2007.* 4. *Patric Tabeling "Introduction to Microfluids" Oxford U. Press, 2005.* 5. *Christ of M. Niemeyer & Chad A. Mirkin, "Nanobiotechnology: Concepts, Application and Perspectives", Wiley VCH, 2004.* 6. *Sarit K.Das, Stephen U.S. Choi, Whenhua Yu & T. Pradeep, "Nanofluids Science and Technology" Wiley Interscience, 2007.*

Learning Assessment

	Bloom's Level of Thinking	Continuous Learning Assessment (50% weightage)								Final Examination (50% weightage)	
		CLA – 1 (10%)		CLA – 2 (15%)		CLA – 3 (15%)		CLA – 4 (10%)#			
		Theory	Practice	Theory	Practice	Theory	Practice	Theory	Practice	Theory	Practice
Level 1	Remember Understand	30 %	-	30 %	-	30 %	-	30 %	-	30%	-
Level 2	Apply Analyze	40 %	-	40 %	-	40 %	-	40 %	-	40%	-
Level 3	Evaluate Create	30 %	-	30 %	-	30 %	-	30 %	-	30%	-
	Total	100 %		100 %		100 %		100 %		100 %	

CLA – 4 can be from any combination of these: Assignments, Seminars, Tech Talks, Mini-Projects, Case-Studies, Self-Study, MOOCs, Certifications, Conf. Paper etc.,

Course Designers

Experts from Industry	Experts from Higher Technical Institutions	Internal Experts
1. Mr. Sameer Sharda, New Age Instruments & Materials Pvt. Ltd, Gurgaon, sameer@newagein.com	*1. Dr. Basavaraj Madivala Gurappa, IIT Madras, Chennai, basa@iitm.ac.in*	*1. Dr. Junaid Masud Laskar, SRMIST*
2. Mr. Mohammed Shafi, Holmarc Opto-Mechatronics Pvt. Ltd, Cochin, optics@holmarc.com	*2. Dr. Dillip K. Satapathy, IITM, Chennai, dks@iitm.ac.in*	*2. Dr. Surya K Ghosh, SRMIST*

Course Code	18NTE403T	Course Name	NANOTECHNOLOGY FOR ENERGY SYSTEMS	Course Category	E	Professional Elective	L	T	P	C
							3	0	0	3

Pre-requisite Courses	Nil	Co-requisite Courses	Nil	Progressive Courses	Nil
Offering Department	NanotechnologTtty	Data Book / Codes/Standards	Nil		

Learning Rationale (CLR):	The purpose of learning this is to:
CLR-1 :	Learn the importance of renewable energies for the safe survival of human kind on the earth
CLR-2 :	Understand the basics of green energy production, storage and transport
CLR-3 :	Understand how nanotechnology can improve the green energy production from various sources
CLR-4 :	Explore the methods of hydrogen production and storage
CLR-5 :	Acquire knowledge on the fabrication, characterization of nanomaterials useful for energy production, transportation and storage
CLR-6 :	Acquire knowledge on design, fabrication, characterization of advanced energy systems

Learning Outcomes (CLO):	At the end of this , learners will be able to:	Learning 1: Level of Thinking (Bloom)	2: Expected Proficiency (%)	3: Expected Attainment (%)	PLO 1: Engineering Knowledge	2: Problem Analysis	3: Design & Development	4: Analysis, Design, Research	5: Modern Tool Usage	6: Society & Culture	7: Environment & Sustainability	8: Ethics	9: Individual & Team Work	10: Communication	11: Project Mgt. & Finance	12: Life Long Learning	13: PSO - 1	14: PSO - 2	15: PSO - 3
CLO-1 :	Identify the urgency of energy solutions and the expectations of Nanotechnology in providing long term solutions to these problems	2	80	75	H	M	H	H	H	H	M	H	H	H	M	H	H	H	H
CLO-2 :	Describe the concepts of heterogeneous catalysis, and further apply in the designing of various nanocatalysts for energy applications	2	80	70	H	M	M	H	M	M	H	H	M	M	H	H	M	M	M
CLO-3 :	Apply Nanotechnology and nanomaterials in the designing of solar energy conversion systems and fuel cell technologies	2	75	70	H	M	H	H	H	H	H	M	H	M	H	H	H	H	H
CLO-4 :	Apply the Nanotechnology and nanomaterials for energy storage technologies	2	80	75	M	H	H	M	H	H	H	H	H	M	M	H	H	H	H
CLO-5 :	Apply the thermoelectric principles and nanotechnology to design high figure-of-merit thermoelectric devices	2	80	70	H	H	H	H	H	M	M	M	M	H	H	H	H	H	H
CLO-6 :	Apply Nanotechnology in the sensing and remediation of pollutants in air and water	2	80	75	H	H	M	H	H	M	M	M	H	H	M	H	H	M	H

Duration (hour)		9	9	9	9	9
S-1	SLO-1	Energy Challenge in the 21st Century	Terawatt challenges in photovoltaics	Bulk thermoelectric materials	Low temperature fuel cells	Introduction to contribution of nanotechnology to hydrogen production
	SLO-2	Fuel share of world total primary energy supply	How can photovoltaics meet a significant fraction of energy demand?	Basics of thermoelectricity, Seebeck effect, Peltier effect, Figure of merit, Wiedemann-Franz relationship	Impact on nanostructured materials, development of low-temperature fuel cells	Methods of hydrogen production, Importance of hydrogen energy
S-2	SLO-1	Nanotechnology in energy research	Limits in conversion efficiency	Bulk thermoelectric materials- size effects, Selection criteria for bulk thermoelectric materials	Cathode and anode reaction	Nanomaterial based photoelectron chemical cell
	SLO-2	The importance of nanotechnology in improving the nanoscale energy devices	Theoretical limits of photovoltaics efficiency and possible improvements by different approaches	Important three guidelines	Oxygen reduction reaction, cathodic reactions, reactions at anode surface	Nanocrystalline thin films of metal oxides in PEC solar cells, Water splitting for producing hydrogen
S-3	SLO-1	Conventional fossil fuels Unconventional fossil fuels	Hybrid concepts	Effect of size of the quantum dots, nanowires on the conversion efficiency, classical and quantum size effects	Practical fuel cell catalysts and Electrolytes	Semiconductors with specific morphology such as nanotubes and discs for production of hydrogen
	SLO-2	Discussion about greenhouse gases, Clean energy sources and advantages	Combining organic and inorganic cells, concept of heterojunction-type photoactive layer, hole-electron pair	Thermoelectric properties on nanoscale: modeling	Nanostructured materials in low-temperature cell, Non-precious catalysts, electrolytes	Sensitization, Hydrogen storage: technological barriers
S-4	SLO-1	Nanotechnology in fuel production	Semiconductors optical properties	Understanding thermoelectric properties on the nanoscale using modeling	High-temperature polymer electrolyte membranes, membrane-electrode assembly	Methods of improving efficiency of cells, HOMO-LUMO gap, several examples of sensitization
	SLO-2	Making efficient and economical engines	Basics of semiconductors, bandgap	Importance of characteristic length scale, Bi nanostructures	High temperature fuel cells	Hydrogen storage technology –potential storage materials hydrogen sorption

S-5	SLO-1	Renewable energy sources-Photovoltaics	charge carrier transport in semiconductors	Importance of Bi nanowire and its diameter in thermoelectricity	Development of cells that operate up to 700ºC	Hydrogen storage by Physiosorption and chemisorption methods
	SLO-2	Emission spectra and color as a function of particle size of a quantum dot	Optical properties of semiconducting thin films, Optical absorption	Silicon nanowire and importance at nanoscale	High temperature ceramic electro catalysts	Properties of materials: physical storage, thermodynamic and kinetics
S-6	SLO-1	Example of nc-CdTe film on ITO-coated glass solar cell	Narrow and wide band gap materials, importance of optical absorption	How surface roughness effects thermal conductivity. Phonon effects on the Seebeck coefficient and thermal conductivity	Electrochemical reaction at high temperatures, triple phase boundary	Bond strengths for Physiosorption and chemisorption, The desirable range of bonding energies
	SLO-2	Gratzel Cell Examples of nanostructured films used for PV cells	Selection of Dye sensitizer for better optical absorption, n-CdS band gap	Thermionics nanocomposites	Porous Ni-Ceramic electrolyte (YSZ), LaSrMnOe ceramic electrolyte	Nanostructured carbon
S-7	SLO-1	Hydrogen production	Dye molecular engineering	Description of electron motion across the barrier	Application of high temperature ceramic electro catalysts	MWNT, SWNT, carbon nanorods and aerogels etc.
	SLO-2	Mechanisms of dye sensitization and sensitization by composite semiconductors	HOMO-dye, LUMO gap	Si/SiGe superlattice nanowire, prototype InP/InAs superlattice nanowire	Various examples of high temperature fuel cells where ceramic electro catalysts are used	zeolites- clathrates- polymers
S-8	SLO-1	Hydrogen energy system. Advantages of hydrogen fuel	Stable self-assembling dye. Monomolecular layer	Thermoelectric nanocomposites	Solid oxide fuel cells (SOFCs)	Reversible occlusion of gases. Metal-organic frame works and their storage efficiency
	SLO-2	Fuel cells, REDOX potentials, electrochemical reactions in different types of fuel cells	Structure of the Z-907 amphiphilic Dye	PbTe-PhSeTe quantum dot	Mechanical properties, Efficiency, operating temperatures	Metals and complex hydrides- chemical hydrides nanocomposites
S-9	SLO-1	Microbial fuel cells, polymer electrolyte fuel cells	Electron transfer mechanism from TiO2 to Dye, Dye excitation and relaxation mechanisms	PbTe-PbSe bulk alloys, superlattice systems	Dry hydrocarbons in SOFC	Hydrogen storage by chemisorption, basic structures of metal and complex hydrides, chemical hydrides, Nanocomposites
	SLO-2	Introduction to Thermoelectricity	The nanostructured semiconductors	Application of thermionic and thermoelectric nanocomposites	Applications of Fuel cells	Some examples of storing hydrogen with the above materials

Learning Resources	1. Javier Garcia-Martinez, Nanotechnology for the Energy Challenge, WILEY-VCH Verlag GmbH & Co., 2010 2. 2. Anatoli Korkin, David J, Nanoscale Applications for Information and Energy Systems, Springer, 2013	3. Darren P. Broom, Hydrogen Storage materials: The characterization of their properties, Springer, 2011

Learning Assessment

	Bloom's Level of Thinking	Continuous Learning Assessment (50% weightage)								Final Examination (50% weightage)	
		CLA – 1 (10%)		CLA – 2 (15%)		CLA – 3 (15%)		CLA – 4 (10%)#			
		Theory	Practice	Theory	Practice	Theory	Practice	Theory	Practice	Theory	Practice
Level 1	Remember Understand	30 %	-	30 %	-	30 %	-	30 %	-	30%	-
Level 2	Apply Analyze	40 %	-	40 %	-	40 %	-	40 %	-	40%	-
Level 3	Evaluate Create	30 %	-	30 %	-	30 %	-	30 %	-	30%	-
	Total	100 %		100 %		100 %		100 %		100 %	

CLA – 4 can be from any combination of these: Assignments, Seminars, Tech Talks, Mini-Projects, Case-Studies, Self-Study, MOOCs, Certifications, Conf. Paper etc.

Course Designers		
Experts from Industry	Experts from Higher Technical Institutions	Internal Experts
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2. Dr. Krishna Surendra Muvvala, Saint Gobain Research India, India, Krishna.muvvala@saintgobain.com	*2. Prof. M. Ghanashyam Krishna, UOHYD, mgksp@uohyd.ernet.in*	*2. Dr. K. Kamalabharathi, SRMIST*

Course Code	18NTE404T	Course Name	PHOTOVOLTAIC TECHNOLOGY	Course Category	E	Professional Elective	L	T	P	C
							3	0	0	3

Pre-requisite Courses	Nil	Co-requisite Courses	Nil	Progressive Courses	Nil
Course Offering Department	Nanotechnology	Data Book / Codes/Standards	Nil		

Course Learning Rationale (CLR):	*The purpose of learning this course is to:*
CLR-1 :	*Learn the basic principles and design of photovoltaic cell technology*
CLR-2 :	*Understand the key properties of semiconductors used in photovoltaic technology*
CLR-3 :	*Learn about basic photovoltaic device structure and design*
CLR-4 :	*Develop an understanding of the primary photovoltaic device technologies and their design*
CLR-5 :	*Gain exposure to the various applications of photovoltaics*
CLR-6 :	*Acquire knowledge on advanced concepts explored in photovoltaics*

Course Learning Outcomes (CLO):	*At the end of this course, learners will be able to:*	Learning 1 Level of Thinking (Bloom)	2 Expected Proficiency (%)	3 Expected Attainment (%)	PLO 1 Engineering Knowledge	2 Problem Analysis	3 Design & Development	4 Analysis, Design, Research	5 Modern Tool Usage	6 Society & Culture	7 Environment & Sustainability	8 Ethics	9 Individual & Team Work	10 Communication	11 Project Mgt. & Finance	12 Life Long Learning	13 PSO - 1	14 PSO - 2	15 PSO - 3
CLO-1 :	*Differentiate between different types of photovoltaic technologies*	2	80	75	H	H	H	H	H	H	M	H	H	H	H	H	H	H	H
CLO-2 :	*Interpret important properties of semiconductors relevant to photovoltaics*	2	80	70	H	H	M	H	M	H	M	H	M	H	H	H	M	M	M
CLO-3 :	*Apply different photovoltaic device design concepts for different applications*	2	75	70	H	H	H	H	H	H	H	M	M	H	H	H	H	H	H
CLO-4 :	*Appreciate advancement of different generations of solar cells*	2	80	75	M	H	H	M	H	H	H	H	H	H	M	H	H	H	H
CLO-5 :	*Appreciate the advanced concepts and explorations in photovoltaics*	2	80	70	H	M	H	H	H	M	M	H	M	H	H	H	H	H	H
CLO-6 :	*Perform photovoltaic device testing and calculations*	2	80	75	H	M	M	H	H	M	M	H	M	H	M	H	H	M	H

Duration (hour)		9	9	9	9	9
S-1	SLO-1	*Renewable energy technologies*	*Optical absorption*	*Solar Cell parameters*	*Si photovoltaics*	*III-V photovoltaics*
	SLO-2	*Present and future global issues*	*Carrier photogeneration*	*Device testing*	*Fabrication of Si solar cells*	*Multi-junction solar cells*
S-2	SLO-1	*Historical development of PV; drivers-*	*Band gap*	*Efficiency calculations*	*High efficiency single crystal Si solar cells*	*Spectral splitting*
	SLO-2	*Commercialization/economic factors*	*Direct vs. indirect bandgaps*	*(EFF, VOC, JSC) for ideal cells*	*Si PV designs*	*GaInP/GaAs/Ge triple junction solar cell*
S-3	SLO-1	*Basic components of PV systems*	*Minority carrier transport properties-*	*Non-idealities*	*Polycrystalline/microcrystalline Si solar cells*	*Bandgap profile optimization*
	SLO-2	*Mechanism of PV*	*Carrier recombination-lifetime and defects*	*Series resistance, shunt resistance*	*Amorphous Si solar cells*	*Solar spectrum matching*
S-4	SLO-1	*Sun as a source of energy*	*Band to band and Shockley-Read-hall*	*Optical loss mechanisms*	*Heterojunctions - review*	*Tunnel junctions*
	SLO-2	*The solar spectrum*	*High injection effects*	*Implications on device performance*	*p-i-n and n-i-p structures*	*Current matching limitations*
S-5	SLO-1	*Measuring sun light*	*Surface and interface recombination*	*Electrical loss mechanisms*	*Thin film II-VI solar cells*	*Concentrator photovoltaics (CPV)-*
	SLO-2	*Atmospheric effects*	*Implications on device performance*	*Implications on device performance*	*Chalcopyrite photovoltaics*	*Concentrator optics,*
S-6	SLO-1	*Terrestrial and space spectra;*	*PN homojunctions*	*Basics of solar cell device design*	*CdTe/CdS thin film solar cells*	*CPV cells*

	SLO-2	*Air mass (AM0, AM1.5)*	*Carrier transport under broad spectrum illumination*	*Minimization of losses*	*Superstrate structure*	*Terrestrial CPV systems*
S-7	SLO-1	*Classification of photovoltaic technologies*	*Photocurrent*	*Lateral design and Vertical design*	*CuInGaSe2/CdS thin film cell technologies*	*Space photovoltaics*
	SLO-2	*Generations of solar cells*	*Spectral response*	*Cyclotron frequency*	*Earth abundant alternatives*	*Radiation effects in semiconductors and solar cells*
S-8	SLO-1	*1st generation photovoltaics*	*Current transport models*	*Optical versus electrical tradeoffs and optimization*	*Dye-Sensitized solar cells*	*New concepts*
	SLO-2	*Silicon technology*	*Non idealities*	*Band gap and other material properties*	*QDSSCs*	*Quantum dots, wires*
S-9	SLO-1	*2nd generation photovoltaics*	*Real p-n diodes*	*Spectral utilization*	*Organic photovoltaics*	*Intermediate band solar cells*
	SLO-2	*3rd generation photovoltaics*	*Temperature effects*	*Light management*	*Hybrid solar cells*	*Multiple exciton generation*

Learning Resources	1. *Solanki C.S., "Solar photovoltaics - fundamentals, technologies and applications", 3rd edition, PHI LearningPvt Ltd, New Delhi, India* 2. *Fonash S.J., "Solar Cell Device Physics", Academic, 2010*	3. *Moller H.J., "Semiconductors for Solar Cells",Artech House, 1993 .* 4. *Green M.A., "Third Generation Photovoltaics: Advanced Solar Energy Conversion", Springer, 2006Fundamentals of Solid State Engineering, Manijeh Razeghi, KLUWER ACADEMIC PUBLISHERS, 2002*

Learning Assessment

	Bloom's Level of Thinking	Continuous Learning Assessment (50% weightage)								Final Examination (50% weightage)	
		CLA – 1 (10%)		CLA – 2 (15%)		CLA – 3 (15%)		CLA – 4 (10%)#			
		Theory	Practice	Theory	Practice	Theory	Practice	Theory	Practice	Theory	Practice
Level 1	Remember Understand	30 %	-	30 %	-	30 %	-	30 %	-	30%	-
Level 2	Apply Analyze	40 %	-	40 %	-	40 %	-	40 %	-	40%	-
Level 3	Evaluate Create	30 %	-	30 %	-	30 %	-	30 %	-	30%	-
	Total	100 %		100 %		100 %		100 %		100 %	

CLA – 4 can be from any combination of these: Assignments, Seminars, Tech Talks, Mini-Projects, Case-Studies, Self-Study, MOOCs, Certifications, Conf. Paper etc.,

Course Designers

Experts from Industry	Experts from Higher Technical Institutions	Internal Experts
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Course Code	18NTE405T	Course Name	NANOTECHNOLOGY IN COSMETICS	Course Category	E	Professional Elective	L	T	P	C
							3	0	0	3

Pre-requisite Courses	Nil	Co-requisite Courses	Nil	Progressive Courses	Nil
Offering Department	Nanotechnology	Data Book / Codes/Standards	Nil		

Learning Rationale (CLR):	*The purpose of learning this is to:*
CLR-1 :	*Understand the basis of cosmeceuticals*
CLR-2 :	*Know the classification and various types of cosmetics*
CLR-3 :	*Acquire knowledge about ingredients and effect of inclusion of nanoparticles in cosmetics*
CLR-4 :	*Get acquainted with current trends in the field of nano based cosmetics*
CLR-5 :	*Get acquainted with future aspects of cosmetics*
CLR-6 :	*Get acquainted with future aspects of aesthetic implants*

Learning Outcomes (CLO):	*At the end of this , learners will be able to:*	Learning 1: Level of Thinking (Bloom)	2: Expected Proficiency (%)	3: Expected Attainment (%)	PLO 1: Engineering Knowledge	2: Problem Analysis	3: Design & Development	4: Analysis, Design, Research	5: Modern Tool Usage	6: Society & Culture	7: Environment & Sustainability	8: Ethics	9: Individual & Team Work	10: Communication	11: Project Mgt. & Finance	12: Life Long Learning	13: PSO - 1	14: PSO - 2	15: PSO - 3
CLO-1 :	*Apply basic concepts of nanotechnology in cosmetics*	2	80	75	H	M	H	H	H	M	M	H	H	H	M	H	H	H	H
CLO-2 :	*Distinguish effects of using nanoparticles over conventional methods in cosmetics*	2	80	70	H	M	H	H	M	M	M	H	M	H	M	H	M	M	M
CLO-3 :	*Analyze about current trends in the field of cosmetics*	2	75	70	H	M	H	H	H	H	H	M	H	H	H	H	H	H	H
CLO-4 :	*Apply basic cosmetic concepts in making nanoformulation*	2	80	75	M	H	H	M	H	H	H	H	H	H	M	H	H	H	H
CLO-5 :	*Apply knowledge in making organosilicone formulation*	2	80	70	H	M	H	H	H	M	M	H	M	H	M	H	H	H	H
CLO-6 :	*Apply knowledge in making aesthetic implants*	2	80	75	H	M	M	H	H	M	M	H	H	H	M	H	H	M	H

Duration (hour)		9	9	9	9	9
S-1	SLO-1	*Introduction to cosmetics*	*Oily materials: introduction, oils and fats, wax*	*Film formers*	*Multiple emulsions as novel delivery systems*	*Dual nanodelivery systems*
	SLO-2	*Purpose of cosmetics*	*Hydrocarbons*	*Polymers as film formers*	*Nanoemulsion in cosmetics*	*Dual nanodelivery systems-Introduction*
S-2	SLO-1	*Meaning of cosmetics*	*Higher fatty acids*	*Thickeners*	*Nanocrystals in cosmetics*	*Synthesis of dual nanodelivery systems containing vitamin e for cosmetics*
	SLO-2	*Classification of cosmetics*	*Higher alcohols, esters, silicones*	*Types of thickners*	*Silicones and beyond*	*Synthesis of dual nanodelivery systems containing vitamin e for pharmaceuticals*
S-3	SLO-1	*Cosmeceuticals*	*Surface active agents : introduction*	*Polymers in hair colouring*	*Organomodified silicones*	*Characterization of dual nanodelivery systems containing vitamin e*
	SLO-2	*Pharmaceuticals in cosmetics*	*Anionic surfactant*	*Types of polymers in hair colour*	*New esters mimicking property for organomodified silicones*	*Various characterization techniques used*
S-4	SLO-1	*Quality characteristics*	*Cationic surfactants*	*Conditioning polymers*	*Silicones in shampoo*	*Orthopedic implant*
	SLO-2	*Quality assurance*	*Amphoteric surfactant*	*Surfactants in conditioners*	*Minimalizing undesirable side effects*	*Conventional types of Orthopedic implant*
S-5	SLO-1	*Development process of cosmetics*	*Non-ionic surfactant*	*Cleansing agents*	*Substantive silicones*	*Orthopedic implant titanium rods*
	SLO-2	*Cosmetics for Skin*	*Other surfactants*	*Ethoxylated alcohols*	*Effect of substantive silicones*	*Advantages of Orthopedic implant of titanium rods*
S-6	SLO-1	*Cosmetics for hair*	*Humectants : introduction*	*Silicones*	*Organo-modified delivery systems*	*Preparation of keratin coatings for orthopedic implant titanium rods*
	SLO-2	*Cosmetics for nails*	*Choice of humectants*	*Emulsions*	*Types of Organo-modified delivery systems*	*Characterization of keratin coatings*

S-7	SLO-1	*Cosmetics colour materials*	*Unusual humectants*	*Types of polymeric systems*	*Silicones personal care delivery system*	*Nanotherapeutics as a treatment for inflammation*
	SLO-2	*Cosmetics and fragrances*	*Special uses of humectants*	*Natural polymers*	*Liposomes in cosmetics*	*Cosmetic repair and restoration*
S-8	SLO-1	*Oral care cosmetics*	*Antioxidants : introduction*	*Stimuli responsive polymeric systems*	*Niosomes in cosmetics*	*Moisturization of skin*
	SLO-2	*Body cosmetics*	*General oxidative theory, measurement of oxidation*	*pH-responsive*	*Microemulsion in cosmetics*	*Fortification of the skin barrier*
S-9	SLO-1	*Physical chemistry of cosmetics*	*Assessment of oxidant efficiency*	*Thermal responsive*	*Nanoemulsion in cosmetics*	*Contact lenses types*
	SLO-2	*Stability of cosmetics*	*Choice of antioxidant*	*Photo responsive*	*Cyclodextrin complexes in cosmetics*	*Beauty from contact lenses beyond vision correction*

Learning Resources	*1. New Cosmetic Science, Mitsui T. , Elsevier, 1998* *2 .CosmeticNanotechnology: Polymers and Colloids in Cosmetics, Sarah E.M., Kathleen O.H., Robert Y.L.,American Chemical Society, 2006*	*3. Delivery System Handbook for Personal Care and Cosmetic Products, Meyer R.R. ,William Andrew ASP, 2005.*

Learning Assessment											
	Bloom's Level of Thinking	Continuous Learning Assessment (50% weightage)								Final Examination (50% weightage)	
		CLA – 1 (10%)		CLA – 2 (15%)		CLA – 3 (15%)		CLA – 4 (10%)#			
		Theory	Practice	Theory	Practice	Theory	Practice	Theory	Practice	Theory	Practice
Level 1	Remember Understand	30 %	-	30 %	-	30 %	-	30 %	-	30%	-
Level 2	Apply Analyze	40 %	-	40 %	-	40 %	-	40 %	-	40%	-
Level 3	Evaluate Create	30 %	-	30 %	-	30 %	-	30 %	-	30%	-
	Total	100 %		100 %		100 %		100 %		100 %	

CLA – 4 can be from any combination of these: Assignments, Seminars, Tech Talks, Mini-Projects, Case-Studies, Self-Study, MOOCs, Certifications, Conf. Paper etc.,

Course Designers		
Experts from Industry	Experts from Higher Technical Institutions	Internal Experts
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Course Code	18NTE406T	Course Name	GREEN NANOTECHNOLOGY	Course Category	E	Professional Elective	L	T	P	C
							3	0	0	3

Pre-requisite Courses	Nil	Co-requisite Courses	Nil	Progressive Courses	Nil
Offering Department	Nanotechnology	Data Book / Codes/Standards	Nil		

Learning Rationale (CLR):	*The purpose of learning this is to:*
CLR-1 :	*Familiarize with the field of traditional manufacturing to green manufacturing*
CLR-2 :	*Understand the various p techniques for sustainable green manufacturing*
CLR-3 :	*Able to green nanotechnology concepts in Industrial process*
CLR-4 :	*Gain knowledge on industrial policies and operations in industry*
CLR-5 :	*Understand the list of metrics in the industry*
CLR-6 :	*Familiarize the life cycle process of industrial production*

Learning Outcomes (CLO):	*At the end of this , learners will be able to:*	Learning 1: Level of Thinking (Bloom)	2: Expected Proficiency (%)	3: Expected Attainment (%)	PLO 1: Engineering Knowledge	2: Problem Analysis	3: Design & Development	4: Analysis, Design, Research	5: Modern Tool Usage	6: Society & Culture	7: Environment & Sustainability	8: Ethics	9: Individual & Team Work	10: Communication	11: Project Mgt. & Finance	12: Life Long Learning	13: PSO - 1	14: PSO - 2	15: PSO - 3
CLO-1 :	*Apply the concepts of green manufacturing in industry*	2	80	75	H	M	H	H	H	M	M	H	H	H	M	H	H	H	H
CLO-2 :	*Solve the general problems associated with the sustainable green manufacturing*	2	80	70	H	M	M	H	M	M	M	H	M	H	M	H	M	M	M
CLO-3 :	*Utilize and reuse the resources effectively in industrial process*	2	75	70	H	M	H	H	H	H	H	M	H	H	H	H	H	H	H
CLO-4 :	*Follow the policies & metrics in industrial process*	2	80	75	M	H	H	M	H	H	H	H	H	H	M	H	H	H	H
CLO-5 :	*Analyze the life cycle production systems using analyzing machine tools*	2	80	70	H	M	H	H	H	M	M	H	M	H	M	H	H	H	H
CLO-6 :	*Utilize green manufacturing in semiconductor manufacturing process*	2	80	75	H	M	M	H	H	M	M	H	H	H	M	H	H	M	H

Duration (hour)		9	9	9	9	9
S-1	SLO-1	*Green manufacturing*	*Social, business & policy environment*	*Metrics for green manufacturing*	*Closed loop production systems*	*Semiconductor manufacturing*
	SLO-2	*Sustainability*	*Need for change*	*Current metrics*	*Life cycle production systems*	*Semiconductor fabrication*
S-2	SLO-1	*Regulation pressure*	*Internal stake holders*	*Financial metrics*	*Economic and ecological benefits*	*Micro fabrication process*
	SLO-2	*Economic incentives*	*External stake holders*	*Metrics for ecology*	*Reduction of investment & increase of resources*	*Lithography*
S-3	SLO-1	*Comprehensive advantages*	*Components of next transition*	*Metrics for society*	*Machine tools*	*Oxidation & annealing*
	SLO-2	*Barriers*	*Linear to circular transition*	*Multiple metrics*	*Energy consumption*	*Cleaning*
S-4	SLO-1	*Environment impact on waste generation*	*Product production to service provision*	*Impact assessment*	*Life cycle assessment machine tools*	*Facility systems – resource use*
	SLO-2	*Toxic chemical releases*	*Integrated, information – Rich Communication*	*Risk assessment*	*Methods & results*	*Abatement*
S-5	SLO-1	*Energy consumption and carbon emission*	*Policy environment – Changing policy trends*	*Material flow analysis*	*Process parameter optimization*	*Green manufacturing in industry*
	SLO-2	*Strategies for green manufacturing*	*Fostering co-operation*	*Energy flow analysis*	*Constant feed per tooth*	*Concepts & challenges*
S-6	SLO-1	*Green supply chain*	*Principles of green manufacturing*	*Metric development methodologies*	*Constant spindle speed*	*Use phase issues*
	SLO-2	*Motivation for green supply chain (GSC)*	*Technology – wedgels*	*Ecological metric choice model*	*Conventional vs high speed machining*	*Analysis phase of semiconductor manufacturing*

S-7	SLO-1	*Definition of GSC*	*1st principle of green manufacturing*	*Decision tree model for equipment's Supply*	*Dry machining and minimum quantity lubrication*	*Upstream materials*
	SLO-2	*Issues in GSC*	*2nd principle of green manufacturing*	*Metrics development for component systems*	*Health & environmental hazards*	*Chemicals, silicon, water*
S-8	SLO-1	*Level of approach*	*3rd principle of green manufacturing*	*Green energy supply*	*Remanufacturing – product recovery & industrial practice*	*Infrastructure & equipment*
	SLO-2	*General problems in GSC*	*4th principle of green manufacturing*	*Green energy technologies*	*Challenges & opportunities*	*Electricity*
S-9	SLO-1	*Techniques of GSC*	*Mapping of principles*	*Solar photovoltaics, wind energy*	*Reuse*	*Semiconductor manufacturing*
	SLO-2	*Future of GSC*	*Solutions*	*Application potentials of green energy*	*Approaches for sustainable factory design*	*Transportation & use phase*

Learning Resources	1. *Green Manufacturing- Fundamentals and Applications, David A Dornfeld, Springer science publishing, 2013*	2. *Green Nanotechnology: Solutions for Sustainability and Energy in the Built Environment, Geoffrey B. Smith, Claes-Goran S. Granqvist, CRC Press, 2010*

Learning Assessment

	Bloom's Level of Thinking	Continuous Learning Assessment (50% weightage)								Final Examination (50% weightage)	
		CLA – 1 (10%)		CLA – 2 (15%)		CLA – 3 (15%)		CLA – 4 (10%)#			
		Theory	Practice	Theory	Practice	Theory	Practice	Theory	Practice	Theory	Practice
Level 1	Remember Understand	30 %	-	30 %	-	30 %	-	30 %	-	30%	-
Level 2	Apply Analyze	40 %	-	40 %	-	40 %	-	40 %	-	40%	-
Level 3	Evaluate Create	30 %	-	30 %	-	30 %	-	30 %	-	30%	-
	Total	100 %		100 %		100 %		100 %		100 %	

CLA – 4 can be from any combination of these: Assignments, Seminars, Tech Talks, Mini-Projects, Case-Studies, Self-Study, MOOCs, Certifications, Conf. Paper etc.,

Course Designers

Experts from Industry	Experts from Higher Technical Institutions	Internal Experts
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Course Code	18NTE407T	Course Name	ADVANCED COMPUTATIONAL TECHNIQUES	Course Category	E	Professional Elective	L	T	P	C
							3	0	0	3

Pre-requisite Courses	NIL	Co-requisite Courses	NIL	Progressive Courses	NIL
Course Offering Department	Nanotechnology	Data Book / Codes/Standards	NIL		

Course Learning Rationale (CLR):	*The purpose of learning this course is to:*
CLR-1 :	*Know the physical effects at the nanometer and sub-nanometer scales: how computational methods can help to understand the properties and at nanoscale*
CLR-2 :	*Acquire knowledge on molecular and optical computing*
CLR-3 :	*Know the basis of Biomedical Computing and its application*
CLR-4 :	*Develop concept on the physics and application of quantum computing*
CLR-5 :	*Acquire knowledge on parallel information processing mechanism and architecture*
CLR-6 :	*Understanding the various computing techniques in advance level*

Course Learning Outcomes (CLO):	*At the end of this course, learners will be able to:*	Learning 1	2	3	Program Learning Outcomes (PLO) 1	2	3	4	5	6	7	8	9	10	11	12	13	14	15
		Level of Thinking (Bloom)	Expected Proficiency (%)	Expected Attainment (%)	Engineering Knowledge	Problem Analysis	Design & Development	Analysis, Design, Research	Modern Tool Usage	Society & Culture	Environment & Sustainability	Ethics	Individual & Team Work	Communication	Project Mgt. & Finance	Life Long Learning	PSO - 1	PSO - 2	PSO - 3
CLO-1 :	*Apply the knowledge of the properties of nanomaterial in advance computing*	*2*	*80*	*75*	*H*	*M*	*H*	*H*	*H*	*H*	*H*	*H*	*M*	*H*	*M*	*H*	*H*	*H*	*H*
CLO-2 :	*Determine design principles through computation*	*2*	*80*	*70*	*H*	*M*	*H*	*H*	*M*	*M*	*M*	*H*	*H*	*H*	*M*	*H*	*M*	*M*	*M*
CLO-3 :	*Apply the knowledge of Biomedical Computing*	*2*	*75*	*70*	*H*	*L*	*H*	*H*	*H*	*H*	*H*	*H*	*H*	*H*	*M*	*H*	*H*	*H*	*H*
CLO-4 :	*Execute the basic of Qubit problems and gain depth knowledge about Quantum Computing*	*2*	*80*	*75*	*H*	*M*	*H*	*H*	*H*	*M*	*M*	*H*	*H*	*H*	*M*	*H*	*H*	*H*	*H*
CLO-5 :	*Apply knowledge of computing architecture in efficient optimization of the materials problems*	*2*	*80*	*70*	*H*	*M*	*H*	*H*	*H*	*M*	*M*	*H*	*M*	*H*	*M*	*H*	*H*	*H*	*H*
CLT-6:	Demonstration of the ability to design new functional materials	2	80	70															

Duration (hour)		9	9	9	9	9
S-1	SLO-1	*History of computing – Nanocomputing*	*Molecular Computing*	*Introduction to Biochemical Computing*	*Bit and Qubit*	*Parallel computing*
	SLO-2	*Nanocomputing Technologies – Alternative to Transistor Technology*	*Applications of Molecular Computing*	*Examples of Biochemical Computing*	*Coherence and Entanglement*	*Shared and Distributed Memory Clusters*
S-2	SLO-1	*Quantum Computing*	*Modeling molecules*	*Application of DFT in biological system*	*Concept Coherence*	*Parallel algorithm*
	SLO-2	*Quantum Computing: Applications*	*Modeling clusters of atoms*	*Application of MD in biological system*	*Concept of Entanglement with Examples*	*MPI based algorithm as example*
S-3	SLO-1	*Nano Information Processing*	*Overview of various first-principles methods*	*Genetic Algorithm*	*Theory Quantum Parallelisms*	*Working Concept of Mono and Multiprocessor Systems*
	SLO-2	*Prospects and Challenges*	*Discussion on Limitation and Application*	*Application of GA to Biological Systems*	*Application of Quantum Parallelisms*	*Applications: Mono and Multiprocessor Systems*
S-4	SLO-1	*Digital Signals*	*Density Functional Theory (DFT)-*	*Biological Neurons*	*Classical Gates – Reversible Operations*	*Some considerations to Parallel Processing*
	SLO-2	*Digital Gates*	*Density Functional Theory (DFT)- HK and KS equations*	*Biological Neurons in information processing*	*Sqrt (NOT) Operation*	*Usefulness of Parallel processing in various device applications*
S-5	SLO-1	*Concept Silicon Nanoelectronics*	*Structural, Electronic of nanomaterials from DFT calculations (Examples only)*	*Function of neuron cell on silicon*	*Concept of Quantum Algorithm*	*Influence of Delay Time*
	SLO-2	*Application of Silicon Nanoelectronics*	*Magnetic properties (examples only)*	*Function of neuron cell on silicon for Signal processing*	*Application Quantum Algorithms*	*Performance efficiency on Delay time*
S-6	SLO-1	*Introduction to Carbon Nanotube Electronics*	*Concept of Optical Computing*	*Modeling of neuron cells by VLSI circuits*	*Challenges to large Quantum Computers*	*Power Dissipation*

	SLO-2	*Application of CNT electronics*	*Application of Optical Computing*	*Problems on Modeling of neuron cells by VLSI circuits*	*Fabrication, Testing Architectural Challenges*	*Power Dissipation in different system*
S-7	SLO-1	*Concept of Silicon Nanoelectronics*	*Current use of optics for Computing in Industry*	*Neural networks and distributed data processing*	*Working Concept of Quantum dot cellular automata*	*Architecture for Processing in Nanosystems*
	SLO-2	*Application of Silicon Nanoelectronics*	*Optics for Computing: Future Applications*	*Problems on Neural networks and distributed data processing*	*Application with Example of Quantum dot cellular automata*	*Classic Systolic Arrays*
S-8	SLO-1	*Concept of Carbon Nanotube Electronics*	*Optical Computing Paradigms*	*Working concept of DNA Computer*	*Introduction and Working principle of Computing with QCA*	*Processor with large memory*
	SLO-2	*Application of Carbon Nanotube Electronics*	*Optical Computing Paradigms: Examples*	*Application of a DNA Computer*	*Application of Computing with QCA*	*Application of Processor with large memory*
S-9	SLO-1	*Modeling of Carbon Nanotube*	*Working concept of Photonic Switches.*	*Information Processing with Chemical reactions: Working Concept*	*QCA Clocking.*	*Processor array with SIMD*
	SLO-2	*Field Effect Transistors based on CNT*	*Application of Photonic Switches.*	*Information Processing with Chemical reactions: Example*	*QCA Design Rules.*	*PIP Architectures.*

Learning Resources	1. *Vishal Sahni et.al, Nanocomputing: The Future of Computing, Tata McGraw-Hill Education, 2008.* 2. *Feliciano Giustino, Materials Modelling using Density Functional Theory: Properties and Predictions, Oxford: Oxford University Press, 2014.*	3. *J.M. Thijssen, Computational Physics, Cambridge University Press, 2007.* 4. *Andrew R. Leach, Molecular modelling: principles and application, Pearson Education, 2001*

Learning Assessment

	Bloom's Level of Thinking	Continuous Learning Assessment (50% weightage)								Final Examination (50% weightage)	
		CLA – 1 (10%)		CLA – 2 (15%)		CLA – 3 (15%)		CLA – 4 (10%)#			
		Theory	Practice	Theory	Practice	Theory	Practice	Theory	Practice	Theory	Practice
Level 1	Remember Understand	40 %	-	30 %	-	30 %	-	30 %	-	30%	-
Level 2	Apply Analyze	40 %	-	40 %	-	40 %	-	40 %	-	40%	-
Level 3	Evaluate Create	20 %	-	30 %	-	30 %	-	30 %	-	30%	-
	Total	100 %		100 %		100 %		100 %		100 %	

CLA – 4 can be from any combination of these: Assignments, Seminars, Tech Talks, Mini-Projects, Case-Studies, Self-Study, MOOCs, Certifications, Conf. Paper etc.,

Course Designers

Experts from Industry	Experts from Higher Technical Institutions	Internal Experts
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2. Dr. Murali Kota, Global Foundaries, USA, kvrmmurali@gmail.com	2. Dr.Biswarup Pathak, IIT Indore, biswarup@iiti.ac.in	2. Dr. Saurabh Ghosh, SRMIST

Course Code	18NTE408T	Course Name	NANOTECHNOLOGY IN TEXTILES	Course Category	E	Professional Elective	L	T	P	C
							3	0	0	3

Pre-requisite Courses	Nil	Co-requisite Courses	Nil	Progressive Courses	Nil
Offering Department	Nanotechnology	Data Book / Codes/Standards	Nil		

Learning Rationale (CLR):	The purpose of learning this is to:
CLR-1 :	*Acquire knowledge on nanotechnology for textile applications*
CLR-2 :	*Learn the smart materials and devices for textile industry*
CLR-3 :	*Study the various nanostructures for improving the textile yarn and fabric*
CLR-4 :	*Understand the nanomaterials processing for textile industry*
CLR-5 :	*Learn various nanodevices for improving the textile fabrics*
CLR-6 :	*Get familiarize with the integration of nanodevices in textiles*

Learning Outcomes (CLO):	At the end of this , learners will be able to:	Learning 1: Level of Thinking (Bloom)	2: Expected Proficiency (%)	3: Expected Attainment (%)	1: Engineering Knowledge	2: Problem Analysis	3: Design & Development	4: Analysis, Design, Research	5: Modern Tool Usage	6: Society & Culture	7: Environment & Sustainability	8: Ethics	9: Individual & Team Work	10: Communication	11: Project Mgt. & Finance	12: Life Long Learning	13: PSO - 1	14: PSO - 2	15: PSO - 3
CLO-1 :	*Utilize the scientific concepts of nanotechnology in textile applications*	2	80	75	H	M	H	H	H	M	M	H	H	H	M	H	H	H	H
CLO-2 :	*Apply the nanoparticles & nanofibers in textile fabric designs*	2	80	70	H	M	M	H	M	H	M	H	M	H	M	M	M	M	M
CLO-3 :	*Familiarize the characteristics and classification of the nanomaterials for nanofabrics*	2	75	70	H	M	H	H	H	H	H	M	H	H	H	M	H	H	H
CLO-4 :	*Apply various nanocoating methodologies for improving textile fabrics*	2	80	75	M	H	H	M	H	H	H	H	H	H	M	M	H	H	H
CLO-5 :	*Familiarize with new concepts of Nanotechnology based product in Textiles*	2	80	70	H	M	H	H	H	H	M	H	M	H	M	H	H	H	H
CLO-6 :	*Apply the various nanostructures and materials in textiles fabrics*	2	80	75	H	M	M	H	H	M	M	H	H	H	M	H	M	M	H

Duration (hour)		9	9	9	9	
S-1	SLO-1	*Introduction to smart nanotextiles*	*Responsive Polymers*	*Nanocomposites for textiles*	*Nanocoatings for textiles*	*Nanogenerators for textiles*
	SLO-2	*Nanotechnology & nanomaterials*	*Classification of stimuli-responsive polymers*	*Classifications*	*Various methods of nanocoating*	*Working of nanogenartors*
S-2	SLO-1	*Nanofibers*	*Responsive polymers as sensors*	*Structure & properties*	*Sol-gel Processing*	*Classification of nanogenerators*
	SLO-2	*Advantages of nanofibers*	*Responsive polymers in drug delivery systems*	*Production methods of nanocomposites*	*Sol-gel coating methodology*	*Piezoelectric Nanogenerators (PENG)*
S-3	SLO-1	*Nanofibers fabrication*	*Responsive polymers in cell application*	*Carbon structures*	*Photocatalytic self-cleaning*	*Triboelectric Nanogenerators (TENG)*
	SLO-2	*Electrospinning*	*Responsive polymers based filters*	*Nanocellulose*	*Super hydrophobic self-cleaning*	*Theoretical origin of Nanogenerators*
S-4	SLO-1	*Enhancing the mechanical properties*	*Nanowires for textiles*	*Conducting polymers*	*Antibacterial coating*	*Fiber based PENGs*
	SLO-2	*Large scale production of fibers*	*Properties of nanowires in textiles*	*Nanoparticles, clays & wires*	*UV-Protection coating*	*Textile based PENGs*
S-5	SLO-1	*Formation of yarn & fabric*	*Balancing transparency and conductance*	*Laminated nanocomposites and fibers*	*Impregnation*	*TENGs Classifications*
	SLO-2	*Moisture management & waterproof*	*High specific surface area*	*Membranes, coatings, & Hydrogels*	*Cross linking method*	*Fibers based TENGs*
S-6	SLO-1	*Thermoregulation*	*Direct charge transport path*	*Sensing of Nanocomposites*	*Plasma surface activation*	*Textiles based TENGs*
	SLO-2	*Personal protection*	*Oriented assembly of Nanowires*	*Actuators of Nanocomposites*	*Surface modification process*	*1D materials based TENGs*

S-7	SLO-1	*Wearables and sensors*	*Metal conducting Nanowires*	*Antibacterial activity of Nanocomposites*	*Flame retardant coatings*	*2D fabrics for TENGs*
	SLO-2	*Medical care of nanofibers*	*Conducting polymer Nanowires*	*Defense applications of Nanocomposites*	*Carbon materials*	*3D woven textile TENGs*
S-8	SLO-1	*Nanosols as coating agent*	*Oxide semiconducting Nanowires*	*Fire protection*	*Phase change materials in thermal regulation*	*Integrating energy harvesting devices*
	SLO-2	*Applications of nanosols in textiles*	*Sulphide semiconducting Nanowires*	*Fire retardant materials*	*Nanowires in thermal regulation*	*TENGs with solar cells*
S-9	SLO-1	*Photocatalytic and light responsivity of nanosols*	*Other semiconducting Nanowires*	*Self-cleaning*	*Carbon based conducting coating*	*Integrating energy storage devices*
	SLO-2	*Antimicrobials and bioactive systems*	*Current and future perspective of Nanowires*	*Energy harvesting of Nanocomposites*	*Metal based conducting coating*	*Future prospects of Nanogenerators*

Learning Resources	1. *Nazire D. Yilmaz, Smart Textiles, Wearable Nanotechnology, Ist Ed., Scrivener Publishing, 2019* 2. *P. J. Brown and K. Stevens, Nanofibers and nanotechnology in textiles, CRC Press, 2007*	3. *Nanotechnology in Textiles: Theory and Application, Jiří Militký and Rajesh Mishra, Elsevier Publications, 2018*

Learning Assessment

	Bloom's Level of Thinking	Continuous Learning Assessment (50% weightage)								Final Examination (50% weightage)	
		CLA – 1 (10%)		CLA – 2 (15%)		CLA – 3 (15%)		CLA – 4 (10%)#			
		Theory	Practice	Theory	Practice	Theory	Practice	Theory	Practice	Theory	Practice
Level 1	Remember Understand	30 %	-	30 %	-	30 %	-	30 %	-	30%	-
Level 2	Apply Analyze	40 %	-	40 %	-	40 %	-	40 %	-	40%	-
Level 3	Evaluate Create	30 %	-	30 %	-	30 %	-	30 %	-	30%	-
	Total	100 %		100 %		100 %		100 %		100 %	

CLA – 4 can be from any combination of these: Assignments, Seminars, Tech Talks, Mini-Projects, Case-Studies, Self-Study, MOOCs, Certifications, Conf. Paper etc.,

Course Designers

Experts from Industry	Experts from Higher Technical Institutions	Internal Experts
1. Mr.Hitesh Rathore, SHT Distributors – Salem, TN, hitheshrathore@gmail.com	*1. Dr. Dr. M. Madhusoothanan, Anna University-Chennai, mmadhu@annauniv.edu*	*1. Dr. C.Siva, SRMIST*
2. Mr. T.Raajasekar, Allwin Exports, fabric@allwinexport.com	*2. Dr.T.S. Natarajan, IIT Tirupati, tsniit@iittp.ac.in*	*2. Dr. K. Mani Rahulan, SRMIST*

Course Code	18NTE409T	Course Name	CANCER NANOTECHNOLOGY	Course Category	E	Professional Elective	L	T	P	C
							3	0	0	3

Pre-requisite Couses	Nil	Co-requisite Courses	Nil	Progressive Courses	Nil
Offering Department	Nanotechnology	Data Book / Codes/Standards	Nil		

Learning Rationale (CLR):	The purpose of learning this is to:
CLR-1 :	*Understanding the basis of cancer biology*
CLR-2 :	*Know the various types of cancer biomarkers*
CLR-3 :	*Getting knowledge about ways to treat cancer growth*
CLR-4 :	*Get acquainted with nanomaterial based current therapies available for cancer treatment.*
CLR-5 :	*Get acquainted with the current trend in cancer theranostics*
CLR-6:	*Know about the market requirements for nanomaterial based therapies*

Learning Outcomes (CLO):	At the end of this , learners will be able to:	Learning 1: Level of Thinking (Bloom)	Learning 2: Expected Proficiency (%)	Learning 3: Expected Attainment (%)	PLO 1: Engineering Knowledge	2: Problem Analysis	3: Design & Development	4: Analysis, Design, Research	5: Modern Tool Usage	6: Society & Culture	7: Environment & Sustainability	8: Ethics	9: Individual & Team Work	10: Communication	11: Project Mgt. & Finance	12: Life Long Learning	13: PSO - 1	14: PSO - 2	15: PSO - 3
CLO-1 :	*Analyze the nature of cancer*	2	80	75	H	M	H	H	H	M	M	H	H	H	M	H	H	H	H
CLO-2 :	*Analyze the concepts of cancer nanotechnology*	2	80	70	H	M	H	H	M	M	M	H	H	H	M	H	M	M	M
CLO-3 :	*Apply concepts of cancer nanotechnology to a focused clinical area of their choice*	2	75	70	H	M	H	H	H	H	H	M	H	H	H	H	H	H	H
CLO-4 :	*Apply these nanosystems for the diagnosis and therapy*	2	80	75	M	H	H	M	H	H	H	H	H	H	M	H	H	H	H
CLO-5 :	*Apply the concepts of nano theronostic strategy*	2	80	70	H	M	H	H	H	M	M	H	H	H	M	H	H	H	H
CLO-6 :	*Apply concept of gene silencing for cancer therapy*	2	80	75	H	M	H	H	H	M	M	H	H	H	M	H	H	M	H

Duration (hour)		9	9	9	9	9
S-1	SLO-1	*The biology and genetics of cells and organisms*	*Cell immortalization*	*Theranostic cancer biomarkers*	*Magnetic nanoparticles as contrast agents for MRI application*	*Pancreatic cancer stem cells as new targets for diagnostics*
	SLO-2	*The nature of cancer*	*Tumorigenesis*	*Targetted cancer theranostics*	*Magnetic nanoparticles as contrast agents for therapeutic application*	*Pancreatic cancer stem cells as new targets for therapy*
S-2	SLO-1	*Tumor viruses*	*Cancer development*	*Molecular imaging in cancer theranostics*	*Ultrasound-responsive nanoparticles as drug delivery carriers*	*Nanomedicine approaches for cancer stem cell targeting*
	SLO-2	*DNA oncoviruses*	*The biology of angiogenesis*	*Imaging-guided cancer therapy*	*Ultrasound-responsive nanoparticles as gene delivery carriers*	*Personalized cancer treatment*
S-3	SLO-1	*RNA oncoviruses*	*Invasion*	*Theranostic platforms*	*Noble metal nanoparticle platform*	*Methods adopted for Personalized cancer treatment*
	SLO-2	*Non-human oncoviruses*	*Metastasis*	*Nanomaterials for theranostics of gastric cancer*	*Cancer theranostics with Gold nanoparticle*	*Lipid based nanosystem for theranostictics*
S-4	SLO-1	*Cellular oncogenes*	*Types of cancers*	*Photo triggered drug delivery strategies For cancer theranostics*	*Cancer theranostics with Silver nanoparticle*	*Lipid based nanosystem for delivery of siRNA*
	SLO-2	*Growth Factors*	*Liver cancer*	*Proteomics-based theranostics*	*Metal oxide for cancer theranostics*	*Gene therapy for cancer*
S-5	SLO-1	*Growth Factor receptors*	*Lung cancer*	*Radionuclide imaging of cancer therapy*	*Cancer theranostics with carbon-based nanoplatforms*	*Gene silencing by DNAzymes*
	SLO-2	*Cytoplasmic signal circuitry program*	*Skin cancer*	*Nanotargetted radionuclide imaging*	*CNT and grapheme based theranostics*	*Gene silencing ribozymes*
S-6	SLO-1	*Traits of Cancer*	*Colon cancer*	*Bioluminescence imaging of cancer therapy*	*Cancer theranostics with silica nanoparticle platform*	*Gene silencing by antisense DNA*
	SLO-2	*Tumor Suppressor genes*	*Stem cells and cancer*	*Imaging in luciferase labeled cancer cells*	*Silica tethered particles for cancer theranostics*	*Gene silencing by microRNA*

S-7	SLO-1	*Types of Tumour Suppressor genes*	*Molecular genetics of cancer*	*Magnetic resonance imaging of cancer therapy*	*Polymer- -based nanotechnologies for cancer theranostics*	*Rationale for immunotherapy*
	SLO-2	*Characteristics of pRb*	*Chemical modifications of chromatin-associated proteins*	*CT based imaging of cancer therapy*	*Protein-based nanotechnologies for cancer theranostics*	*Adoptive immunotherapy*
S-8	SLO-1	*pRb gene-Control of cell cycle clock*	*Genetic alterations in cancer cells: mutations*	*Boron capture therapy and imaging*	*Production of theranostic nanoparticles*	*Antibody based therapy*
	SLO-2	*Characteristics of p53*	*Three types of mutation*	*Ultrasound imaging of cancer therapy*	*Scale-up of theranostic nanoparticles*	*Galectins as targets for novel and specific antibody therapies in gynecologic cancer therapies*
S-9	SLO-1	*Mutation of p53 and apoptosis*	*Chromosomal abnormalities*	*Gene expression microarrays*	*Market considerations*	*Glycans and mucins as targets for novel and specific antibody therapies in gynecologic cancer therapies*
	SLO-2	*Role of p53 in cell cycle progression*	*Acquired abnormalities*	*Tissue arrays*	*Nanotechnology and nanomedicine patenting systems*	*Commercial development of antibodies as drugs*

Learning Resources	*1. The Biology of Cancer, Robert A. Weinberg,Garland Science, 2010.* *2. Cancer Biology, Raymond W. Ruddon,Oxford University press, 2007.*	*3. Cancer Theranostics, Chen &Wong,Academic Press, 2014.*

Learning Assessment

	Bloom's Level of Thinking	Continuous Learning Assessment (50% weightage)								Final Examination (50% weightage)	
		CLA – 1 (10%)		CLA – 2 (15%)		CLA – 3 (15%)		CLA – 4 (10%)#			
		Theory	Practice	Theory	Practice	Theory	Practice	Theory	Practice	Theory	Practice
Level 1	Remember Understand	30 %	-	30 %	-	30 %	-	30 %	-	30%	-
Level 2	Apply Analyze	40 %	-	40 %	-	40 %	-	40 %	-	40%	-
Level 3	Evaluate Create	30 %	-	30 %	-	30 %	-	30 %	-	30%	-
	Total	100 %		100 %		100 %		100 %		100 %	

CLA – 4 can be from any combination of these: Assignments, Seminars, Tech Talks, Mini-Projects, Case-Studies, Self-Study, MOOCs, Certifications, Conf. Paper etc.,

Course Designers

Experts from Industry	Experts from Higher Technical Institutions	Internal Experts
1. Mr. K. Chandru Trivitron Healthcare Pvt. Ltd. Chennai, chandru.k@trivitron.com	*1. Dr.Amit Kumar Mishra , IIT Jodhpur, amit@iitj.ac.in*	*1. Dr. Devanandh venkata subhu, SRMIST*
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Course Code	18NTE410T	Course Name	VACUUM AND THIN FILM TECHNOLOGY	Course Category	E	Professional Elective	L	T	P	C
							3	0	0	3

Pre-requisite Courses	Nil	Co-requisite Courses	Nil	Progressive Courses	Nil
Offering Department	Nanotechnology	Data Book / Codes/Standards	Nil		

Learning Rationale (CLR):	The purpose of learning this is to:
CLR-1 :	*Acquire knowledge on vacuum systems and technology*
CLR-2 :	*Understand the functionalities of various vacuum pumps and gauges*
CLR-3 :	*Gain Knowledge on various physical and chemical vapor deposition techniques*
CLR-4 :	*Understand the various thin film growth mechanisms and theories explaining them*
CLR-5 :	*Gain knowledge on various characterization techniques tools to characterize thin films*
CLR-6 :	*Acquire knowledge on various physical, optical and chemical properties of thin films*

Learning Outcomes (CLO):	At the end of this , learners will be able to:	Learning 1: Level of Thinking (Bloom)	2: Expected Proficiency (%)	3: Expected Attainment (%)	1: Engineering Knowledge	2: Problem Analysis	3: Design & Development	4: Analysis, Design, Research	5: Modern Tool Usage	6: Society & Culture	7: Environment & Sustainability	8: Ethics	9: Individual & Team Work	10: Communication	11: Project Mgt. & Finance	12: Life Long Learning	13: PSO - 1	14: PSO - 2	15: PSO - 3
CLO-1 :	*Apply the functionalities of vacuum systems and can operate them*	2	80	75	H	M	H	H	H	M	M	H	H	H	H	H	H	H	H
CLO-2 :	*Utilize the knowledge acquired to operate vacuum pumps and create vacuum and measure at various regimes*	2	80	70	H	H	H	H	H	H	M	H	H	H	M	H	M	M	M
CLO-3 :	*Grow thin films using various physical and chemical vapor deposition techniques*	2	80	70	H	M	H	H	H	H	H	M	H	H	H	H	H	H	H
CLO-4 :	*Construe the physics and chemistry of growth mechanisms and measure the thickness using various techniques*	2	80	75	H	M	H	H	H	H	H	H	H	H	H	H	H	H	H
CLO-5 :	*Apply the concept of various characterization tools and operate them*	2	80	70	H	H	H	H	H	M	M	H	H	H	H	H	H	H	H
CLO-6 :	*Elucidate various properties of thin films and measure them using different tools*	2	80	75	H	M	H	H	H	M	M	H	H	H	H	H	H	M	H

Duration (hour)		9	9	9	9	9
S-1	SLO-1	*Over view of vacuum systems and technology*	*Over view of Physical vapor deposition techniques*	*Introduction to chemical deposition*	*Basic physics and chemistry behind thin films layer formation*	*Thin films characteristics*
	SLO-2	*Units and different regions of vacuum*	*Thermal evaporation, Resistive heating and RF-heating*	*Electrodeposition*	*Nucleation and early stages of film growth*	*Topography*
S-2	SLO-1	*Kinetic theory of gases*	*Flash evaporation*	*Electrolytic deposition*	*Thermodynamic aspects of nucleation*	*Structure integrity- X-ray diffraction (XRD)*
	SLO-2	*Gas flow and Mean free path*	*Laser evaporation*	*Electro less deposition*	*Thin film growth modes*	*Scanning electron microscopy*
S-3	SLO-1	*Conductance*	*Co-evaporation*	*Anodic oxidation*	*Capillary theory*	*Transmission electron microscopy*
	SLO-2	*Different types of pumps*	*Electron bombardment heating*	*Spray pyrolysis*	*Volmert-Weber growth*	*Energy dispersive analysis of thin films*
S-4	SLO-1	*Mechanical pumps*	*Sputtering plasma, discharges and arc*	*Dip coating and Spin coating*	*Frank-van der Merwe (FM) growth*	*Auger electron spectroscopy*
	SLO-2	*Diffusion and turbo molecular pump*	*Sputtering variants, yield and low pressure sputtering*	*Chemical vapor deposition (CVD)*	*Stranski-Krastanov growth*	*X-ray photoelectron spectroscopy*
S-5	SLO-1	*Ion pumps*	*RF-sputtering*	*Homogenous and heterogeneous process*	*Thickness dependent properties of thin films*	*Rutherford backscattering spectroscopy*
	SLO-2	*Measurement of vacuum*	*Reactive sputtering*	*CVD reactions*	*Thickness measurements*	*Secondary ion mass spectrometry*
S-6	SLO-1	*Direct and indirect gauges*	*Magnetron sputtering*	*Hydrogen reduction*	*Roughness*	*Resistance – 2-point probe*

	SLO-2	*Pirani gauge*	*Magnetron configurations*	*Halide disproportionation, transfer reactions*	*Electrical methods*	*Resistance – 4-point probe*
S-7	SLO-1	*Capacitance gauge*	*Bias sputtering*	*CVD processes and systems*	*Microbalance monitors*	*Optical properties*
	SLO-2	*Penning gauge*	*Evaporation versus sputtering*	*Low pressure CVD*	*Quartz crystal monitor*	*Characterization of layered structures*
S-8	SLO-1	*Vacuum system*	*Pulsed laser deposition (PLD) design and basics*	*Laser enhanced CVD*	*Mechanical method (stylus)*	*Atomic force microscopy (AFM)*
	SLO-2	*Components and operation of vacuum system*	*PLD operating procedure and its various application*	*Metalorganic CVD (MOCVD)*	*Optical interference methods*	*X-Ray Reflectivity (XRR)*
S-9	SLO-1	*Safety practices in vacuum systems*	*Molecular beam epitaxy (MBE) basics*	*Plasma Assisted Chemical Vapor Deposition (PACVD)*	*Ellipsometry*	*Reflection high energy electron diffraction (RHEED)*
	SLO-2	*Applications of vacuum technology*	*MBE operating procedure*	*Safety considerations*	*Interference fringes*	*In-situ RHEED*

Learning Resources	*1. M. Ohring, Materials Science of Thin Films: Deposition and Structure, 2nd Ed., Academic Press (An Imprint of Elsevier), 2002.* *2. K.L.Chopra, Thin Film Phenomena, Robert E.Krieger Publishing Company, 1979.*	*3. S. Campbell, The Science and Engineering of Microelectronic Fabrication, 2nd Ed., OUP, 1996.* *4. Kaufmann, Characterization of Materials, 2 nd Ed., Wiley, 2003.*

Learning Assessment

	Bloom's Level of Thinking	Continuous Learning Assessment (50% weightage)								Final Examination (50% weightage)	
		CLA – 1 (10%)		CLA – 2 (15%)		CLA – 3 (15%)		CLA – 4 (10%)#			
		Theory	Practice	Theory	Practice	Theory	Practice	Theory	Practice	Theory	Practice
Level 1	Remember Understand	30 %	-	30 %	-	30 %	-	30 %	-	30%	-
Level 2	Apply Analyze	40 %	-	40 %	-	40 %	-	40 %	-	40%	-
Level 3	Evaluate Create	30 %	-	30 %	-	30 %	-	30 %	-	30%	-
	Total	100 %		100 %		100 %		100 %		100 %	

CLA – 4 can be from any combination of these: Assignments, Seminars, Tech Talks, Mini-Projects, Case-Studies, Self-Study, MOOCs, Certifications, Conf. Paper etc.,

Course Designers		
Experts from Industry	Experts from Higher Technical Institutions	Internal Experts
1. Dr. Krishna Surendra Muvvala, Saint Gobain Research India, India, Krishna.muvvala@saintgobain.com	*1. Dr. Kasiviswanathan, IIT Madras, kasi@iitm.ac.in*	*1. Dr. K. Kamala Bharathi, SRMIST*
2. Mr. Ramanujam, HHV, India	*2. Dr. M. S. Ramachandra Rao, IIT Madras, msrrao@iitm.ac.in*	*2. Dr. E. Senthil Kumar, SRMIST*

Course Code	18NTE411T	Course Name	ATOMISTIC MODELING	Course Category	E	Professional Elective	L	T	P	C
							3	0	0	3

Pre-requisite Courses	Nil	Co-requisite Courses	Nil	Progressive Courses	Nil
Course Offering Department	Nanotechnology	Data Book / Codes/Standards	Nil		

Course Learning Rationale (CLR):	The purpose of learning this course is to:
CLR-1 :	*Learn about basic modeling*
CLR-2 :	*Understand the DFT for materials modeling*
CLR-3 :	*Understand the MD simulation*
CLR-4 :	*Gain knowledge about Monte Carlo Simulation*
CLR-5 :	*Learn advance-modeling technique.*
CLR-6 :	*Learn materials modeling to understand materials properties*

Course Learning Outcomes (CLO):	At the end of this course, learners will be able to:	Learning 1: Level of Thinking (Bloom)	2: Expected Proficiency (%)	3: Expected Attainment (%)	PLO 1: Engineering Knowledge	2: Problem Analysis	3: Design & Development	4: Analysis, Design, Research	5: Modern Tool Usage	6: Society & Culture	7: Environment & Sustainability	8: Ethics	9: Individual & Team Work	10: Communication	11: Project Mgt. & Finance	12: Life Long Learning	13: PSO - 1	14: PSO - 2	15: PSO - 3
CLO-1 :	*Acquire the basics of design and materials modeling*	2	80	75	H	H	H	H	H	H	M	H	H	H	M	H	H	H	H
CLO-2 :	*Gain knowledge DFT and related methods in the context of materials modeling*	2	80	70	H	H	H	H	H	H	M	H	H	H	M	H	M	M	M
CLO-3 :	*Obtain the knowledge on Molecular Dynamics and its application ot solve materials problem*	2	75	70	H	H	H	H	H	H	H	H	M	H	M	H	H	H	H
CLO-4 :	*Improve their knowledge on materials modeling with Monte Carlo Simulation*	2	80	75	H	M	H	H	H	M	M	H	M	H	M	H	H	H	H
CLO-5 :	*Solve problems to understand the electronic, mechanical and optical properties of Materials*	2	80	70	H	M	H	H	H	M	H	H	M	H	M	H	H	H	H
CLR-6 :	Explain the structural, electronic and magnetic properties of a given material	2	80	70															

Duration (hour)		9	9	9	9	9
S-1	SLO-1	*Classical mechanics, Hamiltonians*	*Born-Oppenheimer approximation*	*Integrating F=ma*	*Introduction - key concepts*	*Introduction to various DFT codes*
	SLO-2	*Coordinate systems in the context of solving the physical problems*	*Limitations of BO approximation*	*Detail time steps*	*Starting structure - energy cutoff*	*Basic DFT outputs*
S-2	SLO-1	*Potential energy-Definition and Concept*	*Introduction to DFT*	*The basic MD algorithm*	*State space sampling*	*Basic output of QM code*
	SLO-2	*Basic pair potentials and their limitations*	*Hohenberg-Kohn Theorems*	*The MD steps*	*Classical momentum*	*Energies, electronic structure*
S-3	SLO-1	*Definition - Elastic constant*	*Kohn-Sham Equation*	*Taylor expansion,*	*Metropolis algorithm*	*Using the energies: molecular statics, MD, MC*
	SLO-2	*Calculation of elastic constants from potential function*	*Interpretation of KS equations*	*Verlet algorithms - choosing the time step*	*Examples with a problem*	*Using the energies: MC*
S-4	SLO-1	*Potentials for ionic systems*	*Exchange-correlation functions and LDA/GGA*	*Predictor-corrector algorithm*	*Monte Carlo simulation analysis*	*Using the electronic structure: optical properties*
	SLO-2	*Potentials for ceramics Systems*	*Accuracy of LDA/GGA*	*Discussion with Examples*	*Limitations of Monte Carlo simulations*	*Transitions between electronic states*
S-5	SLO-1	*Concept of Many-body potential*	*Pseudopotentials*	*MD in different ensembles*	*Introducing ensemble sin MC*	*Electrical conductivity*
	SLO-2	*Many -body potentials for metals*	*Types of Pseudopotentials*	*MD in constant temperature*	*Kinetic Monte Carlo*	*Mobility of electrons, scattering of electrons between states*
S-6	SLO-1	*Many-body potentials for covalently bonded systems*	*Brillouin zone*	*Molecular dynamics in constant pressure*	*Key concepts: starting structure in MD*	*Excited electron states due to thermal (or optical) excitations*
	SLO-2	*Comparative Study*	*K-points, Monkhorst-Pack mesh, Gama point*	*Examples of MD in constant temperature and pressure*	*Key concepts: starting structure in KMC*	*Type of bonding - tunneling rates*

S-7	SLO-1	*Energy optimization*	*Concept of Basis Set*	*Energies: molecular statics*	*Convergence criteria*	*Excited electron states due optical excitations*
	SLO-2	*Significance of Lowest energy structure*	*The need for self-consistency*	*Problems on Molecular Statistics*	*Scaling with lattice parameters*	*Example with a Material problem*
S-8	SLO-1	*Molecular statistics*	*Setting up structures, key parameters, Volume optimization Metals vs. insulators*	*MD Simulation analysis*	*Understanding the electronic structure*	*Understanding the electronic structure from different Methods, Comparative study*
	SLO-2	*Problems on Molecular Statistics*	*Basis sets, energy cutoff, exchange-correlation function, K-points*	*Limitations of MD*	*Electrical conductivity, Excited electron states*	*Wave functions, charge density, band structure, density of states*
S-9	SLO-1	*Thermo statistics*	*Convergence and scaling with lattice parameters,*	*Application of MD as Case Study: 3D system*	*Application of MC method as Case Study: Temperature effect*	*Confinement effect on Electronic Structure*
	SLO-2	*Problems on Thermo statistics problems*	*DOS and BAND Structure*	*Application of MD as Case Study: 2D system*	*Determination of Tc*	*3D, 2D, 1D Carbon based materials as example*

Learning Resources	1. *Jörg-Rüdiger Hill, Lalitha Subramanian and AmiteshMaiti, Molecular modeling techniques inmaterial sciences, Taylor & Francis/CRC Press: Boca Raton, 2005* 2. *Andrew R. Leach, Molecular modelling: principles and application, Pearson Education, India, 2001*	3. *R. Martin, Electronic Structure: Basic Theory and Practical Methods, Cambridge University Press, 2004* 4. *J.M. Thijssen, Computational Physics, Cambridge, UK: Cambridge University Press, 2000*

Learning Assessment

	Bloom's Level of Thinking	Continuous Learning Assessment (50% weightage)								Final Examination (50% weightage)	
		CLA – 1 (10%)		CLA – 2 (15%)		CLA – 3 (15%)		CLA – 4 (10%)#			
		Theory	Practice	Theory	Practice	Theory	Practice	Theory	Practice	Theory	Practice
Level 1	Remember Understand	30 %	-	30 %	-	30 %	-	30 %	-	30%	-
Level 2	Apply Analyze	40 %	-	40 %	-	40 %	-	40 %	-	40%	-
Level 3	Evaluate Create	30 %	-	30 %	-	30 %	-	30 %	-	30%	-
	Total	100 %		100 %		100 %		100 %		100 %	

CLA – 4 can be from any combination of these: Assignments, Seminars, Tech Talks, Mini-Projects, Case-Studies, Self-Study, MOOCs, Certifications, Conf. Paper etc.,

Course Designers

Experts from Industry	Experts from Higher Technical Institutions	Internal Experts
1. Dr. Hemant Dixit, GlobalFoundaries, aplahemant@gmail.com	*1. Dr. Ranjit Kumar Nanda, IITM Chennai, nandab@iitm.ac.in*	*1. Dr. C. Preferencial Kala, SRMIST*
2. Dr. Murali Kota, Global Foundaries, USA, kvrmmurali@gmail.com	*2. Prof. G.P. Das, IIT M, KGP, msgpd@iacs.res.in*	*2. Dr. Saurabh Ghosh, SRMIST*

Course Code	18NTE412T	Course Name	SOCIETAL IMPLICATIONS OF NANOTECHNOLOGY	Course Category	E	Professional Elective	L	T	P	C
							3	0	0	3

Pre-requisite Courses	Nil	Co-requisite Courses	Nil	Progressive Courses	Nil
Course Offering Department	Nanotechnology	Data Book / Codes/Standards	Nil		

Course Learning Rationale (CLR):	*The purpose of learning this course is to:*
CLR-1 :	*Provide an insight into the fundamentals of ethical implications of nanotechnology*
CLR-2 :	*Provide an insight into the fundamentals of social-economic implications of nanotechnology*
CLR-3 :	*Understand the implications of nanotechnology in quality of life*
CLR-4 :	*Understand the legal risks related with the nanotechnology*
CLR-5 :	*Explore the matters related to patents associated with nanotechnology*
CLR-6 :	*Understand the problems of governance of nanotechnology*

Course Learning Outcomes (CLO):	*At the end of this course, learners will be able to:*	Learning			Program Learning Outcomes (PLO)														
		1	2	3	1	2	3	4	5	6	7	8	9	10	11	12	13	14	15
		Level of Thinking (Bloom)	Expected Proficiency (%)	Expected Attainment (%)	Engineering Knowledge	Problem Analysis	Design & Development	Analysis, Design, Research	Modern Tool Usage	Society & Culture	Environment & Sustainability	Ethics	Individual & Team Work	Communication	Project Mgt. & Finance	Life Long Learning	PSO - 1	PSO - 2	PSO - 3
CLO-1 :	*Apply the knowledge of ethical implications pertaining to nanotechnology*	2	80	75	H	H	H	H	H	H	H	H	H	H	M	H	H	H	H
CLO-2 :	*Address the socioeconomic implications of nanotechnology*	2	80	70	H	H	M	H	H	H	H	M	M	H	M	H	M	M	M
CLO-3 :	*Improve the quality of life*	2	75	70	M	M	H	H	H	H	H	M	M	H	M	H	H	H	H
CLO-4 :	*Address the legal risks related with the nanotechnology*	2	80	75	H	H	M	H	M	H	H	H	H	H	M	H	H	H	H
CLO-5 :	*Handle the issues related to patents associated with nanotechnology*	2	80	70	H	M	H	H	H	M	M	M	M	H	H	H	H	H	H
CLO-6 :	*Address the problems of governance of nanotechnology*	2	80	75	M	M	M	H	M	H	H	M	M	H	M	H	H	M	H

Duration (hour)		9	9	9	9	9
S-1	SLO-1	*Economic Impacts and Commercialization of Nanotechnology*	*Ethics, Law and Governance – Introduction*	*Social Scenarios - Introduction*	*Converging Technologies - Introduction*	*Public Perceptions and Education*
	SLO-2	*Introduction to societal implications of nanotechnology*	*Ethics and law*	*Nanoparticle toxicity and risk*	*Integrative Technology*	*Public perceptions-societal implications of nanoscience*
S-2	SLO-1	*Socio-economic impact of nanoscale science : initial results*	*Ethical issues in nanoscience and nanotechnology: reflections and suggestions*	*Navigating nanotechnology through society*	*Nanotechnology's implications for the quality of life*	*An agenda for public interaction research*
	SLO-2	*Socio-economic impact of nanoscale science : nanobank*	*Concerns of Nano scientists and engineers in Ethics and law*	*Public and private goods*	*Social implications*	*Communicating nanotechnological risks*
S-3	SLO-1	*Managing the nanotechnology revolution*	*Ethics and nano: a survey*	*Nanoparticle Toxicity and risk*	*Management of innovation for convergent technologies*	*Risk Assessment*
	SLO-2	*Malcolm Baldrige national quality criteria*	*Recent developments in nanotechnology*	*Nanotechnology, surveillance, and society*	*The "integration/penetration model"*	*Risk Communication*
S-4	SLO-1	*Emergence of Nanoeconomy*	*law in a new frontier*	*Methodological issues*	*Social impacts of nano biotechnology issues*	*Problems in Risk Communication*
	SLO-2	*Key drivers, challenges and opportunities*	*An exploration of patent matters associated with nanotechnology*	*Innovations for social research*	*Nanobiotechnology: The Science Dimension*	*A proposal to advance understanding of nanotechnology's social impacts*
S-5	SLO-1	*Moore's law*	*U.S. Patent Statute*	*Nanotechnology: societal implications: individual perspectives*	*The Integration/Penetration Model: The Interface Range*	*Nanotechnology in the media: a preliminary analysis*
	SLO-2	*Transcending Moore's law with molecular electronics*	*The Ethics of Ethics*	*Nanotechnology: individual perspectives*	*New Forms of Knowledge: Computer Simulations and Modeling*	*Public engagement with nanoscale science and engineering*
S-6	SLO-1	*Molecular electronics – a next paradigm*	*Environmental Impacts of nanomaterials*	*Nanotechnology and social trends;*	*Regulatory structures and society*	*Nanophobia*

	SLO-2	*Transcending Moore's law with nanotechnology*	*Problems of governance of nanotechnology*	*Five nanotech social scenarios*	*Social impacts of nanobiotechnology issues*	*Public Engagement with nanotechnology*
S-7	SLO-1	*Transition from Microelectronics to nanoelectronics*	*Negotiations over quality of life in the nanotechnology initiative. Governance*	*Technological revolutions and the limits of Ethics in an age of commercialization*	*The use of analogies for interdisciplinary research in the convergence of nanotechnology*	*Nanotechnology: moving beyond risk*
	SLO-2	*Semiconductor scaling as a model for nanotechnology commercialization*	*Societal implications of emerging science and technologies: a research agenda for science and technology studies (STS)*	*Implications of Experiential data recorder*	*Interdisciplinary research in the convergence of bio technology*	*Communication streams and nanotechnology: the (Re) interpretation of a new technology nanotechnology*
S-8	SLO-1	*Sustaining the impact of nanotechnology on productivity*	*Institutional impacts of government science initiatives*	*Vision, innovation, and policy*	*Interdisciplinary research in the convergence of information technology*	*Societal implications- individual perspectives*
	SLO-2	*Sustaining the impact of nanotechnology on sustainability, and equity*	*Challenges for government and universities*	*Institutionalizing Multi-Disciplinary Engagement*	*Converging technologies: innovation, legal risks, and society*	*The case of Cold Fusion*
S-9	SLO-1	*Implications of Information*	*Nanotechnology for national security*	*Post-hoc Versus Therapeutic Ethics*	*Converging technologies and their societal implications*	*The case of Recombinant DNA*
	SLO-2	*Non-Nano effects of nanotechnology on the economy*	*Nanotechnology in Defense*	*Nano revolution implications for the artist*	*Short-term implications of convergence for scientific and engineering disciplines*	*Historical comparisons for anticipating public reactions to nanotechnology*

Learning Resources	1. *C.R. Mihail, and S.B. William, Nanotechnology: societal implications, Springer publication, 2011 (978-1-4020-5432-7)* 2. *Ronald Sandler, Nanotechnology the Social & Ethical Issues, Woodrow Wilson, 2009*	3. *Mihail C. Roco and William Sims Bainbridge, Societal Implications of Nanoscience and Nanotechnology, National Science Foundation, 2001.*

Learning Assessment

	Bloom's Level of Thinking	Continuous Learning Assessment (50% weightage)								Final Examination (50% weightage)	
		CLA – 1 (10%)		CLA – 2 (15%)		CLA – 3 (15%)		CLA – 4 (10%)#			
		Theory	Practice	Theory	Practice	Theory	Practice	Theory	Practice	Theory	Practice
Level 1	Remember Understand	30 %	-	30 %	-	30 %	-	30 %	-	30%	-
Level 2	Apply Analyze	40 %	-	40 %	-	40 %	-	40 %	-	40%	-
Level 3	Evaluate Create	30 %	-	30 %	-	30 %	-	30 %	-	30%	-
	Total	100 %		100 %		100 %		100 %		100 %	

CLA – 4 can be from any combination of these: Assignments, Seminars, Tech Talks, Mini-Projects, Case-Studies, Self-Study, MOOCs, Certifications, Conf. Paper etc.,

Course Designers		
Experts from Industry	Experts from Higher Technical Institutions	Internal Experts
1. Mr.Ajay Kumar, Avansa Technology and services, India ajaykumar@avansa.co.in	*1. Dr. Hirendra N Ghosh, Institute of Nanoscience and Technology, Punjab, hnghosh@inst.ac.in*	*1. Dr. C. Gopalakrishnan, SRMIST*
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Course Code	18NTE413T	Course Name	NANOTECHNOLOGY IN TISSUE ENGINEERING	Course Category	E	Professional Elective	L	T	P	C
							3	0	0	3

Pre-requisite Courses	Nil	Co-requisite Courses	Nil	Progressive Courses	Nil
Course Offering Department	Nanotechnology	Data Book / Codes/Standards	Nil		

Learning Rationale (CLR):	The purpose of learning this is to:
CLR-1 :	*Understand the general scientific concepts of tissue engineering*
CLR-2 :	*Know the various tissue culture techniques*
CLR-3 :	*Acquire knowledge about the role of nanotechnology in tissue engineering and regenerative medicine*
CLR-4 :	*Get acquainted with the current trend in tissue engineering and regenerative technology*
CLR-5 :	*Understand the tissue responses to biomaterial*
CLR-6 :	*Acquire knowledge on various methods adopted tissue scaffold generation*

Learning Outcomes (CLO):	At the end of this , learners will be able to:	Learning 1: Level of Thinking (Bloom)	Learning 2: Expected Proficiency (%)	Learning 3: Expected Attainment (%)	PLO 1: Engineering Knowledge	PLO 2: Problem Analysis	PLO 3: Design & Development	PLO 4: Analysis, Design, Research	PLO 5: Modern Tool Usage	PLO 6: Society & Culture	PLO 7: Environment & Sustainability	PLO 8: Ethics	PLO 9: Individual & Team Work	PLO 10: Communication	PLO 11: Project Mgt. & Finance	PLO 12: Life Long Learning	PLO 13: PSO - 1	PLO 14: PSO - 2	PLO 15: PSO - 3
CLO-1 :	*Apply basic knowledge of tissue anatomy for tissue mimicking*	*2*	*80*	*75*	*H*	*M*	*H*	*H*	*H*	*M*	*M*	*H*	*H*	*H*	*M*	*H*	*H*	*H*	*H*
CLO-2 :	*Analyze the basic challenges of tissue engineering*	*2*	*80*	*70*	*H*	*M*	*M*	*H*	*M*	*M*	*M*	*H*	*M*	*H*	*M*	*M*	*M*	*M*	*M*
CLO-3 :	*Apply concepts of tissue engineering in biomedical applications*	*2*	*75*	*70*	*H*	*M*	*H*	*H*	*H*	*H*	*H*	*M*	*H*	*H*	*H*	*M*	*H*	*H*	*H*
CLO-4 :	*Apply these nanosystems for the therapy*	*2*	*80*	*75*	*M*	*H*	*H*	*M*	*H*	*H*	*H*	*H*	*H*	*H*	*M*	*M*	*H*	*H*	*H*
CLO-5 :	*Apply concepts in making nanoscaffold and bioactive substrates*	*2*	*80*	*70*	*H*	*M*	*H*	*H*	*H*	*M*	*M*	*H*	*M*	*H*	*M*	*M*	*H*	*H*	*H*
CLO-6 :	*Apply the tissue engineering principles to future therapy*	*2*	*80*	*75*	*H*	*M*	*M*	*H*	*H*	*M*	*M*	*H*	*H*	*H*	*M*	*H*	*H*	*M*	*H*

Duration (hour)		9	9	9	9	9
S-1	SLO-1	*The Cell*	*First Cultures: culture containers*	*Characteristics of biomaterials*	*Electrospinning*	*Electrospun Nanofibers for Neural Applications*
	SLO-2	*The cell as a functional unit*	*First Cultures: culture media*	*Design of biomaterials*	*Experimental setup and basic principle*	*Nanofiber-Based Integrative Repair of Orthopedic Soft Tissues*
S-2	SLO-1	*Tissue types*	*Serum free culture media*	*Fundamental aspects of tissue responses to biomaterials*	*Effects of parameters on electrospinning*	*Nanotechnologies for Peripheral Nerve Regeneration*
	SLO-2	*Soft and Hard tissue*	*Growth factors*	*Types of tissue responses*	*Solution parameters*	*Nanofibrous Materials for Vascular Tissue Engineering and Regeneration*
S-3	SLO-1	*Extracellular matrix*	*Cell Culture Techniques*	*Repair and regeneration*	*Environmental parameters*	*Engineering Soft Nanostructures for Guided Cell Response*
	SLO-2	*Extracellular matrix components and function*	*Hybridomas*	*Evaluation of biomaterial behavior*	*Biomedical Applications of electrospun nanofibres*	*Nanoparticles-Incorporated Scaffolds for Tissue Engineering Applications*
S-4	SLO-1	*Emergence of tissue*	*Cardiomyocites cultivation*	*Adhesion, migration and survival*	*Nanofibres as 3D scaffold for tissue regeneration*	*Electrospun Pseudo Poly (Amino Acids) for Tissue Engineering Applications*
	SLO-2	*Germ layers and Ground tissue*	*Cryopreservation*	*Properties of biomaterials assessed through in vivo experiments*	*Nanofibre scaffolds for interface regeneration*	*Nano-enabled Platforms for Metastatic Malignant Melanoma*
S-5	SLO-1	*Regeneration*	*Slow programmable freezing*	*Hydrogels*	*Techniques to improve porosity*	*Immune Response to Implanted Nanostructured Materials*
	SLO-2	*Various phase of regeneration*	*Vitrification*	*Types of hydrogels used in tissue engineering*	*Techniques to improve cell infiltration*	*3D Bioprinting – introduction*
S-6	SLO-1	*Concept of tissue construction*	*Persufflation*	*Chitosan as biomaterial for tissue engineering*	*Hybrid fibres for bone regeneration*	*3D Bioprinting-pricipies*

	SLO-2	*Three steps of tissue development*	*Tissue culture: Migration*	*Nanobiomaterials for regeneration*	*Hybrid fibres for ligament regeneration*	*CAD based bioprinting*
S-7	SLO-1	*Stem cells- types*	*Tissue culture: new formation*	*Carbon Nanobiomaterial*	*Hybrid fibres for tendon regeneration*	*CAM based bioprinting*
	SLO-2	*Embryonic stem cell*	*Dedifferentiation*	*Self assembling nanobomaterials*	*Bioactive nanofibres*	*Laser based bioprinting*
S-8	SLO-1	*Mesenchymal stem cell*	*Organ culture: principles*	*Polymeric Nanobiomaterials*	*Types of Bioactive nanofibres*	*Bioprinted scaffolds*
	SLO-2	*Adult stem cells*	*Plasma clot method*	*Types of Polymeric Nanobiomaterials*	*Application of Bioactive nanofibres*	*Challenges and future development of 3D bio printing*
S-9	SLO-1	*Stem cells properties and source*	*Agar gel method*	*Ceramic nanobiomaterials*	*Biomolecules on nanofibers*	*Materials used for bio printing*
	SLO-2	*Responsible use of stem cells*	*Formation of organ from tissue*	*Types of Ceramic nanobiomaterials*	*Methods for immobilizing biomolecules*	*Bioprinting based tissue engineering applications*

Learning Resources	1. *W.M.Will, Raimund Strehl, Karl Schumacher, Tissue Engineering: From Cell Biology to Artificial Organs, WileyVCH, 2005.* 2. *Ketul Popat, Nanotechnology in Tissue Engineering and Regenerative Medicine, CRC Press/Taylor and Francis, 2011*	3. *Lijie Grace Zhang, John P Fisher, Kam Leong, 3D Bioprinting and Nanotechnology in Tissue Engineering and Regenerative medicine, Elsevier, 2015*

Learning Assessment

	Bloom's Level of Thinking	Continuous Learning Assessment (50% weightage)								Final Examination (50% weightage)	
		CLA – 1 (10%)		CLA – 2 (15%)		CLA – 3 (15%)		CLA – 4 (10%)#			
		Theory	Practice	Theory	Practice	Theory	Practice	Theory	Practice	Theory	Practice
Level 1	Remember Understand	30 %	-	30 %	-	30 %	-	30 %	-	30%	-
Level 2	Apply Analyze	40 %	-	40 %	-	40 %	-	40 %	-	40%	-
Level 3	Evaluate Create	30 %	-	30 %	-	30 %	-	30 %	-	30%	-
	Total	100 %		100 %		100 %		100 %		100 %	

CLA – 4 can be from any combination of these: Assignments, Seminars, Tech Talks, Mini-Projects, Case-Studies, Self-Study, MOOCs, Certifications, Conf. Paper etc.,

Course Designers

Experts from Industry	Experts from Higher Technical Institutions	Internal Experts
1. Mr. K. Chandru Trivitron Healthcare Pvt. Ltd. Chennai, chandru.k@trivitron.com	*1. Dr.Amit Kumar Mishra , IIT Jodhpur, amit@iitj.ac.in*	*1. Dr. Devanandh Venkata Subbu, SRMIST*
2. Dr.Nagesh Kini,Thermax,Pune,Maharastra,nagesh.kini@gmail.com	*2. Dr. T.S Sampath Kumar, IIT Madras, tssk@iitm.ac.in*	*2. S. Anandhakumar, SRMIST*

Course Code	18NTE414T	Course Name	NANOMAGNETISM AND SPINTRONICS	Course Category	E	Professional Elective Course	L	T	P	C
							3	0	0	3

Pre-requisite Courses	Nil	Co-requisite Courses	Nil	Progressive Courses	Nil
Course Offering Department	Nanotechnology	Data Book / Codes/Standards	Nil		

Learning Rationale (CLR):	The purpose of learning this is to:
CLR-1 :	*Understand the basic concepts related various type of magnetism and magnetic properties of materials*
CLR-2 :	*Provide in-depth knowledge about low dimensional magnetic materials*
CLR-3 :	*Understand the magnetization behavior of magnetic nanostructures and thin films*
CLR-4 :	*Give an overview of different Experimental Approaches to characterize magnetic nanostructures*
CLR-5 :	*Acquire knowledge about fundamentals in spintronics with glimpse of contemporary topics in this field*
CLR-6 :	*Provide in-depth knowledge of spin polarized current and spin transfer torque*

Learning Outcomes (CLO):	At the end of this , learners will be able to:	Learning 1: Level of Thinking (Bloom)	Learning 2: Expected Proficiency (%)	Learning 3: Expected Attainment (%)	PLO 1: Engineering Knowledge	PLO 2: Problem Analysis	PLO 3: Design & Development	PLO 4: Analysis, Design, Research	PLO 5: Modern Tool Usage	PLO 6: Society & Culture	PLO 7: Environment & Sustainability	PLO 8: Ethics	PLO 9: Individual & Team Work	PLO 10: Communication	PLO 11: Project Mgt. & Finance	PLO 12: Life Long Learning	PLO 13: PSO - 1	PLO 14: PSO - 2	PLO 15: PSO - 3
CLO-1 :	*Realize the importance of "magnetism" in contributing to past and for the advancement of new technology*	2	80	75	H	M	H	H	H	M	M	H	H	H	M	H	H	H	H
CLO-2 :	*Appreciate the significance of in-depth understanding of magnetic properties in low dimension*	2	80	70	H	H	M	H	M	M	H	H	M	H	M	H	M	M	M
CLO-3 :	*Obtain the knowledge about fabrication of magnetic nanostructures and properties of the magnetic nanostructures*	2	75	70	H	H	H	H	H	H	H	M	H	M	H	H	H	H	H
CLO-4 :	*Know various sensitive characterization techniques for magnetic nanostructures.*	2	80	75	M	H	H	M	H	H	H	H	H	M	M	H	H	H	H
CLO-5 :	*Analyze the mechanism of spin transport in magnetic nanostructures and its relevance in advancing the existing magnetic recording technology*	2	80	70	H	H	H	H	H	M	H	H	M	H	M	H	H	H	H
CLO-6 :	*Gain the conceptual knowledge related to nanomagnetism and spintronics for energy efficient devices*	2	80	75	H	M	M	H	H	M	M	H	H	H	M	H	H	M	H

Duration (hour)		9	9	9	9	9
S-1	SLO-1	*Basics of magnetism, Units in magnetism*	*Concept of Magnetic ordering*	*Magnetism in thin films*	*Introduction to various magnetometers*	*Introduction to spin transport*
	SLO-2	*Introduction to ferromagnetism, paramagnetism, diamagnetism*	*Magnetic ordering in low dimensions*	*Magnetism in multilayers*	*Working principle of magnetometers*	*Spin angular momentum*
S-2	SLO-1	*Introduction to Ferrimagnetism and Anti-ferromagnet*	*Physical origin of Magnetic anisotropy*	*Fabrication of nanomagnets using various techniques*	*Vibrating Sample Magnetometer*	*Spin Current*
	SLO-2	*Origin of various type of magnetization behavior*	*Shape anisotropy and Magnetocrystalline anisotropy*	*Top down and bottom up approach*	*Superconducting Quantum Interference Device*	*Spin valve devices*
S-3	SLO-1	*Magnetization curves and hysteresis loops, Saturation magnetization,*	*Dipolar anisotropy, Interface magnetic anisotropy*	*Single domain versus multi domain behavior*	*Magnetic imaging techniques*	*Giant magneto resistance (GMR)*
	SLO-2	*Coercive field, Magnetic susceptibility*	*Competing energy scale determining magnetic anisotropy*	*Chemical synthesis of magnetic nano-particles*	*Magneto-optical Kerr effect*	*Spin dependent scattering*
S-4	SLO-1	*Formation of magnetic domains*	*Mechanisms of magnetization reversal,*	*Self assembly of magnetic nanoparticles*	*Longitudinal, Transverse and Polar Kerr effect*	*Valet-Fert model for GMR*
	SLO-2	*Domain walls, Domain wall width*	*Coherent rotation*	*Magnetic nanowires*	*Faraday effect*	*Magnetic tunnel junction*
S-5	SLO-1	*Various type of domain walls*	*Fanning, curling*	*Physical vapor deposition of magnetic thin films*	*Magnetic force microscopy*	*Tunnel magneto resistance (TMR)*
	SLO-2	*Bloch walls and Neel walls*	*Domain wall movement*	*Physical vapor deposition of multilayers*	*Scanning electron microscopy with polarization analysis*	*Application of GMR and TMR*
S-6	SLO-1	*Quantum mechanical picture of Heisenberg exchange interaction*	*Introduction to Gilbert damping*	*DC and RF Sputter deposition of Magnetic materials*	*Interpretation of magnetic contrast from thin films and nanostructures*	*Spin transfer torque*
	SLO-2	*Role of Heisenberg exchange interaction in magnetism*	*Significance of Gilbert damping in choosing magnetic material for application*	*Magnetic Material deposition using E-beam evaporation technique*	*Magnetic contrast from nanostructures*	*Spin-orbit coupling induced phenomena*

S-7	SLO-1	*Energy scales involved in magnetism*	*In-plane magnetic anisotropy*	*Magnetization reversal in magnetic thin films*	*Spin-polarized scanning tunneling microscope (SP-STM)*	*Spin dynamics*
	SLO-2	*Zeeman energy*	*Magnetic domains in in-plane magnetized materials*	*Domain walls and magnetization reversal nanostructures*	*Interpretation of SP-STM results*	*Advanced spintronics based devices*
S-8	SLO-1	*Magnetic anisotropy energy, exchange energy*	*Perpendicular magnetic anisotropy*	*Magnetic properties of nanostructured soft magnetic materials NiFe*	*Introduction to magnetic recording*	*Domain wall based memory*
	SLO-2	*Discussion on Magnetostatic energy*	*Magnetic domains in out-of-plane magnetized materials*	*Magnetic properties of nanostructured soft magnetic materials CoFeB*	*Magnetic recording principles*	*Magnetic random access memory*
S-9	SLO-1	*Introduction to hard magnetic materials*	*Formation of magnetic vortex*	*Magnetic properties of nanostructured hard magnetic materials FePt*	*Nanomagnetic disks*	*Heat assisted magnetic recording*
	SLO-2	*Introduction to soft magnetic materials*	*Formation of antivortex and Skyrmions*	*Magnetic properties of nanostructured hard magnetic materials CoPt*	*Read and write head*	*Microwave assisted magnetic recording*

Learning Resources	*1. Principles of Nanomagnetism, by Alberto P. Guimaraes, XII, Springer Berlin Heidelberg New York, 2009* *2. Advanced Magnetic Nanostructures, by David Sellmyer, Ralph Skomski, Springer Heidelberg, 2010*	*3. Spin dynamics and damping in ferromagnetic thin films and nanostructures, by Anjan Barman and Jaivardhan Sinha, Springer, Switzerland, 2018*

Learning Assessment

	Bloom's Level of Thinking	Continuous Learning Assessment (50% weightage)								Final Examination (50% weightage)	
		CLA – 1 (10%)		CLA – 2 (15%)		CLA – 3 (15%)		CLA – 4 (10%)#			
		Theory	Practice	Theory	Practice	Theory	Practice	Theory	Practice	Theory	Practice
Level 1	Remember Understand	30 %	-	30 %	-	30 %	-	30 %	-	30%	-
Level 2	Apply Analyze	40 %	-	40 %	-	40 %	-	40 %	-	40%	-
Level 3	Evaluate Create	30 %	-	30 %	-	30 %	-	30 %	-	30%	-
	Total	100 %		100 %		100 %		100 %		100 %	

CLA – 4 can be from any combination of these: Assignments, Seminars, Tech Talks, Mini-Projects, Case-Studies, Self-Study, MOOCs, Certifications, Conf. Paper etc.,

Course Designers		
Experts from Industry	Experts from Higher Technical Institutions	Internal Experts
1. Dr. Hemant Dixit, GlobalFoundaries,USA, aplahemant@gmail.com	*1. Dr. Arabinda Haldar, IIT Hyderabad, arabinda@iith.ac.in*	*1. Dr. Jaivardhan Sinha, SRMIST*
2. Dr. Krishna Surendra Muvvala, Saint Gobain Research India, India, Krishna.muvvala@saintgobain.com	*2. Dr. M. S. Ramachandra Rao, IIT Madras, msrrao@iitm.ac.in*	*2. Dr. Kamala Bharathi, SRMIST*

ACADEMIC CURRICULA

Project Work, Seminar,

Internship in Industry / Higher Technical Institutions

Courses

Regulations 2018

SRM INSTITUTE OF SCIENCE AND TECHNOLOGY

(Deemed to be University u/s 3 of UGC Act, 1956)

Kattankulathur, Kancheepuram, Tamil Nadu, India

Course Code	18ASP101L 18ASP104L 18AUP101L 18AUP104L 18BTP101L 18BTP104L 18CHP101L 18CHP104L 18CEP101L 18CEP104L 18CSP101L 18CSP104L 18EEP101L 18EEP104L 18ECP101L 18ECP104L 18MEP101L 18MEP104L 18MHP101L 18MHP104L 18NTP101L 18NTP104L	Course Name	MOOC -1 / MOOC - 2	Course Category	P	Project Work, Seminar, Internship in Industry / Higher Technical Institutions	L	T	P	C
							0	0	2	1

Course Learning Rationale (CLR):	The purpose of learning this course is to:
CLR-1 :	*Improve Student Academic Characteristics and learning goals through forums, discussion groups, and blogs*
CLR-2 :	*Improve Student Personal Characteristics through self-learning habits*
CLR-3 :	*Characterize self-learning environment that includes pedagogy, tools, tasks, duration, feedback and assessments*
CLR-4 :	*Improve lifelong learning habits and Learning process*
CLR-5 :	*Characterize learning engagement methods and activities*
CLR-6 :	*Inculcate self-learning behavior and lifelong learning tendency*

Course Learning Outcomes (CLO):	At the end of this course, learners will be able to:	Learning 1 Level of Thinking (Bloom)	2 Expected Proficiency (%)	3 Expected Attainment (%)	Program Learning Outcomes (PLO) 1 Engineering Knowledge	2 Problem Analysis	3 Design & Development	4 Analysis, Design, Research	5 Modern Tool Usage	6 Society & Culture	7 Environment & Sustainability	8 Ethics	9 Individual & Team Work	10 Communication	11 Project Mgt. & Finance	12 Life Long Learning	13 PSO - 1	14 PSO - 2	15 PSO - 3
CLO-1 :	*Inculcate student characteristics: prior-knowledge, prior-experience, expertise, academic achievement and matriculation*	3	95	85	H	M	M	H	H	H	-	H	H	H	-	H	-	-	-
CLO-2 :	*Inculcate self-motivation, self-confidence, intrinsic motivation, participation, social economic statute, and task-orientation*	3	95	85	H	M	M	H	H	H	-	H	H	H	-	H	-	-	-
CLO-3 :	*Enhance self-learning through peer learning, learning groups, positive collaboration*	3	95	85	H	M	M	H	H	H	-	H	H	H	-	H	-	-	-
CLO-4 :	*Explore different learning styles and activities, identify self-learning pace, difficulties and remedial measures*	3	95	85	H	M	M	H	H	H	-	H	H	H	-	H	-	-	-
CLO-5 :	*Identify ways of students' engagement, achievement, and attrition*	3	95	85	H	M	M	H	H	H	-	H	H	H	-	H	-	-	-
CLO-6 :	*Identify ethical practices in self-learning and practice both individual and group learning dynamics*	3	95	85	H	M	M	H	H	H	-	H	H	H	-	H	-	-	-

MOOC Course Selection : List of MOOC Courses that are Approved to be learned by the student in the respective semester will be displayed by the Department MOOC Committee. Student can pick any course from that list.

Learning Assessment	
MOOC Certification Obtained (80% weightage)	Final Presentation (20% weightage)

Note : Final Presentation by the student would be evaluated by the Department MOOC Committee.

Course Code	18ASP102L 18ASP105L 18AUP102L 18AUP105L 18BTP102L 18BTP105L 18CHP102L 18CHP105L 18CEP102L 18CEP105L 18CSP102L 18CSP105L 18EEP102L 18EEP105L 18ECP102L 18ECP105L 18MEP102L 18MEP105L 18MHP102L 18MHP105L 18NTP102L 18NTP105L	Course Name	INDUSTRIAL TRAINING – 1 / INDUSTRIAL TRAINING – 2	Course Category	P	Project Work, Seminar, Internship in Industry / Higher Technical Institutions	L	T	P	C
							0	0	2	1

Course Learning Rationale (CLR):	*The purpose of learning this course is to:*
CLR-1 :	*Train oneself in finding the aspects in real-time work environment and prepare them to join the workforce in the future*
CLR-2 :	*Gain Exposure to the actual working conditions including rules, regulations and safety practices*
CLR-3 :	*Enhance and supplement the knowledge and skills of the students*
CLR-4 :	*Develop the students in terms of ability, competence and interpersonal relationship*
CLR-5 :	*Enhance students' knowledge in one particular technology*
CLR-6 :	*Provide learning platform that can enhance their employ ability skills*

Course Learning Outcomes (CLO):	*At the end of this course, learners will be able to:*	Learning 1 Level of Thinking (Bloom)	2 Expected Proficiency (%)	3 Expected Attainment (%)	Program Learning Outcomes (PLO) 1 Engineering Knowledge	2 Problem Analysis	3 Design & Development	4 Analysis, Design, Research	5 Modern Tool Usage	6 Society & Culture	7 Environment & Sustainability	8 Ethics	9 Individual & Team Work	10 Communication	11 Project Mgt. & Finance	12 Life Long Learning	13 PSO - 1	14 PSO - 2	15 PSO - 3
CLO-1 :	*Apply knowledge of Mathematics, Science, and Engineering Fundamentals in the real world of work*	*3*	*95*	*85*	*H*	*M*	*M*	*H*	*H*	*H*	*L*	*H*	*H*	*H*	*H*	*H*	-	-	-
CLO-2 :	*Demonstrate competency in relevant engineering fields through problem identification, formulation and solution*	*3*	*95*	*85*	*H*	*M*	*M*	*H*	*H*	*H*	*L*	*H*	*H*	*H*	*H*	*H*	-	-	-
CLO-3 :	*Effectively implement skills in professional communication, technical writing and using multimedia tools*	*3*	*95*	*85*	*H*	*M*	*M*	*H*	*H*	*H*	*L*	*H*	*H*	*H*	*H*	*H*	-	-	-
CLO-4 :	*Develop ability to work as an individual and in a group as an effective team member*	*3*	*95*	*85*	*H*	*M*	*M*	*H*	*H*	*H*	*L*	*H*	*H*	*H*	*H*	*H*	-	-	-
CLO-5 :	*Master the professional and ethical responsibilities of an engineer*	*3*	*95*	*85*	*H*	*M*	*M*	*H*	*H*	*H*	*L*	*H*	*H*	*H*	*H*	*H*	-	-	-
CLO-6 :	*Generate a report based on the experiences and projects carried out in a real-world work environment*	*3*	*95*	*85*	*H*	*M*	*M*	*H*	*H*	*H*	*L*	*H*	*H*	*H*	*H*	*H*	-	-	-

Industrial Training Selection : List of Industries for Industrial Training for students would be finalized by the Department Internship/Industrial Training Committee.

Learning Assessment	
Industrial Training Certification Obtained (80% weightage)	Final Presentation (20% weightage)

Note : Final Presentation Evaluation would be done by the Internship/Industrial Training Committee formed by the Department.

Course Code	18ASP103L 18ASP106L 18AUP103L 18AUP106L 18BTP103L 18BTP106L 18CHP103L 18CHP106L 18CEP103L 18CEP106L 18CSP103L 18CSP106L 18EEP103L 18EEP106L 18ECP103L 18ECP106L 18MEP103L 18MEP106L 18MHP103L 18MHP106L 18NTP103L 18NTP106L	Course Name	SEMINAR – 1 / SEMINAR – 2	Course Category	P	Project Work, Seminar, Internship in Industry / Higher Technical Institutions	L	T	P	C
							0	0	2	1

Course Learning Rationale (CLR):	*The purpose of learning this course is to:*
CLR-1 :	*Utilize fundamental principles, generalizations, or theories and ability to present the same*
CLR-2 :	*Increase self-motivation, personal responsibility, understand one's role of being an informed participant*
CLR-3 :	*Create an environment that helps the student establish healthy relationships and support networks*
CLR-4 :	*State and explain some specific skills, competencies, and points of view*
CLR-5 :	*Identify, apply appropriate note-taking, test-taking, and time-management strategies to the academic studies*
CLR-6 :	*Develop critical thinking, information literacy, Interdisciplinary Inquiry, Engaging with Big Questions and Major Works*

Course Learning Outcomes (CLO):	*At the end of this course, learners will be able to:*	Learning 1 Level of Thinking (Bloom)	2 Expected Proficiency (%)	3 Expected Attainment (%)	Program Learning Outcomes (PLO) 1 Engineering Knowledge	2 Problem Analysis	3 Design & Development	4 Analysis, Design, Research	5 Modern Tool Usage	6 Society & Culture	7 Environment & Sustainability	8 Ethics	9 Individual & Team Work	10 Communication	11 Project Mgt. & Finance	12 Life Long Learning	13 PSO - 1	14 PSO - 2	15 PSO - 3
CLO-1 :	*Gaining factual knowledge (terminology, classifications, methods, trends)*	3	95	85	H	M	M	H	H	H	L	H	H	H	-	H	-	-	-
CLO-2 :	*Rlate to their interests, abilities, career choices, and personal development*	3	95	85	H	M	M	H	H	H	L	H	H	H	-	H	-	-	-
CLO-3 :	*Develop a plan that demonstrates their responsibility for their own education*	3	95	85	H	M	M	H	H	H	L	H	H	H	-	H	-	-	-
CLO-4 :	*Explain the role of self-efficacy, personal goals, and motivation in improving academic life*	3	95	85	H	M	M	H	H	H	L	H	H	H	-	H	-	-	-
CLO-5 :	*Describe the behaviors and characteristics of an effective learner*	3	95	85	H	M	M	H	H	H	L	H	H	H	-	H	-	-	-
CLO-6 :	*Improve the Presentation Skills, Discussion Skills, Listening Skills, Argumentative Skills, Critical Thinking, Questioning*	3	95	85	H	M	M	H	H	H	L	H	H	H	-	H	-	-	-

Seminar Selection : List of Seminar Topics that are Approved to be learned by the student in the respective semester will be displayed by the Department Seminar Selection/Evaluation Committee. Student can pick any topic from that list.

Learning Assessment	
Seminar Preparation Materials & Report (80% weightage)	Final Presentation (20% weightage)

Note : Final Presentation Evaluation would be done by the Seminar Evaluation Committee formed by the Department.

Course Code	18ASP107L 18EEP107L	18AUP107L 18ECP107L	18BTP107L 18MEP107L	18CHP107L 18MHP107L	18CEP107L 18NTP107L	18CSP107L	Course Name	MINOR PROJECT	Course Category	P	Project Work, Seminar, Internship in Industry / Higher Technical Institutions	L	T	P	C
												0	0	2	1

Course Learning Rationale (CLR):	The purpose of learning this course is to:
CLR-1 :	*Learn responsible and professional way of working*
CLR-2 :	*Practice development-oriented approach to work*
CLR-3 :	*Enhance students' knowledge in one particular technology*
CLR-4 :	*Create awareness of the social, cultural, global and environmental responsibility as an engineer*
CLR-5 :	*Grow more empathetic, become systems thinkers, become explorers, problem-solvers.*
CLR-6 :	*Learn project management.*

Course Learning Outcomes (CLO):	At the end of this course, learners will be able to:	Learning 1: Level of Thinking (Bloom)	2: Expected Proficiency (%)	3: Expected Attainment (%)	PLO 1: Engineering Knowledge	2: Problem Analysis	3: Design & Development	4: Analysis, Design, Research	5: Modern Tool Usage	6: Society & Culture	7: Environment & Sustainability	8: Ethics	9: Individual & Team Work	10: Communication	11: Project Mgt. & Finance	12: Life Long Learning	13: PSO - 1	14: PSO - 2	15: PSO - 3
CLO-1 :	*Develop capability to acquire and apply fundamental principles of engineering*	3	95	85	H	M	M	H	H	H	L	H	H	H	H	H	-	-	-
CLO-2 :	*Become updated with all the latest changes in technological world*	3	95	85	H	M	M	H	H	H	L	H	H	H	H	H	-	-	-
CLO-3 :	*Make deep connections between ideas*	3	95	85	H	M	M	H	H	H	L	H	H	H	H	H	-	-	-
CLO-4 :	*Learn to take creative risks*	3	95	85	H	M	M	H	H	H	L	H	H	H	H	H	-	-	-
CLO-5 :	*Be ready for the creative economy also engage in iterative thinking and divergent thinking*	3	95	85	H	M	M	H	H	H	L	H	H	H	H	H	-	-	-
CLO-6 :	*Identify, formulate and model problems and find engineering solution based on a systems approach*	3	95	85	H	M	M	H	H	H	L	H	H	H	H	H	-	-	-

Project Work Selection : Project Work Titles for students would be finalized by the Department Project Work Evaluation Committee.

Learning Assessment	
MOOC Certification Obtained (80% weightage)	Final Presentation (20% weightage)

Note : Final Presentation Evaluation would be done by the Department Project Work Evaluation Committee formed by the Department.

Course Code	18ASP108L 18AUP108L 18BTP108L 18CHP108L 18CEP108L 18CSP108L 18EEP108L 18ECP108L 18MEP108L 18MHP108L 18NTP108L	Course Name	INTERNSHIP	Course Category	P	Project Work, Seminar, Internship in Industry / Higher Technical Institutions	L	T	P	C
							0	0	2	1

Course Learning Rationale (CLR):	The purpose of learning this course is to:
CLR-1 :	*Understanding of industry/organization customs and practices*
CLR-2 :	*Demonstrate professional skills that pertain directly to the internship experience*
CLR-3 :	*Demonstrate effective verbal and written communication skills, Allocate time effectively*
CLR-4 :	*Demonstrate effective listening skills*
CLR-5 :	*Participate well as a team member and build professional network*
CLR-6 :	*Build a record of work experience, Develop work habits and attitudes necessary for job success*

Course Learning Outcomes (CLO):	At the end of this course, learners will be able to:	Learning 1	2	3	Program Learning Outcomes (PLO) 1	2	3	4	5	6	7	8	9	10	11	12	13	14	15
		Level of Thinking (Bloom)	Expected Proficiency (%)	Expected Attainment (%)	Engineering Knowledge	Problem Analysis	Design & Development	Analysis, Design, Research	Modern Tool Usage	Society & Culture	Environment & Sustainability	Ethics	Individual & Team Work	Communication	Project Mgt. & Finance	Life Long Learning	PSO - 1	PSO - 2	PSO - 3
CLO-1 :	*Adapt effectively to changing conditions*	3	95	85	H	M	M	H	H	H	L	H	H	H	H	H	-	-	-
CLO-2 :	*Demonstrate appropriate workplace attitudes*	3	95	85	H	M	M	H	H	H	L	H	H	H	H	H	-	-	-
CLO-3 :	*Demonstrate individual responsibility*	3	95	85	H	M	M	H	H	H	L	H	H	H	H	H	-	-	-
CLO-4 :	*Demonstrate effective management of personal behavior, ethics and attitudes*	3	95	85	H	M	M	H	H	H	L	H	H	H	H	H	-	-	-
CLO-5 :	*Practice ethical standards appropriate to the internship site*	3	95	85	H	M	M	H	H	H	L	H	H	H	H	H	-	-	-
CLO-6 :	*Explore career alternatives prior to graduation, Integrate theory and practice*	3	95	85	H	M	M	H	H	H	L	H	H	H	H	H	-	-	-

Internship Training Selection : List of Industries / Research Centre's for Internship Training for students would be finalized by the Department Internship/Industrial Training Committee.

Learning Assessment	
Internship Certification Obtained (80% weightage)	Final Presentation (20% weightage)

Note : Final Presentation Evaluation would be done by the Internship/Industrial Training Committee formed by the Department.

Course Code	18ASP109L 18AUP109L 18BTP109L 18CHP109L 18CEP109L 18CSP109L 18EEP109L 18ECP109L 18MEP109L 18MHP109L 18NTP109L	Course Name	PROJECT	Course Category	P	Project Work, Seminar, Internship in Industry / Higher Technical Institutions	L	T	P	C
							0	0	2	1

Course Learning Rationale (CLR):	The purpose of learning this course is to:
CLR-1 :	*Learn responsible and professional way of working*
CLR-2 :	*Practice development-oriented approach to work*
CLR-3 :	*Enhance students' knowledge in one particular technology*
CLR-4 :	*Create awareness of the social, cultural, global and environmental responsibility as an engineer*
CLR-5 :	*Grow more empathetic, become systems thinkers, become explorers, problem-solvers.*
CLR-6 :	*Learn project management.*

Course Learning Outcomes (CLO):	At the end of this course, learners will be able to:	Learning			Program Learning Outcomes (PLO)														
		1	2	3	1	2	3	4	5	6	7	8	9	10	11	12	13	14	15
		Level of Thinking (Bloom)	Expected Proficiency (%)	Expected Attainment (%)	Engineering Knowledge	Problem Analysis	Design & Development	Analysis, Design, Research	Modern Tool Usage	Society & Culture	Environment & Sustainability	Ethics	Individual & Team Work	Communication	Project Mgt. & Finance	Life Long Learning	PSO - 1	PSO - 2	PSO - 3
CLO-1 :	*Develop capability to acquire and apply fundamental principles of engineering*	3	95	85	H	M	M	H	H	H	L	H	H	H	H	H	-	-	-
CLO-2 :	*Become updated with all the latest changes in technological world*	3	95	85	H	M	M	H	H	H	L	H	H	H	H	H	-	-	-
CLO-3 :	*Make deep connections between ideas*	3	95	85	H	M	M	H	H	H	L	H	H	H	H	H	-	-	-
CLO-4 :	*Learn to take creative risks*	3	95	85	H	M	M	H	H	H	L	H	H	H	H	H	-	-	-
CLO-5 :	*Be ready for the creative economy also engage in iterative thinking and divergent thinking*	3	95	85	H	M	M	H	H	H	L	H	H	H	H	H	-	-	-
CLO-6 :	*Identify, formulate and model problems and find engineering solution based on a systems approach*	3	95	85	H	M	M	H	H	H	L	H	H	H	H	H	-	-	-

Project Work Selection : Project Work Titles for students would be finalized by the Department Project Work Evaluation Committee.

Learning Assessment	
Project Report (80% weightage)	Final Presentation (20% weightage)

Note : Final Presentation Evaluation would be done by the Department Project Work Evaluation Committee formed by the Department.

Course Code	18ASP110L 18AUP110L 18BTP110L 18CHP110L 18CEP110L 18CSP110L 18EEP110L 18ECP110L 18MEP110L 18MHP110L 18NTP110L	Course Name	SMESTER INTERNSHIP	Course Category	P	Project Work, Seminar, Internship in Industry / Higher Technical Institutions	L	T	P	C
							0	0	2	1

Course Learning Rationale (CLR):	*The purpose of learning this course is to:*
CLR-1 :	*Become job ready along with real corporate exposure*
CLR-2 :	*Increase self-confidence and helps in finding their own proficiency*
CLR-3 :	*Cultivate leadership ability and responsibility to perform or execute the given task*
CLR-4 :	*Inculcate learners hands on practice within a real job situation*
CLR-5 :	*Create awareness of the social, cultural, global and environmental responsibility as an engineer*
CLR-6 :	*Become able to identify, formulate and model problems and find engineering solution based on a systems approach*

Course Learning Outcomes (CLO):	*At the end of this course, learners will be able to:*	Learning 1 Level of Thinking (Bloom)	2 Expected Proficiency (%)	3 Expected Attainment (%)	PLO 1 Engineering Knowledge	2 Problem Analysis	3 Design & Development	4 Analysis, Design, Research	5 Modern Tool Usage	6 Society & Culture	7 Environment & Sustainability	8 Ethics	9 Individual & Team Work	10 Communication	11 Project Mgt. & Finance	12 Life Long Learning	13 PSO - 1	14 PSO - 2	15 PSO - 3
CLO-1 :	*Enhance capability to acquire and apply fundamental principles of engineering*	3	95	85	H	M	M	H	H	H	L	H	H	H	H	H	-	-	-
CLO-2 :	*Become master in one's specialized technology*	3	95	85	H	M	M	H	H	H	L	H	H	H	H	H	-	-	-
CLO-3 :	*Become updated with all the latest changes in technological world*	3	95	85	H	M	M	H	H	H	L	H	H	H	H	H	-	-	-
CLO-4 :	*Demonstrate hands on practice within a real job situation*	3	95	85	H	M	M	H	H	H	L	H	H	H	H	H	-	-	-
CLO-5 :	*Inculcate self-improvement through continuous professional development and life-long learning*	3	95	85	H	M	M	H	H	H	L	H	H	H	H	H	-	-	-
CLO-6 :	*Be a multi-skilled engineer with good technical knowledge, management, leadership and entrepreneurship skills*	3	95	85	H	M	M	H	H	H	L	H	H	H	H	H	-	-	-

Internship Training Selection : List of Industries / Research Centre's for Internship Training for students would be finalized by the Department Internship/Industrial Training Committee.

Learning Assessment	
Internship Certification Obtained (80% weightage)	Final Presentation (20% weightage)

Note : Final Presentation Evaluation would be done by the Internship/Industrial Training Committee formed by the Department.

SRM INSTITUTE OF SCIENCE AND TECHNOLOGY

(Deemed to be University u/s 3 of UGC Act, 1956)

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