ACADEMIC CURRICULA

POSTGRADUATE DEGREE PROGRAMMES

Master of Technology in Computer Aided Design

Two Years(Full Time)

Learning Outcome Based Education

Choice Based Flexible Credit System

Academic Year

2020 - 2021

SRM INSTITUTE OF SCIENCE AND TECHNOLOGY

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

Kattankulathur, Chengalpattu District 603203, Tamil Nadu, India

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M.Tech in Computer Aided Design

1. Department Vision Statement	
Stmt - 1	*We envisage to become an internationally acclaimed research department by fostering creativity and innovation amongst faculty to empower students for a holistic progress.*
2. Department Mission Statement	
Stmt - 1	To impart quality education to produce mechanical engineers and enhance their skills to become world renowned professionals
Stmt - 2	To establish centers of research excellence to inculcate research acumen in faculty and students on the areas like; machining, bio-mechanics, bio-fuels, composites and energy
Stmt - 3	To provide state-of-the-art education and training programs to the faculty and student fellowship
3. Program Education Objectives (PEO)	
PEO - 1	Specialize in the domain of engineering design with the support of computing technology.
PEO - 2	Engage in professional practice to meet global standards with ethical and social responsibility.
PEO - 3	Strengthen capability in upcoming areas of research and development in engineering design and analysis.
PEO - 4	Leverage necessary ecosystem for self-employment.
PEO - 5	Apply independent life-long learning ability to actively participate in nation building.

4. Consistency of PEO's with Mission of the Department

	Mission Stmt. - 1	Mission Stmt. - 2	Mission Stmt. - 3
PEO - 1	H	H	L
PEO - 2	M	M	M
PEO - 3	H	H	H
PEO - 4	H	L	H
PEO - 5	H	M	H

H – High Correlation, M – Medium Correlation, L – Low Correlation

5. Consistency of PEO's with Program Learning Outcomes (PLO)

	Program Learning Outcomes (PLO)														
	1.	2.	3.	4.	5.	6.	7.	8.	9.	10.	11.	12.	13.	14.	15.
	Disciplinary Knowledge	Critical Thinking	Problem Solving	Analytical Reasoning	Research Skills	Team Work	Scientific Reasoning	Reflective Thinking	Self-Directed Learning	Multicultural Competence	Ethical Reasoning	Community Engagement	ICT Skills	Leadership Skills	Life Long Learning
PEO - 1	H	H	H	H	M	M	H	M	M	M	M	M	H	M	M
PEO - 2	H	H	H	H	M	H	H	H	M	H	H	H	H	H	H
PEO - 3	H	H	H	H	H	M	H	H	M	M	H	M	H	M	M
PEO - 4	M	L	M	M	M	H	M	H	H	H	H	H	H	H	H
PEO - 5	H	H	H	M	M	H	M	M	H	M	H	L	M	H	H

H – High Correlation, M – Medium Correlation, L – Low Correlation

6. Programme Structure (70 Total Credits)

1. Professional Core Courses (C)
(4 Courses)

Course Code	Course Title	Hours/ Week L	T	P	C
20MAC501T/ 20MAE501T	Computational Methods in Engineering	3	1	0	4
20MEC501J	Modeling and Simulation	3	0	2	4
20MEC502J	Finite Element Analysis	3	0	2	4
20MEC503J	Mechanical Vibrations	3	0	2	4
20MEC504J	Optimization in Engineering Design	3	0	2	4
Total Learning Credits					**20**

2. Professional Elective Courses (E)
(4 Courses)

Course Code	Course Title	Hours/ Week L	T	P	C
20MEE501T	Integrated Product Design and Development	4	0	0	4
20MEE502J	Tribology in Design	3	0	2	
20MEE503T	Advanced Mechanics of Solids	3	1	0	4
20MEE504T	Mechanical Behavior of Engineering Materials	3	1	0	
20MEE505J	Computer Graphics and Virtual Reality	3	0	2	4
20MEE506T	Bio-Mechanics	4	0	0	
20MEE601J	Advanced Finite Element Analysis	4	0	0	4
20MEE602J	Composites Materials-Mechanics. Design and Manufacturing	3	0	2	
Total Learning Credits					**16**

3. Skill Enhancement Courses (S)
(2 Courses)

Course Code	Course Title	Hours/ Week L	T	P	C
20GNS501J	Research Publishing and Presenting Skills	1	0	2	2
20MES501J	Research Methods in Mechanical Sciences	2	0	2	3
Total Learning Credits					**5**

4. Open Elective Courses (O)
(Any 1 Course)

Course Code	Course Title	Hours/ Week L	T	P	C
20MBO601T	Business Analytics	3	0	0	3
20MEO601T	Industrial Safety	3	0	0	3
20MAO601T	Operations Research	3	0	0	3
20MBO602T	Cost Management	3	0	0	3
20NTO601T	Composite Materials	3	0	0	3
20CEO601T	Waste to Energy	3	0	0	3
20MEO602T	Entrepreneurship and IPR	3	0	0	3
20GNO601T	MOOC	-	-	-	3
20MEO603T	Solar Passive Architecture	3	0	0	3
Total Learning Credits					**3**

5. Project Work, Internship In Industry / Higher Technical Institutions (P)

Course Code	Course Title	Hours/ Week L	T	P	C
20MEP601L	Internship (4-6 weeks during 2nd sem vacation)	0	0	8	4
20MEP602L	Minor Project	0	0	8	
20MEP603L	Project Work Phase I	0	0	12	6
20MEP604L	Project Work Phase II	0	0	32	16
Total Learning Credits					**26**

6. Audit Courses (M)
(2 Courses)

Course Code	Course Title	Hours/ Week L	T	P	C
20CEA501J	Disaster Management	1	0	1	0
20LEA501J	Constitution of India	1	0	1	0
20LEA502J	Value Education	1	0	1	0
20GNA501J	Physical and Mental Health using Yoga	1	0	1	0

7. Mandatory Courses (M)
(3 Courses)

Course Code	Course Title	Hours/ Week L	T	P	C
20PDM501J	Career Advancement for Engineers – 1	1	0	1	0
20PDM502J	Career Advancement for Engineers – 2	1	0	1	0
20PDM601J	Career Advancement for Engineers – 3	1	0	1	0

7. Implementation Plan

Semester - I

Code	Course Title	Hours/ Week L	T	P	C
20MAC501T/ 20MAE501T	Computational methods in Engineering	3	1	0	4
20MEC501J	Modeling and Simulation	3	0	2	4
20MEC502J	Finite Element Analysis	3	0	2	4
20MEE501T	Integrated Product Design and Development	4	0	0	4
20MEE502J	Tribology in Design	3	0	2	
20GNS501J	Research Publishing and Presenting Skills	1	0	2	2
20PDM501J	Career Advancement for Engineers – 1	1	0	1	0
	Audit Course - 1	1	0	1	0
Total Learning Credits					18

Semester - II

Code	Course Title	Hours/ Week L	T	P	C
20MEC503J	Mechanical Vibrations	3	0	2	4
20MEC504J	Optimization in Engineering Design	3	0	2	4
20MEE503T	Advanced Mechanics of Solids	3	1	0	4
20MEE504T	Mechanical Behavior of Engineering Materials	3	1	0	
20MEE505J	Computer Graphics and Virtual Reality	3	0	2	4
20MEE506T	Bio-Mechanics	4	0	0	
20MEE601T	Advanced Finite Element Analysis	4	0	0	4
20MEE602J	Composites Materials-Mechanics. Design and Manufacturing	3	0	2	
20MES501J	Research Methods in Mechanical Sciences	2	0	2	3
20PDM502J	Career Advancement for Engineers – 2	1	0	1	0
	Audit Course - 2	1	0	1	0
Total Learning Credits					23

Semester - III

Code	Course Title	Hours/ Week L	T	P	C
	Open Elective	3	0	0	3
	MOOC	-	-	-	
20MEP602L	Minor Project	0	0	8	4
20MEP601L	Internship (4-6 weeks-to be done in the vacation after II semester)				
20MEP603L	Project Work Phase I	0	0	12	6
20PDM601J	Career Advancement for Engineers – 3	1	0	1	0
Total Learning Credits					13

Semester - IV

Code	Course Title	Hours/ Week L	T	P	C
20MEP604L	Project Work Phase II	0	0	32	16
Total Learning Credits					16

8. Program Articulation Matrix

Course Code	Course Name	Programme Learning Outcomes														
		Disciplinary Knowledge	Critical Thinking	Problem Solving	Analytical Reasoning	Research Skills	Team Work	Scientific Reasoning	Reflective Thinking	Self-Directed Learning	Multicultural Competence	Ethical Reasoning	Community Engagement	ICT Skills	Leadership Skills	Life Long Learning
20MAC501T/20 MAE501T	*Computational Methods in Engineering*															
20MEC501J	*Modeling and Simulation*	H	H	H	H	M	H	M	M	H	M	M	M	H	H	H
20MEC502J	*Finite Element Analysis*	H	H	H	H	M	L	M	M	H	L	L	L	L	L	H
20MEC503J	*Mechanical Vibrations*	H	H	H	H	H	L	H	H	H	L	L	L	M	M	H
20MEC504J	*Optimization in Engineering Design*	H	H	H	H	H	L	H	M	M	L	L	L	M	L	H
20MEE501T	*Integrated Product Design and Development*	H	H	H	H	M	H	M	M	H	M	M	M	H	H	H
20MEE502J	*Tribology in Design*	H	H	H	H	H	H	H	M	M	M	M	H	H	H	H
20MEE503T	*Advanced Mechanics of Solids*	H	H	H	H	M	L	M	M	H	L	L	L	L	L	H
20MEE504T	*Mechanical Behavior of Engineering Materials*	H	H	H	M	M	-	M	-	-	-	-	-	-	-	M
20MEE505J	*Computer Graphics and Virtual Reality*	H	H	H	H	H	M	H	H	H	L	L	H	H	L	H
20MEE506T	*Bio-Mechanics*	H	H	H	H	H	L	H	H	H	H	H	M	H	L	H
20MEE601T	*Advanced Finite Element Analysis*	H	H	H	H	H	L	H	H	H	L	L	L	H	L	H
20MEE602J	*Composites Materials-Mechanics. Design and Manufacturing*	H	H	H	H	H	M	M	M	M	L	L	L	M	L	M
20GNS501J	*Research Publishing and Presenting Skills*	L	H	H	M	M	-	L	H	M	-	H	-	L	-	M
20MES501J	*Research Methods in Mechanical Sciences*	L	M	M	L	H	M	L	L	H	M	H	L	H	L	H
20MBO601T	Business Analytics															
20MEO601T	Industrial Safety	H	M	H	-	H	M	H	M	H	H	M	H	-	H	H
20MAO601T	Operations Research															
20MBO602T	Cost Management															
20NTO601T	Composite Materials															
20CEO601T	Waste to Energy															
20MEO602T	Entrepreneurship and IPR	-	-	-	-	-	M	-	H	-	-	-	H	-	H	H
20GNO601T	MOOC															
20MEO603T	Solar Passive Architecture	H	H	L	H	L	L	L	H	L	L	L	H	H	L	H
20MEP601L	Internship (4-6 weeks during 2nd sem vacation)															
20MEP602L	Minor Project															
20MEP603L	Project Work Phase I															
20MEP604L	Project Work Phase II															
20CEA501J	Disaster Management															
20LEA501J	Constitution of India															
20LEA502J	Value Education															
20GNA501J	Physical and Mental Health using Yoga															
20PDM501T	Career Advancement for Engineers – 1															
20PDM502T	Career Advancement for Engineers – 2															
20PDM601T	Career Advancement for Engineers – 3															
	Program Average															

H – High Correlation, M – Medium Correlation, L – Low Correlation

1. Professional Core Courses (C)

Course Code	20MAC501T/20MAE501T	Course Name	COMPUTATIONAL METHODS IN ENGINEERING	Course Category	BS	Basic Sciences	L	T	P	C
							3	1	0	4

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

Course Learning Rationale (CLR):	The purpose of learning this course is as follows:
CLR-1 :	Describe different types of Partial differential equations interpret the solutions by L.T and F.T relate to the respective branch of mechanical engineering
CLR-2 :	Expose the students to numerical technique to solve algebraic equation s, transcendental equations
CLR-3 :	Numerical solution of parabolic, elliptic and hyperbolic PDEs and variation problems
CLR-4 :	To expose the students to probabilistic approach to solve the real life problems
CLR-5 :	Introduce the students to the concept of statistical problems in real life

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 of analytical solution of partial differential equation	3	85	80	M	L	L						M			L			
CLO-2 :	Able to construct the solution of algebraic equations, differential equations	1	85	80	M	H		M	M				M	L					
CLO-3 :	Able to find the numerical solution of PDE and variatioal problems	1	85	80	M	L							M			L			
CLO-4 :	Understanding of probability in real problem	3	85	80	M	H		M					M	L					
CLO-5 :	Statistical problem related to day to day life	1	85	80	M	L	L						M			L			

		Learning Unit / Module 1	Learning Unit / Module 2	Learning Unit / Module 3	Learning Unit / Module 4	Learning Unit / Module 5
Duration (hour)		12	12	12	12	12
S-1	SLO-1	Introduction and classification of second order PDEs	Introduction to Numerical methods	Numerical solution to PDEs	Introduction to Probability	Linear Regression
	SLO-2	Parabolic PDE	Solution of algebraic equation	Liebmann's iteration method	Independent events	Principle of least squares
S-2	SLO-1	Examples	Bisection method	Laplace equation	Multiplication theorem for independent events	Regression coefficients
	SLO-2	Hyperbolic PDE	Solving Problems	Problems solving	Problems Solving	Properties of Regression coefficient
S-3	SLO-1	Example	Fixed point iteration method	Poisson equation	Conditional probability	Fitting of straight lines
	SLO-2	Elliptic PDE	Problems solving	Bender-Schmidth Method	Examples	Problems solving
S-4	SLO-1	Tutorial 1	Tutorial 4	Tutorial 7	Tutorial 10	Tutorial 13
	SLO-2	Tutorial 1	Tutorial 4	Tutorial 7	Tutorial 10	Tutorial 13
S-5	SLO-1	Boundary value problem	Secant method	One dimensional heat equation	Examples	Problems solving
	SLO-2	Example in real life	Problems solving	Explicit scheme	Random Variables	Curve linear regression
S-6	SLO-1	Laplace Transform -L.T	Solution system of nonlinear algebraic equations	One dimensional wave equation	Discrete Random variable	Fitting of parabola
	SLO-2	one dimensional wave equation	Interpolation	Introduction to calculus of variations	Moments and Standard Deviation	Problems Solving
S-7	SLO-1	Solution of wave equation using L.T	Lagrange interpolation	Functional	Probability mass function	Correlation

	SLO-2	Problem solving	Hermite interpolation	Euler equation and solution of Euler equation	Distribution function	Linear correlation
S-8	SLO-1	Tutorial 2	Tutorial 5	Tutorial 8	Tutorial 11	Tutorial 14
	SLO-2	Tutorial 2	Tutorial 5	Tutorial 8	Tutorial 11	Tutorial 14
S-9	SLO-1	Heat conduction problem in semi infinite string	Numerical Differentiation	Functional dependent on higher order derivative	Problems solving	Examples
	SLO-2	Solution of heat conduction problem using F.T	Numerical Integration	Formula and Examples	Continuous Random variable	Plane of regression
S-10	SLO-1	Solving Problems	Trapezoidal rule	Variational problem involving several independent variables	Moments and S.D	Coefficient of multiple correlation
	SLO-2	Laplace equation	Simpson's Rules	Solving Problems	Normal Distribution	Examples
S-11	SLO-1	Examples	Problems solving	Isoperimetric problems	Exponential Distribution	Coefficient of partial correlation
	SLO-2	Solution of Laplace equation	Gauss-Quadrature rule	Problems	Problems solving	Problems solving
S-12	SLO-1	Tutorial 3	Tutorial 6	Tutorial 9	Tutorial 12	Tutorial 15
	SLO-2	Tutorial 3	Tutorial 6	Tutorial 9	Tutorial 12	Tutorial 15
Learning Resources		1. Sankar Rao K., Introduction to Partial Differential Equations, 4th Printing, PH1, New Delhi, April 2003 2. Elsgolts L., Differential Equations and Calculus of Variations, Mir Publishers, Moscow, 1966 3. S. S. Sastry, Introductory Methods of Numerical Analysis, 3rd Edition, PH1, 2001 4. Gupta S.C. and Kapoor V. K., Fundamentals of Mathematical Statistics, Sultan Chand and Sons, New Delhi, Reprint 2003				

	Level of Thinking	Continuous Learning Assessment Test (60%)			Final Examination (40%)
		CLA – 1 (20%)	CLA – 2 (25%)	CLA – 3 (15%) #	
Level 1	Remember Understand	40 %	30 %	30 %	30 %
Level 2	Apply Analyze	40 %	40 %	40 %	40 %
Level 3	Evaluate Create	20 %	30 %	30 %	30 %

Assignment and Surprise Test

Course Designer: Dr. B. Bira, Assistant Professor (Sr.G), SRMIST, bibekanb@srmist.edu.in							
(a) Experts from Industry							
1	**Mr.V.Maheshwaran**	**CTS, Chennai**	**maheswaran@yah oo.com**				
(b) Experts from Higher Technical Institutions							
1	**Dr. Y.V.S.S. Sanyasiraju**	**IIT Madras, Chennai**	**sryedida@iitm.ac.in**	**2**	**Dr.K.C.SivaKumar**	**IIT Madras, Chennai**	**kcskumar@iit m.ac.in**
(c) Internal Experts							
1	**Dr.A.Govindarajan**	**SRMIST**	**govindaa@srmist.edu.in**	**2**	**Prof. K.S. Gnapathy Subramanian.**	SRMIST	ganapatk@srmist.edu.in

Course Code	20MEC501J	Course Name	MODELLING AND SIMULATION	Course Category	C	Professional Core	L	T	P	C
							3	0	2	4

Pre-requisite Courses	*Nil*	Co-requisite Courses	*Nil*	Progressive Courses	20MEE505J, 20MEE506T
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 of abstracting physical systems
CLR-2 :	Understand the 3D model generation
CLR-3 :	Understand the modeling of biosystems
CLR-4 :	Understand the simulation techniques for mechanical systems
CLR-5 :	Understand the visualization of data for effective presentation
CLR-6 :	Understand the concept and complete process of product development and its management

Course Learning Outcomes (CLO):	*At the end of this course, learners will be able to:*	Learning: Level of Thinking (Bloom)	Expected Proficiency (%)	Expected Attainment (%)	PLO 1 Disciplinary Knowledge	2 Critical Thinking	3 Problem Solving	4 Analytical Reasoning	5 Research Skills	6 Team Work	7 Scientific Reasoning	8 Reflective Thinking	9 Self-Directed Learning	10 Multicultural Competence	11 Ethical Reasoning	12 Community Engagement	13 ICT Skills	14 Leadership Skills	15 Life Long Learning
CLO-1 :	Be familiar with and analyze the mathematics behind the modeling of mechanical systems	1	70	65	H	H	H	H	M	H	H	H	M	H	M	M	M	L	M
CLO-2 :	Undertake to generate 3D solid models	2	80	75	H	H	H	H	H	H	H	H	H	M	H	M	H	H	H
CLO-3 :	Undertake to generate 3D solid models of biosystems	3	65	60	H	M	L	L	M	M	M	M	L	L	L	L	L	M	M
CLO-4 :	Carry out the process of simulating mechanical systems	3	75	70	H	H	H	H	L	M	H	M	H	M	M	M	H	M	H
CLO-5 :	Be familiar with the visualization techniques of data for effective interpretation of analytical solutions	2	70	65	L	L	L	L	L	L	L	L	M	L	M	M	L	M	M
CLO-6 :	Model, simulate and visually interpret the models of any physical systems	3	70	65	H	H	H	H	M	H	M	M	H	M	M	M	H	H	H

Duration (hour)		MATHEMATICAL MODELLING OF MECHANICAL SYSTEMS	GEOMETRIC MODELLING	MODELLING OF BIOSYSTEMS	MECHANICAL SYSTEM SIMULATION	Data Visualization
		15	15	15	15	15
S-1	SLO-1 SLO-2	Idealized Modeling Elements/ basic elements of mechanical systems	2-D Projection (Drawings) • Wireframe Modeling, Surface Modeling Analytical Surface Free-form, Curved, & Sculptured Surface	Introduction to biomechanics - Anatomical morphology	Introduction of system and Models	Data to Visualization – Mapping data onto Aesthetics
S-2	SLO-1 SLO-2	Modeling Methods	Solid Modeling Constructive Solid Geometry (CSG)	History of anatomical models, digital 3D models	System Study, System Simulation	Coordinate systems and axes
S-3	SLO-1 SLO-2	Two mass system	Boundary Representation (B-Rep)	Creating a 3D Model Using Graphics Software	Input Data Model	Colour scales
S-4	SLO-1 SLO-2	Three mass system	Feature Based Modeling	Creating a 3D Model Using Imaging and Scanning – steps involved, techniques	Continuous System Simulation	Directory of Visualizations
S-5	SLO-1 SLO-2	Electric Motor, Mass Pulley system	Primitive Instancing, Cell Decomposition, Spatial Enumeration, Octree	Image reconstruction	Discreet System Simulation	Visualization amounts – Bar plots, Stacked bars, dot plots, heat maps
S-6	SLO-1 SLO-2	Translational mass element, Rotational mass element, translation spring element, Damper element	Basic Part Modeling techniques	Creating a 3D Model Using Segmentation	System Dynamics	Visualization distribution – Histograms and density plots – single distribution and multiple distribution
S-7	SLO-1 SLO-2	Newton's Law and D'Alemberts principle	Parametric Modeling techniques	Digital 3D Anatomical Models to Create Physical Models	Simulation Language - GPSS	Visualization proportions
S-8	SLO-1	Transfer Function and State's space	Creation of assembly models	3D printing – materials, resolution and accuracy,	Validation of modelling and Simulation	Visualizations associations, Time series and

	SLO-2			costs and safety concerns		trends
S-9	SLO-1	Lagrange's equation, Hamiltonian equation	Advanced assembly operations	Emerging trends in 3D modeling	Real world application of simulation	Visualizing geospatial data
	SLO-2	Modeling of static and dynamic systems				

Learning Resources	1. Kishore V. Pochiraju , "Modeling and Simulation for Mechanical Engineers", John Wiley & Sons 2. James McConville," Introduction to Mechanical System Simulation Using Adams" 2015 3. Kevin Russell, Qiong Shen, Rajpal S. Sodhi. "Kinematics and Dynamics of Mechanical Systems, Second Edition: Implementation in MATLAB® and SimMechanics", 2018, Taylor and Francis 4. Pushpa Singh, Narendra Singh, "Modelling And Simulation", S.K. Kataria & Sons, 2008 5. Ibrahim Zeid, CAD / CAM – Theory and Practice", 2009, McGraw Hill 6. Jun Ueda and Yuichi Kurta, "Human Modeling for bio-Inspired Robotics – Mechanical Engineering in Assistive Technologies", 2016, Science Direct 7. Claus O'Wilke, "Fundamentals of Data Visualization", O'Reilly, Kindle Edition .

	Bloom's Level of Thinking	Continuous Learning Assessment (CLA) (60% weightage)					Final Examination (40% weightage)	
		CLA-1 (20%)		CLA-2 (25%)		CLA-3 (15%)		
		Theory	Practice	Theory	Practice		Theory	Practice
Level 1	Remember Understand	40%	**40%**	20%	**20%**	20%	20%	**20%**
Level 2	Apply Analyze	40%	**40%**	40%	**40%**	40%	35%	**35%**
Level 3	Evaluate Create	20%	**20%**	40%	**40%**	40%	45%	**45%**
	Total	100 %		100 %		100 %	100 %	

CLA – 3 can be from any combination of these: Assignments, Seminars, Tech Talks, Mini-Projects, Case-Studies, Self-Study, MOOCs, Certifications, Conf. Paper etc.,

Laboratory practice:

1. **Write codes for mathematical models of mechanical systems**
2. **Create 3D part models using commercial software package**
3. **Assemble 3D part models to form a product**
4. **Create 3D models from MRI scans of human systems**
5. **Model mechanical systems, simulate using any commercial software package**
6. **Exercises of data visualization**

Course Designers		
Experts from Industry	Experts from Higher Technical Institutions	Internal Experts
1. Dr. Mani S Manivasagam, Global Head of Vehicle Engineering, Tata Technologies, Pune, India	*1. Dr. Jayakumar, Principal, Agni Institute of Technology, Chennai*	*1. Dr. T.V. Gopal, SRMIST*
2. Velmurugan Sivaraman, AGM, Ashok Leyland		*2. Dr. S.H. Venkatasubramanian, SRMIST*

Course Code	20MEC502J	Course Name	FINITE ELEMENT ANALYSIS	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	Mechanical Engineering	Data Book / Codes/Standards	NIL		

Course Learning Rationale (CLR):	The purpose of learning this course is to be able to understand application of finite element analysis method in:
CLR-1 :	Solving differential equations. The learner will 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-2 :	a few representative 1-D linear structural analysis problems
CLR-3 :	a few representative 1-D linear heat conduction with convection problems
CLR-4 :	a few representative 2-D linear problems associated with structural analysis and use of two 2-D elements in planar problems
CLR-5 :	1-D linear time dependent heat conduction and structural analysis problems
CLR-6 :	Representative 1-D and 2-D problems so as to build the ability to engage in independent learning, as required, in future

Course Learning Outcomes (CLO):	At the end of this course and after completion of required reading and understanding, 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 (%)	Disciplinary Knowledge	Critical Thinking	Problem Solving	Analytical Reasoning	Research Skills	Team Work	Scientific Reasoning	Reflective Thinking	Self-Directed Learning	Multicultural Competence	Ethical Reasoning	Community Engagement	ICT Skills	Leadership Skills	Life Long Learning
CLO-1 :	Apply weighted residual and Rayleigh-Ritz methods in solving structural mechanics problems / differential equations	1, 2	90	75	H	H	H	H	M	L	M	M	H	L	L	L	L	L	H
CLO-2 :	Solve for displacements and forces/moments, as applicable, using 1-D 2 noded-bar or beam elements as applicable to linear analysis of structural members made of isotropic materials	1, 2	90	75	H	H	H	H	M	L	M	M	H	L	L	L	L	L	H
CLO-3 :	Solve for nodal temperatures related to 1-D steady state heat conduction problems using 2-noded bar elements	1, 2	90	75	H	H	H	H	M	L	M	M	H	L	L	L	L	L	H
CLO-4 :	Solve for displacements, strains and stresses, as applicable, using 3-noded triangular and/or 4-noded quadrilateral elements in linear analysis of structural members made of isotropic materials	1, 2	90	75	H	H	H	H	M	L	M	M	H	L	L	L	L	L	H
CLO-5 :	Solve for nodal temperatures in linear time dependent heat conduction analysis and displacements and forces in linear time dependent structural analysis	1, 2	90	75	H	H	H	H	M	L	M	M	H	L	L	L	L	L	H
CLO-6 :	Learn independently additional material as required in future	1, 2	90	75	H	H	H	H	M	L	M	M	H	L	L	L	L	L	H

		Introduction	1-D Linear Static Analysis	1-D Linear Steady-state Heat Transfer Analysis	2-D Elements for Static structural /steady state Analysis	1-D Linear Time Dependent Heat Transfer and Structural Analysis
Duration (hour)		15	15	15	15	15
S-1	SLO-1	Basic concept of Finite Element Method (FEM), Historical background, Course overview, Evaluation scheme	1D problems – overview & interpolation polynomial; 2-noded Bar element –derivation of element matrix	Review of basic equations of heat transfer - steady state one dimensional heat conduction, governing equation	Review of the basic theory in 2-D elasticity, plane stress and plane strain	Time-dependent problems: general 1-D governing equation – introduction and use of Galerkin method
	SLO-2					
S-2	SLO-1	FEM Applications, Commercial FEM software packages, Weighted residual methods – overview and different methods – Collocation, Sub-domain, Least Squares, Galerkin	Bar problem- solution of a sample problem including element stress determination	1-D steady state heat conduction (continued), boundary conditions, element characteristics	2-D problems using Constant Strain Triangles (CST) – definition of element, interpolation function	Derivation of element matrices as applicable to 1-D transient heat conduction – Consistent formulation
	SLO-2					
S-3	SLO-1	Application of weighted residual methods to sample problems – collocation and sub-domain methods - solution by hand	Co-ordinate systems – global, local, natural; co-ordinate transformation	Derivation of element matrix and "load" vector for linear 2-noded bar element	CST – derivation of element matrix	Introduction to lumped formulation and relevant element capacitance matrix, introduction to finite difference method; finite difference solution in time
	SLO-2					
S-4	SLO-1	Practice problems on collocation method	Exercise on determination of nodal displacements using the computer tool	Practice problems on nodal temperature determination – temperature boundary conditions – by hand	Practice problems on use of CST element – a) determination of shape functions	Practice problems on computation of element matrices
	SLO-2					

S-5	SLO-1 SLO-2	Practice problems on sub-domain method	Exercise on determination of forces in each element and drawing of Free Body Diagrams (FBD)	Practice problems on nodal temperature determination – mixed boundary conditions – by hand	b) nodal values – by hand	Computation of element matrices - continued
S-6	SLO-1 SLO-2	Sample problems – Least squares and Galerkin methods	Planar Truss element, Derivation of element Matrix, Building of global matrix	Heat conduction with convection – derivation of element matrix for convection term – fin example, sample problem – formulation by hand and solution	Bi-linear rectangular element – definition, interpolation function, element matrix derivation procedure	Overview of forward, backward, and central difference schemes, Derivation of Global matrices and setting up of linear system of equations
S-7	SLO-1 SLO-2	Comparison of the four methods, effect of choice of approximation functions	Analysis of a planar truss – by hand and preparation for use of a computer	Additional problems on steady state heat conduction with convection	Derivation of element matrix(continued),	Practical consideration – physical reality, numerical oscillations; guideline for choice of time-step
S-8	SLO-1 SLO-2	Variational formulation approach- Rayleigh-Ritz method, Principle of minimum potential energy	Beam element – definition, interpolation function, derivation of element matrix	Discussion of procedure for solving conduction with convection problems using a computer	Sample problems related to use of bi-linear rectangular elements, Iso-parametric element – definition and example in 2D	Sample problem – 1D transient heat conduction
S-9	SLO-1 SLO-2	Practice problems Least squares & Galerkins methods	Exercise on determination of nodal displacements in a plane truss	Exercise on determination of nodal temperatures – conduction only - with temperature boundary conditions	Demo on use of a finite element software	Development of a program/worksheet to a) compute relevant matrices
S-10	SLO-1 SLO-2	Practice problems on Rayleigh-Ritz method	Exercise on determination of element forces in a plane truss	Exercise on determination of nodal temperatures – conduction only - with mixed boundary conditions	Exercise on bar/truss problems – to be compared with results obtained earlier by another computer tool (in 1D static analysis topic)	b) to build global matrices, "load" vector, c) set-up of solution procedure, and d) solution for given problem(s)
S-11	SLO-1 SLO-2	Application of Rayleigh-Ritz method to sample problems – solution by hand	Beam element - solution of a sample problem	Decision on number of 2-node elements required – conduction only, conduction with convection –basis, Discussion of different boundary conditions, Sample problems	Jacobian – definition and derivation	Time dependent response of un-damped and damped (only viscous damping) single degree-of-freedom spring-mass system- free/forced vibration - governing equation and solution procedure
S-12	SLO-1 SLO-2	Application of Rayleigh-Ritz method to sample problems – solution by hand– Continued – effect of choice of approximation functions, intro to spring element	Iso-parametric elements & numerical integration , Gaussian quadrature	Comparison of governing equation and solution procedure for 1D bar problem with those for 1D steady state heat conduction problem	Determination of Jacobian for a given quadrilateral element – sample problems	Time dependent response of un-damped and damped (only viscous damping) two degree-of-freedom spring-mass system- free/forced vibration - governing equations and solution procedure
S-13	SLO-1 SLO-2	Spring element-stiffness matrix, boundary conditions, sample problems	Sample problems – by hand and procedure to solve using a computer	Overview of commercial finite element analysis softwares, use in industry, how to use a software in the learning process	Use of Gaussian quadrature in 2D element matrix derivation – discussion of procedure, Sample problems – use of a computer for solution	Vibration response - Sample problems
S-14	SLO-1 SLO-2	Demo on use of a computing tool (other than a FE software)	Exercise on determination of nodal displacements in a beam	Exercise on determination of nodal temperatures – conduction with convection – a) computation of element matrices	Exercise on beam problems – to be compared with results obtained earlier by another computer tool (in 1D static analysis topic)	Exercise on determination of response of 1-DOF systems
S-15	SLO-1 SLO-2	Problems solution using the tool – spring systems	Exercise on determination of shear force and bending moments in a beam and corresponding FBDs	b) building of global matrix and "load" vector, c) application of boundary conditions, d) computation of nodal temperatures	Demo on use of software in plane stress analysis	Exercise on determination of response of 2-DOF systems

Learning Resources	1. Segerlind, Larry J., "Applied Finite Element Analysis", John Wiley & Sons, 1984 2. Reddy, J.N. "An introduction to the Finite Element Method", McGraw Hill Book Company New York; 1984 3. Rao S.S. "Finite Element Method in Engineering", Pergamon Press, 1989 4. Chandrupatla & Belagundu, "Finite elements in Engineering", Prentice Hall of India Private Ltd., 1997 5. Krishnamoorthy. C.S., "Finite Element Analysis- Theory and Programming", Tata McGraw-Hill Publishing Co., 1987 6. Hubner. K.H., Donald. L.D, D.E. Smith, Ted G.Byron, "The Finite Element Method for Engineers", John, Willy & Sons, 1982 7. Zienkiewicz. O.C. "The Finite Element Method in Engg. Science", McGraw-Hill, London, 1977

	Bloom's Level of Thinking	Continuous Learning Assessment (CLA) (60% weightage)					Final Examination (40% weightage)	
		CLA-1 (20%)		CLA-2 (25%)		CLA-3 (15%)		
		Theory	Practice	Theory	Practice		Theory	Practice
Level 1	Remember Understand	15%	5%	10%	5%		10%	5%
Level 2	Apply	60%	20%	50%	35%	100%	50%	35%

	Analyze							
Level 3	Evaluate	0%	0%	0%	0%	0%	0%	0%
	Create							
	Total	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, vel_sivam@yahoo.com	2. Dr.R.Prabhu sekar, rprabhusekar@mnnit.ac.in, MNNIT Allahabad	

Course Code	20MEC503J	Course Name	MECHANICAL VIBRATIONS	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	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 free and forced vibration analysis of single degree of freedom systems
CLR-2:	Analyze the forced vibration response of single degree of freedom system under arbitrary forcing function
CLR-3:	Perform the free and forced vibration analysis of multiple degrees of freedom system
CLR-4:	Determine the natural frequencies and mode shapes of multiple degrees of freedom system using numerical techniques and know about various vibration measurement transducers and shakers
CLR-5:	Analyze the free vibration of distributed mass systems with continuous system principles
CLR-6:	Perform the free and forced vibration analysis of any mechanical systems with appropriate approaches

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 a vibrating system problem for different free and forced vibration response	1,2&3	85	75
CLO-2 :	Solve vibrating systems subjected to arbitrary forces, including impulse, step, and ramp forces	1,2&3	75	70
CLO-3 :	Compute the eigenvalues or natural frequencies of vibration and the modal vectors and determine the free-vibration solution using the known initial conditions	1,2&3	75	70
CLO-4 :	Find the approximate natural frequencies of vibration and the modal vectors by using various numerical techniques and understand the various types of transducers, vibration pickups, and frequency measuringinstruments and shakers	1,2&3	75	70
CLO-5:	Find the free-vibration solutions of string, bar, shaft and beam problems	1,2&3	75	70
CLO-6:	Solve free and forced vibration problems with appropriate techniques	1,2&3	75	70

Program Learning Outcomes (PLO)

CLO	1 Disciplinary Knowledge	2 Critical Thinking	3 Problem Solving	4 Analytical Reasoning	5 Research Skills	6 Team Work	7 Scientific Reasoning	8 Reflective Thinking	9 Self-Directed Learning	10 Multicultural Competence	11 Ethical Reasoning	12 Community Engagement	13 ICT Skills	14 Leadership Skills	15 Life Long Learning
CLO-1	H	H	H	H	H	L	H	H	H	L	L	L	M	M	H
CLO-2	H	H	H	H	H	L	H	H	H	L	L	L	M	M	H
CLO-3	H	H	H	H	H	L	H	H	H	L	L	L	M	M	H
CLO-4	H	H	H	H	H	L	H	H	H	L	L	L	M	M	H
CLO-5	H	H	H	H	H	L	H	H	H	L	L	L	M	M	H
CLO-6	H	H	H	H	H	L	H	H	H	L	L	L	M	M	H

		Fundamentals of Vibration in SDOF	Vibration under general forcing	Multiple DOF Systems	Natural frequency and modes of MDOF systemand vibration measurement	Continuous systems and Balancing
Duration (hour)		15	15	15	15	15
S-1	SLO-1	Basic concepts and Classifications of vibration	Fourier series and its applications	Introduction multi DOF system, examples	Orthogonality of normal modes	Introduction to continuous systems, Transverse Vibration of a String or Cable
	SLO-2	methodology of vibration analysis and parameters of a vibrating system	Response under general periodic forcing in first order systems	Equation of motion for a MDOF system using Newton's second law	Orthonormalization of Eigenvectors, modal matrix	Derivation of governing equation of free vibration of string and solution
S-2	SLO-1	Equation of motion and natural frequency of free undamped vibrating system using Newtons second law and principle of energy conservation	Response under general periodic forcing in second order systems	Free vibration analysis of undamped system with two DOF	Forced Vibration of Undamped Systems Using Modal Analysis	Derivation of governing equation of longitudinal vibration of a bar
	SLO-2	Free vibration of torsional system with single rotor, center of percussion	Problems on general periodic input	Determination of natural frequency and mode shape for a two DOF system	Problems on forced Vibration of Undamped Systems Using Modal Analysis	Solution of governing equation of longitudinal vibration of a bar
S-3	SLO-1	Damped free vibration, Types of damping	Response under general periodic force of irregular form	Free vibration response of undamped two DOF system	Determination of natural frequency using Dunkerley's formula	Normal functions, orthogonality of normal function
	SLO-2	Types of damped systems, logarithmic decrement, equation of motion of viscous, coulomb and hysteretic damping system, energy dissipation by damping	Problems with response under general periodic force of irregular form	Problems on free vibration response of undamped two DOF system	Determination of natural frequency using Rayleigh's method	Problems on above
S-4	SLO-1	Determination of natural frequency and damping ratio of a free vibrating system	Forced vibration response under general periodic forcing	Determination of natural frequency and mode shape for a MDOF system	Determination of natural frequency using Dunkerley's and Rayleigh's method	Determination of natural frequencies and modes of longitudinal vibration of bar, comparison with the results obtained by continuous system approach
	SLO-2					
S-5	SLO-1					
	SLO-2					
S-6	SLO-1	SDF system subjected to harmonic excitation	Response under general non-periodic forcing	Forced vibration response of undamped two DOF system	Determination of natural frequency using Holzer's method	Derivation of governing equation of torsional vibration of a shaft
	SLO-2	Response of undamped SDF systems with harmonic input	Convolution integral	Problems on force vibration response of undamped two DOF system	Problems using Holzer's method	Solution of governing equation of torsional vibration of a shaft
S-7	SLO-1	Response of damped SDF systems with harmonic input	Response due to an impulse, impulse response function	Coordinate coupling and principal coordinates	Determination of natural frequency using matrix iteration method	Problems on torsional vibration of a shaft

	SLO-2	Dynamic magnifier, Response of damped SDF system with rotating unbalance	Problems on impulse loading	Problems on pitch-bounce model		Problems on torsional vibration of a shaft
S-8	SLO-1	Solution using Laplace transform	Response due to general forcing function	Equation of motion for a MDOF system using Lagrange's equation	Problems using matrix iteration method	Derivation of governing equation of lateral vibration of a beam
	SLO-2	Self- excitation system, dynamic stability of the system	Problems on general forcing	Problems using Lagrange;s equation, torsional system with two and three rotors, semi definite systems		Solution of governing equation of lateral vibration of a beam
S-9	SLO-1	Simulation of forced vibration response of a SDF system	Forced vibration response under general non-periodic forcing function	Simulation of forced vibration response of a MDOF system	Determination of natural frequency using Holzer's method and matrix iteration method	Determination of natural frequencies and modes of lateral vibration of beam, comparison with the results obtained by continuous system approach
	SLO-2					
S-10	SLO-1					
	SLO-2					
S-11	SLO-1	Vibration isolation	Response spectrum of SDOF system under general forcing	Dynamic vibration absorbers	Vibration measurement, Variable-Resistance transducers	Balancing of Rotating Machines, Single-Plane balancing
	SLO-2	Forcetransmissibility	Examples on response spectrum of SDOF system under general forcing	Torsional dynamic absorbers	Piezoelectric transducers, Electrodynamic Transducers and LVDT	Problems on single plane balancing using vibration measurement
S-12	SLO-1	Support motion, base excitation	Response spectrum of SDOF system under general forcing	Influence coefficients, stiffness coefficients	Seismic instruments, vibration pickups, velometer, accelerometers	Two plane balancing using vibration measurement
	SLO-2	Displacement transmissibility using absolute and relative coordinates	Examples on response spectrum of SDOF system under general forcing	Flexibility coefficients, Maxwell's reciprocal theorem	Frequency-Measuring Instruments	
S-13	SLO-1	Whirling of shaft	Numerical solution for SDOF system under general forcing	Determination of stiffness matrix for lumped mass system and beams using influence coefficients	Vibration exciters, mechanical and electrodynamic shakers	Problems on two plane balancing
	SLO-2	Whirling of shaft	Example problems using Runge-kutta method	Eigen value problem, solution	Experimental modal analysis	
S-14	SLO-1	Determination of transmissibility of a SDOF system / Steady state response due to base excitation	Numerical solution for SDOF system under general forcing	Determination of natural frequency and mode shape for a MDOF system using eigen values and eigen vectors/ design of vibration absorber	Demonstration on machine condition monitoring techniques	Experimental Two plane balancing using balancing machines
	SLO-2					
S-15	SLO-1					
	SLO-2					

Learning Resources	1. Mechanical Vibration 5 th edition in SI units, Singiresu S. Rao, Pearson, 2011. 2. Fundamentals of mechanical vibrations 2nd edition, Kelly,Graham S., McGraw - Hill, 2000. 3. Thomson. W. T., "Theory of Vibration with Applications", CBS Publishers And Distributors, New Delhi, 1990	4. S. Graham Kelly & Shashidar K. Kudari, "Mechanical Vibrations", Tata McGraw–Hill Publishing Com. Ltd New Delhi,2007. 5. William, W. Seto - "Mechanical Vibrations" Schaum Publishing company 6. Vibration and Acoustics Measurement and Signal Analysis, C. Sujatha, Tata Mc Graw Hill Education Pvt Ltd., 2010. 7. Leonard Meirovitch, "Fundamentals of vibrations", McGraw Hill International Edition.

	Bloom's Level of Thinking	Continuous Learning Assessment (CLA) (60% weightage)					Final Examination (40% weightage)	
		CLA-1 (20%)		CLA-2 (25%)		CLA-3 (15%)		
		Theory	Practice	Theory	Practice		Theory	Practice
Level 1	Remember Understand	20%	20%	20%	20%	20%	20%	20%
Level 2	Apply Analyze	20%	20%	20%	20%	20%	20%	20%
Level 3	Evaluate Create	10%	10%	10%	10%	20%	10%	10%
	Total	100 %		100 %		100 %	100 %	

CLA – 3 can be from any combination of these: Assignments, Seminars, Tech Talks, 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. Rajendra Machavaram, rajendra@agfe.iitkgp.ac.in, IIT Kharagpur	Mr. KR. Arunprasath, SRMIST
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Course Code	20MEC504J	Course Name	OPTIMIZATION IN ENGINEERING DESIGN	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	Mechanical Engineering	Data Book / Codes/Standards	Nil		

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 modern methods of optimization
CLR-6 :	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 1 Level of Thinking (Bloom)	2 Expected Proficiency (%)	3 Expected Attainment (%)	1 Disciplinary Knowledge	2 Critical Thinking	3 Problem Solving	4 Analytical Reasoning	5 Research Skills	6 Team Work	7 Scientific Reasoning	8 Reflective Thinking	9 Self-Directed Learning	10 Multicultural Competence	11 Ethical Reasoning	12 Community Engagement	13 ICT Skills	14 Leadership Skills	15 Life Long Learning
CLO-1 :	Understand optimization principles and its need	1&2	90	85	H	M	H	H	H	L	H	M	M	L	L	L	M	L	H
CLO-2 :	Understand and apply the concept of conventional optimization techniques	1,2,3	90	85	H	H	H	H	H	L	H	M	M	L	L	L	M	L	H
CLO-3 :	Understand and apply the concept of constrained in single variable as well as multivariable	1,2,3	90	85	H	H	H	H	H	L	H	M	M	L	L	L	M	L	H
CLO-4 :	Understand and apply the concept unconventional optimization techniques	1,2,3	90	85	H	H	H	H	H	L	H	M	M	L	L	L	M	L	H
CLO-5 :	Understand and apply Modern Methods of Optimization	1,2,3	90	85	H	H	H	H	H	L	H	M	M	L	L	L	M	L	H
CLO-6 :	Apply the methods of optimization in real life situation	1,2,3	90	85	H	H	H	H	H	L	H	M	M	L	L	L	M	L	H

		Introduction optimization techniques	Classical Optimization Techniques	Multi variable and objective	Non-Traditional Optimization Techniques	Optimization in design of machine elements
Duration (hour)		15	15	15	15	15
S-1	SLO-1	Introduction to optimization	Techniques of unconstrained Optimization	Descent methods Gradient of a function	Genetic Algorithm introduction basic elements of natural genetics	Desirable and undesirable effects
	SLO-2	adequate and optimum design	General Approach golden section Fibonacci method	Evaluation of the gradient	reproduction crossover and mutation	
S-2	SLO-1	Principles of optimization	Rate of convergence scaling of design variables	Conjugate gradient method Fletcher -Reeves method	The computational procedure involved in optimizing the fitness function in Genetic Algorithm	Functional requirement
	SLO-2	design vector, design constraints				
S-3	SLO-1	Statement of an optimization problem	Direct search methods, Random jump method, Random walk method	Quasi -newton methods	Tutorials on genetic Algorithm	Material and geometrical parameters
	SLO-2		Random walk method with direction exploitation			
S-4	SLO-1	Practical: Introduction to MATLAB and its Optimization toolbox	Practical: Create optimization variable for each problem variable Create problem and objective	Practical: use of gradient evaluation function	Practical: Function GA tool at the command line, Fitness function, individuals, population and generations	Practical: on design optimization of shafts and torsionally loaded members
S-5	SLO-1					
S-6	SLO-1	Formulation of objective function	Grid search method	Transformation techniques	Simulated Annealing steps involved	Design of simple axial transverse loaded members for minimum cost and minimum weight
	SLO-2		Univariate method			
S-7	SLO-1	Design constraints	Pattern directions	Penalty function	Ant colony optimization	Problems on minimum weight design of a prismatic beam
	SLO-2		Hooke and Jeeves method			
S-8	SLO-1	Single variable optimization techniques	Powells method	Multi objective optimization	Graphical representation of ant colony optimization process	Design for linear and non-linear geometric problems helical springs
	SLO-2					
S-9	SLO-1	Practical: Solution method Choosing the Algorithms	Practical: Non-linear constraints with gradients	Practical: Multi-objective optimization Algorithms	Practical: Simulated Annealing solver Generating file	Practical: Linear and non-linear geometric problems helical springs
S-10	SLO-1					

S-11	SLO-1 SLO-2	Classical optimization for multivariable	Interpolation methods	Utility function method	Particle swarm optimization	Methods of Multi-Disciplinary Optimization
S-12	SLO-1 SLO-2	Basics of maxima and minima convex optimization	Quadratic interpolation method	Inverted utility function method	Swarm size information links initialization equation of motion	Methods of Multi-Disciplinary Optimization (MDO) with case studies in engineering
S-13	SLO-1 SLO-2	Important classes of convex optimization problems	Cubic interpolation method	Global criterion method Goal attainment method Bounded objective function method	Problems on particle swarm optimization	System identification problems with applications on structural health monitoring
S-14 S-15	SLO-1 SLO-2 SLO-1 SLO-2	Practical: Solve a constrained problem using optimization variable	Practical: Linear and quadratic programming problems	Practical: Multi-objective optimization algorithms Compare fminimax and fminunc Goal attainment method	Practical: Particle swarm optimization	Practical: Case studies in engineering

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 ofIndia 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,

	Bloom's Level of Thinking	Continuous Learning Assessment (CLA) (60% weightage)					Final Examination (40% weightage)	
		CLA-1 (20%)		CLA-2 (25%)		CLA-3 (15%)		
		Theory	Practice	Theory	Practice		Theory	Practice
Level 1	Remember Understand	20%	20%	20%	20%	Theory 30%	20%	20%
Level 2	Apply Analyze	20%	20%	20%	20%	40%	20%	20%
Level 3	Evaluate Create	10%	10%	10%	10%	30%	10%	10%
	Total	100 %		100 %		100 %	100 %	

CLA – 3 can be from any combination of these: Assignments, Seminars, Tech 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		Mr. Vamsi krishna dommeti , SRMIST

2. Professional Elective Courses (E)

Course Code	20MEE501T	Course Name	INTEGRATED PRODUCT DESIGN AND DEVELOPMENT	Course Category	E	*Professional Elective*	L	T	P	C
							4	0	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 the product design and development processes
CLR-2 :	Understand the phases of product development over the whole product design cycle
CLR-3 :	Understand the modules of architecture of a product
CLR-4 :	Understand the methodology for refining, enhancement and economics of design
CLR-5 :	Understand the forms and issues involved in protecting the rights of a designer
CLR-6 :	Understand the concept and complete process of product development and its 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 Disciplinary Knowledge	PLO 2 Critical Thinking	PLO 3 Problem Solving	PLO 4 Analytical Reasoning	PLO 5 Research Skills	PLO 6 Team Work	PLO 7 Scientific Reasoning	PLO 8 Reflective Thinking	PLO 9 Self-Directed Learning	PLO 10 Multicultural Competence	PLO 11 Ethical Reasoning	PLO 12 Community Engagement	PLO 13 ICT Skills	PLO 14 Leadership Skills	PLO 15 Life Long Learning
CLO-1 :	Identify and analyze the product design and development processes in any industry.	1	70	65	H	H	H	H	M	H	H	H	M	H	M	M	M	L	M
CLO-2 :	Define the phases of product development over the whole product design cycle	2	80	75	H	H	H	H	H	H	H	H	H	M	H	M	H	H	H
CLO-3 :	Undertake a methodical approach to evolve the architecture of a product	3	65	60	H	M	L	L	M	M	M	M	L	L	L	L	L	M	M
CLO-4 :	Carry out the process of refining and enhancing the design	3	75	70	H	H	H	H	L	M	H	M	H	M	M	M	H	M	H
CLO-5 :	Be familiar with the forms and issues involved in protecting the rights of a designer	2	70	65	L	L	L	L	L	L	L	L	M	L	M	M	L	M	M
CLO-6 :	Deliver newly designed or modified product based on customer needs	3	70	65	H	H	H	H	M	H	M	M	H	M	M	M	H	H	H

Duration (hour)		PRODUCT DEVELOPMENT PROCESS	CONCEPT GENERATION, EVALUATION AND SELECTION	PRODUCT ARCHITECTURE	INDUSTRIAL DESIGN AND DESIGN FOR X	PATENTS AND INTELLECTUAL PROPERTY RIGHTS
		12	12	12	12	12
S-1	SLO-1	Stages in product development	Problem decomposition	Implications of product architecture	Need for industrial design, impact of industrial design	Intellectual Property - types
	SLO-2					
S-2	SLO-1	Recognition of the need for product development	Search externally	Product change, Product variety	Industrial Design Process - Investigation, conceptualization, refinement of customer needs	Legislations coverings IPRs in India
	SLO-2					
S-3	SLO-1	Product Development Process	Search internally	Component Standardization, product performance, manufacturability	Management of the Industrial Design Process	Patent - Types of Patents
	SLO-2					
S-4	SLO-1	Tyco Product Development Process	Systematic exploration	Establishing the architecture – Creation and clustering	Technology driven and User driven products	Patentability criteria - International Patenting
	SLO-2					
S-5	SLO-1	Demand forecasting	Evaluating the solutions	Geometric layout development	Assessing the Quality of Industrial Design	Copy rights – trademark and service marks
	SLO-2					
S-6	SLO-1	understanding customer needs	Hybridizing concepts	fundamental and incidental interactions	Design for Manufacture	Trade secret- Geographical Indication
	SLO-2					
S-7	SLO-1	Data collection and interpretation	Concept selection	Delayed Differentiation	Design for Assembly and Maintenance	Industrial Designs – Plant varieties
	SLO-2					
S-8	SLO-1	Organizing the needs	Concept Screening	Platform Planning	Design for Economics	Preparing a disclosure
	SLO-2					
S-9	SLO-1	Customer involvement in refining the requirements	Concept Scoring	Related System-Level Design Issues	Design for Safety and reliability	Patents –- Product development economics
	SLO-2					
S-10	SLO-1	Conjoint Analysis	Concept Screening and Scoring – Case study	Related system level design issues — secondary systems	Product development economics	Elements of economic analysis- economic analysis process
	SLO-2					
S-11	SLO-1	Establish target specifications	Concept testing	Architecture of the chunks	Reducing the component costs and	Managing projects- project planning
	SLO-2					

					assembly costs	
S-12	SLO-1 SLO-2	Setting the Final Specifications	Concept testing – Case study	Creating detailed interface specifications	Minimize system complexity	Accelerating projects-project execution

Learning Resources	1. Karl Ulrich, Steven Eppinger, Maria C. Yang, “Product Design and Development”, 7th Edition, Mc Graw Hill Education, 2019. 2. Foundation Skills in Integrated Product Development (FSIPD), Student Handbook NASSCOM, 2013. 3. Imad Moustapha, “Concurrent Engineering in Product Design and Development”, New Age International publishers, 2003.	4. Stephen Rosenthal. "Effective Product Design and Development" Business One Orwin, Homewood 1992. ISBN.1-55632-603-4. 5. Staurt Pugh, "Tool Design — Integrated Methods for successful Product Engineering', Addison Wesley Publishing, New York, N.Y.1991. ISBN 0-202-41639-5.

	Bloom’s Level of Thinking	Continuous Learning Assessment (CLA) (60% weightage)					Final Examination (40% weightage)	
		CLA-1 (20%)		CLA-2 (25%)		CLA-3 (15%)		
		Theory	Practice	Theory	Practice		Theory	Practice
Level 1	Remember Understand	40%		20%		20%	20%	
Level 2	Apply Analyze	40%		40%		40%	35%	
Level 3	Evaluate Create	20%		40%		40%	45%	
	Total	100 %		100 %		100 %	100 %	

CLA – 3 can be from any combination of these: Assignments, Seminars, Tech Talks, 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. Mani S Manivasagam, Tata Technologies, Pune	*Dr. Jayakumar, Principal, Agni Institute of Technology, Chennai*	Prof. T.V. Gopal, SRMIST
2. Velmurugan Sivaraman, AGM, Ashok Leyland		*Dr. S.H. Venkatasubramanian, SRMIST*

Course Code	20MEE502J	Course Name	TRIBOLOGY IN DESIGN	Course Category	E	Professional Elective	L	T	P	C
							3	0	2	4

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 the surfaces and friction
CLR-2 :	Understand and analyze the wear mechanisms
CLR-3 :	Understand and analyze the lubricants and lubrication phenomenon
CLR-4 :	Understand and analyze bearings and select suitable materials
CLR-5:	Understand and analyze the surface engineering processes
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)	Learning 2 Expected Proficiency (%)	Learning 3 Expected Attainment (%)	1 Disciplinary Knowledge	2 Critical Thinking	3 Problem Solving	4 Analytical Reasoning	5 Research Skills	6 Team Work	7 Scientific Reasoning	8 Reflective Thinking	9 Self-Directed Learning	10 Multicultural competence	11 Ethical Reasoning	12 Community Engagement	13 ICT Skills	14 Leadership Skills	15 Life Long Learning
CLO-1 :	Understand friction and engineering surfaces	1&2	100	85	H	H	M	M	H	M	H	M	M	M	H	H	H	M	H
CLO-2 :	Apply the knowledge and analyze the failure occurred due to various types of wear	2&3	100	85	H	H	H	H	H	M	H	M	M	M	H	H	H	M	H
CLO-3 :	Apply the knowledge of lubrication to provide solutions	2&3	100	85	H	H	H	H	H	M	H	M	M	M	H	H	H	M	H
CLO-4 :	Apply the knowledge of bearings to provide solution	2&3	100	85	H	H	H	H	H	M	H	M	M	M	H	H	H	H	H
CLO-5:	Analyze various surface conditions and provide new ideas of surface protection techniques	2&3	100	85	H	H	H	H	H	M	H	M	M	M	H	H	H	H	H
CLO-6:	Investigate the failure of a system	2&3	100	85	H	H	H	H	H	H	H	M	M	M	M	H	H	H	H

		friction	Wear	Lubricants and lubrication	Bearings and Surface textures	Applications of Tribology
Duration (hour)		15	15	15	15	15
S-1	SLO-1	Introduction to the concept of tribology	Introduction, background of Wear and Types of Wear with applications.	Types of lubricants and their properties	Thrust bearings	Failure of engineering components due to fatigue
S-2	SLO-1	Engineering surfaces and surface topography	Abrasive wear	Stribeck Curve and its importance	Journal bearings	Failure of engineering components due to fracture
S-3	SLO-1	Measurement of surface topography and roughness parameters	Adhesive wear	Boundary and Mixed Lubrication regime	Rolling element bearings. Pad bearings	High temperature wear
S-4		Practical 1: Measuring the surface roughness using a profilometer	Practical-4: Investigating the wear properties of coper on steel tribo pairs -wet test	Practical 7: investigation the antiwear properties of lubricants using four ball tribometer – engine oil	Practical 10: Investigation the performance characteristics of journal bearings	Practical 13: A case study on failure of gears.
S-5						
S-6	SLO-1	Contact between surfaces, Sources of sliding Friction, Friction characteristics of metals and non-metals	Corrosive wear	Hydrodynamic lubrication	Introduction to Surface Texturing	Conventional surface treatments
S-7	SLO-1	Friction due to ploughing	Fatigue wear	Elasto hydrodynamic lubrication (EHL)	Surface texturing methods	Conventional coating techniques
S-8	SLO-1	Friction due to adhesion	Fretting wear	Importance of film thickness, Lambda ratio	Influence of surface textures on bearing performance	Advanced coating techniques

S-9 S-10		Practical 2: Investigating the frictional properties of steel on steel tribo pairs-dry test	Practical 5:Investigating the wear properties of copper on steel tribo pairs -wet test	Practical 8: Investigation of antiwear properties of lubricants using four ball tribometer – vegetable oil	Practical 11: Investigating the rolling contact fatigue of bearing steel using a four ball tribometer using gear oil at 75 degree Celsius	Practical 14: A case study on failure of high temperature coatings.
S-11	SLO-1	Friction of ceramic materials	Wear of metals	Bio degradable lubricants and nano lubricants	Role of surface textures in reducing friction and wear in dry conditions	Introduction to bio tribology
S-12	SLO-1	Friction of polymers	Wear in polymers	Coatings	Role of surface textures in reducing friction and wear in wet conditions	Wear of titanium alloys in bio tribology
S-13	SLO-1	Measurement of friction	Wear of ceramics	Self-lubricating coatings	Case study of surface textures in reducing friction and wear in pistons	Wear of biopolymers
S-14 S-15	SLO-1	Practical 3- Investigating the frictional properties of copper on steel tribo pairs -dry test	Practical 6: Investigating the wear properties of brass on steel tribo pairs -wet test	Practical 9: Investigating the extreme pressure properties using four ball tribometer	Practical 12: Investigation the rolling contact fatigue properties of lubricants using four ball tribometer at ambient temperature using a vegetable oil	Practical 15: A case study on wear of biomaterials

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. 8. Dieter G.E., " Mechanical Metallurgy", McGrawHill Publication, India, Third Edition, 2013.

	Bloom's Level of Thinking	*Continuous Learning Assessment (CLA) (60% weightage)*					*Final Examination (40% weightage)*	
		CLA-1 (20%)		*CLA-2 (25%)*		*CLA-3 (15%)*		
		Theory	*Practice*	*Theory*	*Practice*		*Theory*	*Practice*
Level 1	*Remember* *Understand*	*40%*	20	*30%*	20	*20%*	20%	20
Level 2	*Apply* *Analyze*	*40%*	20	*30%*	20	*40%*	40%	20
Level 3	*Evaluate* *Create*	*20%*	60	*40%*	60	*40%*	40%	60
	Total	*100 %*		*100 %*		*100 %*	*100 %*	

Course Designers		
Experts from Industry	Experts from Higher Technical Institutions	*Internal Experts*
Dr. Chiradeep Ghosh , Tata Steel chiradeep.ghosh@tatasteel.com	Dr.M. Kamaraj, Professor, IIT Madras	*Dr. Shubrajit Bhaumik, SRM IST ,*
Mr.Bharath Kumar, Rane NSK, bharathkumar@nsk.com		*Dr. TVVNL Rao, SRM IST*

Course Code	20MEE503T	Course Name	Advanced Mechanics of Solids	Course Category	E	Professional Elective	L	T	P	C
							3	1	0	4

Pre-requisite Courses		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
		Level of Thinking (Bloom)	Expected Proficiency (%)	Expected Attainment (%)	Disciplinary Knowledge	Critical Thinking	Problem Solving	Analytical Reasoning	Research Skills	Team Work	Scientific Reasoning	Reflective Thinking	Self-Directed Learning	Multicultural Competence	Ethical Reasoning	Community Engagement	ICT Skills	Leadership Skills	Life Long Learning
CLR-1 :	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 Be able to analyze effects of typical loadings on primary structural members using approximate or exact methods as applicable																		
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 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-5 :	Be able to Study the use of energy methods in structural analysis as an alternative means of solving a structural mechanics problem																		
CLR-6 :	Be able to build the ability to engage in independent learning, as required, in future																		
Course Learning Outcomes (CLO):	At the end of this course, after completion of required reading and understanding, learners will be able to:																		
CLO-1 :	Understand the primary difference between theory of elasticity and mechanics of materials approaches and solve plane stress and torsional problems	1, 2	90	75	H	H	H	H	M	L	M	M	H	L	L	L	L	L	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	H	H	M	L	M	M	H	L	L	L	L	L	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	H	H	M	L	M	M	H	L	L	L	L	L	H
CLO-4 :	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	H	H	M	L	M	M	H	L	L	L	L	L	H
CLO-5 :	Compute strain energy due to various loadings and using it to determine deflection	1, 2	90	75	H	H	H	H	M	L	M	M	H	L	L	L	L	L	H
CLO-6 :	Learn independently additional material as required in future	1,2	90	75	H	H	H	H	M	L	M	M	H	L	L	L	L	L	H

		Introduction to Theory of Elasticity & Its Applications	Bending of Straight & Curved Beams	Bending of flat thin plates	Stress & Strain Transformations	Energy Methods
Duration (hour)		12	12	12	12	12
S-1	SLO-1	Introduction – course overview, Equilibrium, compatibility, and constitutive relations in macroscopic form, simple problems for illustration, Definition of stress at a point in 3D, representation on	Bending Stresses 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	Concept of a tensor (in relation to a scalar and a vector), 2D stress transformation in Cartesian coordinate system using direction cosines – derivation of expressions	Work, Strain energy definition for linear, perfectly elastic materials; strain energy due to - uniaxial stress, additional normal stresses in other perpendicular directions, shear stress

	SLO-2	an element and sign convention		applications. Linear vs non-linear bending – definition. Derivation of governing equation for bending of a flat, thin, rectangular plate – outline of procedure		
S-2	SLO-1 SLO-2	Definition of strain based on small-displacement theory and strain tensor in 3D Cartesian coordinate system, equilibrium and compatibility relations in differential form in Cartesian coordinate system	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	Stress transformation problems in 2D– numerical problems and depiction of results (normal and shear stresses) on an element based on computation	strain energy due to - general state (3D) of stress, plane stress
S-3	SLO-1 SLO-2	Introduction to and comparison with mechanics of materials approach, definition of Plane stress and plane strain linear elastic problems, Airy's stress function - introduction	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	3D stress transformation in Cartesian coordinate system using direction cosines – relevant formulas as an extension based on derivation for 2D	Total strain energy in bars with simple loading conditions – axial loading, torsional loading of a solid circular bar, and transverse loading
S-4	SLO-1 SLO-2	Practice problems on use of equilibrium, compatibility, and constitutive relations	Practice problems on bending stress computation and location of neutral axis	Practice questions on concepts related to plates covered in the earlier lectures	Numerical problems for practice in stress transformation	Practice problems in strain energy computation – due to axial, torsional, and transverse loading
S-5	SLO-1 SLO-2	Airy's stress function in rectangular coordinates – derivation of the biharmonic equation	Deflection due to unsymmetrical bending; A quick review of shear stress in beams due to bending, shear stress computation in beams having rectangular sections	Solution due to sinusoidal bending load on a simply supported plate– step-by-step explanation	Concept of principal stresses, Derivation of characteristic equation for determination of principal stresses in 3D (after doing it for 2D), maximum shear stress	Castigliano's 1st theorem, example problems
S-6	SLO-1 SLO-2	simple problems related to axial loading of bars, bending of beams using Airy's stress function in rectangular coordinates	Intro to shear center, determination of shear center for a symmetrical channel section	Numerical problems on thin, flat rectangular plates – to compute moments and stresses based on given displacement function	Numerical problems (in 2D and 3D based on the above lectures)	brief overview of material non-linearity and plasticity;The complementary energy theorem, and Castigliano's 2nd theorem,
S-7	SLO-1 SLO-2	Additional illustrative problems related to bending of beams using Airy's stress function	determination of shear center for T, unequal I, sections, 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	strain transformation and principal strains in 2D & 3D for linear, homogeneous, isotropic material. Overview of the derivation to show the difference in approach compared to stress transformation and direct adaptation of stress transformation equations	Illustrative problems using Castigliano's 1st & 2nd theorems (for linear materials)
S-8	SLO-1 SLO-2	Practice problems on Airy's stress function	Numerical problems on deflection, location of shear center	Numerical problems for practice in determining deflection, moments, and stresses in flat plates due to bending given displacement function	Numerical problems for practice on determination of principal stresses, maximum shear stress, and orientation of principal axes	Practice problems in the use of Castigliano's theorem(s)
S-9	SLO-1 SLO-2	overview of torsion of structural members having non-circular sections, Prandtl stress function for torsion, derivation of Poisson's equation (using Prandtl stress function)	Derivation of circumferential stress expression	Continued from previous lecture - use of strain-displacement, stress-strain, and equilibrium relations in derivation of governing equation (for bending)	Numerical problems on 3D strain computation, transformation, and determination of principal strains	Rayleigh's method, example problem of beam bending deflection
S-10	SLO-1 SLO-2	Membrane analogy, brief discussion of torsion of rectangular cross section	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	Numerical problems on stress-to-strain and strain-to-stress computation using constitutive relations, transformation, and determination of principal strains/stresses	Rayleigh-Ritz method applied to beams in bending
S-11	SLO-1 SLO-2	torsional stress in hollow closed thin-walled (single cell) tubes – overview and expressions for shear stress and angle of twist	Additional illustrative problems on determination of circumferential stresses (rectangular and square sections); a brief intro (only) to radial stresses in curved beams	Illustrative problems on bending of flat, thin, axi-symmetric circular plates - to compute moments and stresses based on given displacement function	Overview of Maximum principal stress, principal strain, maximum shear stress therories of failure , illustrative examples	Illustrative problems based on Rayleigh-Ritz method
S-12	SLO-1	Practice problems on torsion	Practice problems on determination of	Practice questions/problems on concepts	Numerical problems on strain	Numerical problems for practice in the use

	SLO-2		circumferential stress in curved beams	related to axi-symmetric circular plate bending and determination of related parameters	transformation, determination of principal stress/strain using constitutive relations	of Rayleigh-Ritz method

Learning Resources	1. Arthur Boresi and Richardh 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; 5th ed.,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

	Bloom's Level of Thinking	Continuous Learning Assessment (CLA) (60% weightage)					Final Examination (40% weightage)	
		CLA-1 (20%)		CLA-2 (25%)		CLA-3 (15%)		
		Theory	Practice	Theory	Practice		Theory	Practice
Level 1	Remember Understand	20		20			20	
Level 2	Apply Analyze	80		80		100	80	
Level 3	Evaluate Create							
	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	Dr Joel George M, Asst. Prof., Aerospace Engg, IIT Madras	Dr S H Venkatasubramanian, Visiting Professor, Dept of Mechanical Engg., SRMIST
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Course	*20MEE504T*	Course		Course	*E*	*Professional Elective*	L	T	P	C

Code		Name	Mechanical Behavior of Engineering Materials	Category			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 :	*Be familiar with the structure and properties*
CLR-2 :	*Be familiar with tension and torsion*
CLR-3 :	*Know about fatigue*
CLR-4 :	*Know about creep*
CLR-5 :	*Be familiar with fracture mechanics*
CLR-6 :	*Know about the mechanical behavior of materials*

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 (%)	Disciplinary Knowledge	Critical Thinking	Problem Solving	Analytical Reasoning	Research Skills	Team Work	Scientific Reasoning	Reflective Thinking	Self-Directed Learning	Multicultural Competence	Ethical Reasoning	Community Engagement	ICT Skills	Leadership Skills	Life Long Learning
CLO-1 :	*Recognize and analyze the structure and properties*	*1& 2*	*90*	*85*	*H*	*H*	*M*	*M*	*L*	*-*	*M*	*-*	*-*	*-*	*-*	*-*	*-*	*-*	*M*
CLO-2 :	*Acquire knowledge on tension and torsion*	*1& 2*	*90*	*85*	*H*	*H*	*M*	*L*	*M*	*-*	*L*	*-*	*-*	*-*	*-*	*-*	*-*	*-*	*M*
CLO-3 :	*Acquire knowledge on fatigue*	*1& 2*	*90*	*85*	*H*	*M*	*M*	*M*	*L*	*-*	*L*	*-*	*-*	*-*	*-*	*-*	*-*	*-*	*M*
CLO-4 :	*Acquire knowledge on creep*	*1& 2*	*90*	*85*	*H*	*H*	*L*	*M*	*L*	*-*	*L*	*-*	*-*	*-*	*-*	*-*	*-*	*-*	*L*
CLO-5 :	*Understandfracture mechanics*	*1& 2*	*90*	*85*	*H*	*H*	*H*	*M*	*M*	*-*	*M*	*-*	*-*	*-*	*-*	*-*	*-*	*-*	*H*
CLO-6 :	*Acquire knowledge about mechanical behavior of engineering materials*	*1& 2*	*90*	*85*	*H*	*H*	*H*	*M*	*M*	*-*	*M*	*-*	*-*	*-*	*-*	*-*	*-*	*-*	*M*

		Structure and Properties	**Tension & Torsion**	**Fatigue**	**Creep**	**Fracture and Fracture Mechanics**
Duration (hour)		**12**	**12**	**12**	**12**	**12**
S-1	**SLO-1**	***Crystal Structures***	***Stress - Strain curve***	*Fatigue phenomena*	***Description of creep***	***Types of fracture***
	SLO-2	***Crystallographic planes & directions***				
S-2	**SLO-1**	***Defects in crystals***	*Measures of yielding*	*Theories of fatigue failure*	***Creep curve, Stress-rupture test***	***Theoretical strength of a solid***
	SLO-2					
S-3	**SLO-1**	***Crystal anisotropy***	***Measures of ductility, Toughness***	*Evaluation of fatigue resistance*	***Creep mechanisms***	***Griffith's Theory***
	SLO-2	***Microstructure***				
S-4	**SLO-1**	***Deformation***	***Strain hardening exponent***	*Methods of presenting fatigue data*	***Dislocation glide, Diffusion flow***	***Irwin - Orowan Theory - crack propagation Modes***
	SLO-2	***Dislocation & Twining***	***Strain rate sensitivity***			
S-5	**SLO-1**	***Dislocation – generation & multiplication***	***Anisotropy***	*Fatigue crake propagation*	***Dislocation and Diffusion***	*Dislocation Theories of Brittle fracture*
	SLO-2	***Dislocation – annihilation***				
S-6	**SLO-1**	***Dislocation – Interaction***	***Mechanical properties in torsion***	*Parameters influencing fatigue*	***Creep in two phase alloys***	*Ductile fracture*
	SLO-2	***Dislocation – Mechanical properties***				
S-7	**SLO-1**	***Strengthening mechanisms***	***Tensile test***	*Cyclic stress strain behavior*	*Deformation Mechanism Maps*	*Analysis of crack propagation*
	SLO-2	***Grain boundary strengthening***	***Compression test***			

S-8	SLO-1	***Strain hardening***	***Types of torsion failures***	*Design against fatigue*	*Materials aspects creep design*	*Stress intensity factor*
	SLO-2		***Torsion test***			
S-9	SLO-1	***Solid solution hardening***	***Method of measuring shear stress***	*Low cycle fatigue*	*Estimates of creep behavior*	*Crack opening displacement*
	SLO-2					
S-10	SLO-1	***Precipitation hardening***	***Hardness***	*Fatigue failure of metals*	*Presentation of Engineering creep data Super plasticity*	*J integrals - Fracture toughness measurement methods*
	SLO-2		***Micro-hardness***			
S-11	SLO-1	***Martensitic strengthening***	***Nano-indentation***	*Fatigue of ceramics*	*Creep fracture*	*Material behaviour during crack propagation*
	SLO-2	***Texture hardening***				
S-12	SLO-1	***Strengthening in composite materials***	*Analysing nano-indentation results*	*Fatigue of polymers*	*Increasing the creep resistance*	*Measuring elastic-plastic fracture mechanics parameters*
	SLO-2					

Learning Resources	*1. George E. Dieter, "Mechanical Metallurgy", McGraw Hill,1988*	*3. Joachim Roesler, Harald Harders, Martin Baeker, Mechanical Behaviour of Engineering Materials, Springer, 2007*
	2. Thomas H. Courtney, "Mechanical Behaviour of Materials", McGraw Hill 2000	*4. Joseph Marin, "Mechanical Behaviour of Engineering Materials", Prentice-Hall of India Pvt. Ltd., 1966*

	Bloom's Level of Thinking	*Continuous Learning Assessment (CLA) (60% weightage)*					*Final Examination (40% weightage)*	
		CLA-1 (20%)		*CLA-2 (25%)*		*CLA-3 (15%)*		
		Theory	*Practice*	*Theory*	*Practice*		*Theory*	*Practice*
Level 1	*Remember* *Understand*	*40%*	*--*	*30%*	*--*	*30%*	*30%*	*--*
Level 2	*Apply* *Analyze*	*40%*	*--*	*50%*	*--*	*50%*	*50%*	*--*
Level 3	*Evaluate* *Create*	*20%*	*--*	*20%*	*--*	*20%*	*20%*	*--*
	Total	*100 %*		*100 %*		*100 %*	*100 %*	

CLA –3 can be from any combination of these: Assignments, Seminars, Tech Talks, 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, SRM IST*
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Course Code	*20MEE505J*	*Course Name*	COMPUTER GRAPHICS AND VIRTUAL REALITY	**Course Category**	*E*	*Professional Elective*	L	T	P	C
							3	*0*	*2*	*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 :	*Be familiar with the basics of computer graphics and its components*
CLR-2 :	*Be familiar with the complete knowledge of 2D and 3D graphics*
CLR-3 :	*Be familiar with the curves and surfaces*
CLR-4 :	*Be familiar with the graphical kernel system and graphics exchanges standards*
CLR-5 :	*Be familiar with the concepts of virtual reality and augmented reality*
CLR-6 :	*Conceive the knowledge on graphics and associated topics with introduction to VR&AR.*

Course Learning Outcomes (CLO):	*At the end of this course, learners will be able to:*	Learning: Level of Thinking (Bloom)	Expected Proficiency (%)	Expected Attainment (%)	PLO 1 Disciplinary Knowledge	PLO 2 Critical Thinking	PLO 3 Problem Solving	PLO 4 Analytical Reasoning	PLO 5 Research Skills	PLO 6 Team Work	PLO 7 Scientific Reasoning	PLO 8 Reflective Thinking	PLO 9 Self-Directed Learning	PLO 10 Multicultural Competence	PLO 11 Ethical Reasoning	PLO 12 Community Engagement	PLO 13 ICT Skills	PLO 14 Leadership Skills	PLO 15 Life Long Learning
CLO-1 :	*Understanding the history and development in the computer graphics, and solve 2D&3D transformations*	*1*	*85*	*75*	*H*	*H*	*M*	*H*	*H*	*H*	*H*	*H*	*H*	*L*	*L*	*M*	*H*	*L*	*H*
CLO-2 :	*Understanding the 2D and 3D rendering pipeline*	*1,2*	*80*	*70*	*H*	*M*	*H*	*H*	*H*	*H*	*H*	*H*	*H*	*L*	*L*	*M*	*H*	*L*	*H*
CLO-3 :	*Apply curves and surfaces to create surface modeling for various application.*	*2,3*	*80*	*70*	*H*	*H*	*H*	*H*	*H*	*H*	*H*	*H*	*H*	*L*	*L*	*H*	*H*	*L*	*H*
CLO-4 :	*Create data exchange files to communicate between graphics system*	*1,3*	*75*	*70*	*H*	*H*	*H*	*H*	*H*	*L*	*H*	*H*	*H*	*L*	*L*	*H*	*H*	*L*	*H*
CLO-5 :	*Understanding how virtual reality and augmented reality adds digital elements to a live view for better experience*	*1,2*	*75*	*70*	*H*	*H*	*M*	*H*	*H*	*H*	*H*	*H*	*H*	*L*	*L*	*H*	*H*	*L*	*H*
CLO-6 :	*Understanding the knowledge on computer graphics and connected topics to apply and create graphic system*	*1,2,3*	*75*	*70*	*H*	*H*	*H*	*H*	*H*	*M*	*H*	*H*	*H*	*L*	*L*	*H*	*H*	*L*	*H*

		Introduction to Computer Graphics	*Two and Three Dimensional Graphics*	*Curves and Surfaces*	*Graphics Standards and Open GL*	*Virtual and Augmented Reality*
Duration (hour)		*15*	*15*	*15*	*15*	*15*
S-1	*SLO-1*	*History of Computer Graphics*	*2D viewing – viewing pipeline, viewing coordinate reference frame*	*Introduction to curve and its types*	*Introduction to Graphic Kernel System, Initial Graphics Exchange Specification (IGES)*	*Virtual vs Interactive vs Immersive, Virtual Reality (VR) vs Augmented Reality (AR), Real vs Virtual.*
S-2	*SLO-1*	*Video Display Devices, Raster Scan and Random Scan Systems*	*Window-to-viewport coordinate transformation, Two dimensional viewing functions*	*Hermite curves*	*Standard for the Exchange of Product Model Data (STEP), Drawing Interchange Format, or Drawing Exchange Format (DXF)*	*Benefits of VR: 3D Visualization, Navigation, Interaction, Physical Simulation, Virtual environments.*
S-3	*SLO-1*	*Graphics monitors and Workstations, Input devices, Hard copy Devices, Graphics Software*	*Clipping operations – point, line*	*Bezier curves*	*Continuous Acquisition and Life-cycle Support (CALS), Stereo Lithography (STL)*	*VR Hardware: Computers, Tracking Devices, Input Devices, Output Devices, Glasses, Displays, Audio.*
S-4	*SLO-1*	*Demo on Graphic Systems*	*Exercise on Clipping operations*	*Exercise on curve generation*	*Exercise on data exchange*	*Exercise on VR*
S-5						
S-6	*SLO-1*	*Output primitives – points and lines, line function and line drawing algorithms (DDA & Bresenham's algorithm)*	*Polygon clipping algorithms, Scan Conversion*	*B-Spline*	*Communication Standards - LAN*	*Head Mounted Display (HMD), Motion Trackers*
S-7	*SLO-1*	*circle generating algorithms (mid-point circle algorithm), Loading the frame buffer*	*3D viewing - viewing pipeline, viewing coordinates*	*Rational*	*Communication Standards – WAN. P2P*	*BOOM, CAVE, Sensor Glove, Haptic Feedback devices.*
S-8	*SLO-1*	*Pixel addressing and object geometry, filled area primitives.*	*Projections, Clipping*	*Surface Modeling techniques – Coons patch*	*Open GL – Features in OpenGL, OpenGL operations, Abstractions in OpenGL – GL, GLU & GLUT*	*VR Software: VR Software Features, Web-Based VR, Division's dVISE*
S-9	*SLO-1*	*Exercise on Line & circle drawing algorithms*	*Exercise on Projections*	*Exercise on curve generation*	*Exercise on data exchange*	*Exercise on VR/AR*
S-10						
S-11	*SLO-1*	*2D Transformation - Translation, Rotation, Scaling, composite transformations.*	*Hidden line removal algorithms*	*Bi-cubic patch*	*Input and Interaction in OpenGL*	*Blueberry3D, Boston Dynamics, MultiGen*

S-12	SLO-1	3D Transformation - Translation, Rotation, Scaling, composite transformations.	Hidden surface removal algorithms	Bezier surfaces	3D viewing pipeline in OpenGL	VR and AR Applications: Industrial, Training Simulators, Entertainment
S-13	SLO-1	Composite Transformations	Algorithms for shading and rendering.	B-spline surfaces	Viewing matrix (model-view matrix) specifications	VR/AR Centres
S-14 S-15	SLO-1	Exercise on 2D & 3D transformation	Exercise on Shading and Rendering	Exercise on Surface generation	Exercise on open GL programming	Exercise on VR/AR

Learning Resources	1. Edward Angel and Dave Shreiner, "Interactive Computer Graphics – A Top-down Approach with Shader-Based OpenGL", 6th Edition, Addison Wesley.2012 2. Kunwoo Lee "Principles of CAD/CAM/CAE Systems", Addison Wesley. 1999. 3. Chris McMahon, Jimmie Browne, "CADCAM: Principles, Practice and Manufacturing Management", 2nd Edition, Addison Wesley, 2018. 4. Zeid, Ibrahim. CAD/CAM theory and practice. McGraw Hill, International Edition, 1998.	5. J. D. Foley, A. Van Dam, S. K. Feiner and J. F. Hughes, Computer Graphics – Principles and Practice, 2nd Edition in C, Pearson Education, 2003. 6. D. F. Rogers and J. A. Adams, Mathematical Elements for Computer Graphics, 2nd Edition, McGraw Hill, International Edition, 1990. 7. John Vince, "Introduction to Virtual Reality", Springer-Verlag London, 2004. 8. Gregory Kipper, Joseph Rampolla, "Augmented Reality – An Emerging Technologies Guide to AR", Syngress, 2012.

	Bloom's Level of Thinking	Continuous Learning Assessment (CLA) (60% weightage)					Final Examination (40% weightage)	
		CLA-1 (20%)		CLA-2 (25%)		CLA-3 (15%)		
		Theory	Practice	Theory	Practice		Theory	Practice
Level 1	Remember Understand	20%	20%	20%	20%	20%	20%	20%
Level 2	Apply Analyze	20%	20%	20%	20%	20%	20%	20%
Level 3	Evaluate Create	10%	10%	10%	10%	20%	10%	10%
	Total	100 %		100 %		100 %	100 %	

CLA – 3 can be from any combination of these: Assignments, Seminars, Tech 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. Balamurugan, iRCS, Bangalore	Dr. Seung Nam Min, Shinsung University, South Korea	Dr. T. V. Gopal, SRM IST
	Dr. Kyung-sun Lee, Catholic University, Busan	Dr. S. Murali, SRM IST

Course Code	20MEE506T	Course Name	BIOMECHANICS	Course Category	E	Professional Elective	L	T	P	C
							4	0	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 the fundamental of muscular and skeletal systems
CLR-2 :	To Understand the principles of mechanics muscular and skeletal systems
CLR-3 :	To Understand the mechanics of soft tissues
CLR-4 :	Experimental and computational tools in biomechanics
CLR-5 :	Applications in Biomechanics
CLR-6	To study about the bone structure and functions of skeletal muscle

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 (%)	Disciplinary Knowledge	Critical Thinking	Problem Solving	Analytical Reasoning	Research Skills	Team Work	Scientific Reasoning	Reflective Thinking	Self-Directed Learning	Multicultural Competence	Ethical Reasoning	Community Engagement	ICT Skills	Leadership Skills	Life Long Learning
CLO-1 :	To familiarize the students with the anatomical structure of the human body	1& 2	90	85	H	H	H	H	H	L	H	H	H	H	H	M	H	L	H
CLO-2 :	To familiarize the students with the reference positions, planes, and axes associated with the human body	1	85	80	H	H	H	H	H	L	H	H	H	H	H	M	H	L	H
CLO-3 :	Understand and quantify the Muscle-Tendon Function	1	85	80	H	H	H	H	H	L	H	H	H	H	H	M	H	L	H
CLO-4 :	To understand how to test the biological specimens and human body in a laboratory environment	1&2	85	80	H	H	H	H	H	L	H	H	H	H	H	M	H	L	H
CLO-5 :	To understand the application of Biomechanics and apply biomechanics knowledge to real-world problems	1&2	85	80	H	H	H	H	H	L	H	H	H	H	H	M	H	L	H
CLO-6 :	To understand the skeletal function and biomechanics	1&2	85	80	H	H	H	H	H	L	H	H	H	H	H	M	H	L	H

Duration (hour)		12	12	12	12	12
S-1	SLO-1	Biomechanics: definition and perspective	Standard reference terminology and anatomical reference position	Musculoskeletal Soft Tissue Mechanics	Experimental testing in Biomechanics	Biomechanics in Ergonomics Theories of occupational musculoskeletal injury causation
S-2	SLO-1	Quantitative versus qualitative problems	Directional terms, anatomical reference planes and axes joint movement terminology	Structure of Soft Tissue Cartilage, Tendon and Ligament, Muscle.	Biomechanical testing instruments	Biomechanics in work seating design - biomechanics during ladder and stair climbing and walking on ramps.
S-3	SLO-1	Solving Formal Quantitative Problems	Sagittal plane, frontal plane, transverse plane and other movements and spatial reference systems	Composition of tendons and ligaments Mechanical properties	Problems in testing , repeatability , reproducibility , reliability of results	Injury biomechanics and rehabilitation
S-4	SLO-1	Structure, movements and loads on the shoulder.	Equilibrium and Torque , Resultant Joint Torques	Determination of stress and strain, stress - strain curve for tendons and ligaments	Pit falls of biomechanical testing	Orthotics and prosthetics
S-5	SLO-1	Structure, movements and loads on the wrist	Levers Anatomical levers,	Material Properties Cartilage, Tendon.	Computational methods in biomechanics	Biomaterials for implant design
S-6	SLO-1	Structure, movements and loads on the elbow.	Bone behavior under various loads tension compression shear	Material Properties Ligament, Muscle.	Loading and results in computational studies	Sports biomechanics- Qualitative analysis of kicking technique
S-7	SLO-1	Structure, movements and loads on the hip	Basic concepts related to kinetics, inertia,mass,force	Joint Architecture, Synovial joint and loads in joints	Tools for Measuring Body Angles	Qualitative analysis of batting
S-8	SLO-1	Structure, movements and loads on the knee	Centre of gravity ,weight ,pressure volume, density, torque, impulse	Behavioural properties of the Musculotendinous unit	Tools for measuring kinematic quantities video and film	Qualitative analysis of the basketball free throw
S-9	SLO-1	Structure, movements and loads on the spine	Locating the human body Center of Gravity, Stability and balance, Gait analysis.	Factors affecting muscular Force generation	Other movement-monitoring systems.	Qualitative analysis of squat technique
S-10	SLO-1	Structure, movements and loads on the foot	Properties of Bone, Maxwell & Voight Models of bone	Mechanical characteristics Of muscle Force–velocity relationship	Stride and Temporal Parameters , Motion Measurement,	Qualitative analysis of drop jumps
S-11	SLO-1	Common injuries in shoulder, elbow wrist	Common Bone Injuries	Mechanical characteristics Of muscle Force–length relationship	Ground Reaction Measurement Dynamic Electromyography (EMG)	Cardiac Biomechanics ,Cardiovascular biomechanics,
S-12	SLO-1	Common injuries in hip knee, spine and foot.	Forms of motion -linear motion, angular motion general motion and mechanical systems	Mechanical characteristics Of muscle Force–time relationship	Challenges in - In vitro, In vivo and in silco study a and comparison	Mechanics of Blood Vessels, Dental Biomechanics

Learning Resources	1. . Susan .J. Hall, —Basic biomechanics", Tata Mcgraw Hill, Sixth edition, 2011 2. Y. C. Fung, Biomechanics - Circulation 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. (1996). Biomechanics: A Qualitative Approach for Studying HumanMovement 5. 5.Dr.Ajay Bahi and Dr.Sharad Ranga- Basics of Biomechanics, Jaypee brothers medical publication (P) Ltd.

	Bloom's Level of Thinking	Continuous Learning Assessment (CLA) (60% weightage)					Final Examination (40% weightage)	
		CLA-1 (20%)		CLA-2 (25%)		CLA-3 (15%)		
		Theory	Practice	Theory	Practice		Theory	Practice
Level 1	Remember Understand	20%	20%	20%	20%	20%	20%	20%
Level 2	Apply Analyze	20%	20%	20%	20%	20%	20%	20%
Level 3	Evaluate Create	10%	10%	10%	10%	20%	10%	10%
	Total	100 %		100 %		100 %	100 %	

CLA – 3 can be from any combination of these: Assignments, Seminars, Tech Talks, 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. Amit Roy Chowdhury, amit@aero.iiests.ac.in, IISER Shibpur	Mr.P.Susai Manickam, SRMIST
2. Dr.A.Velayutham, DRDO, Avadi, vel_sivam@yahoo.com		Mr. D. Raja, SRMIST

Course Code	20MEE601T	**Course Name**	ADVANCED FINITE ELEMENT ANALYSIS	**Course Category**	E	Professional Elective	L	T	P	C
							4	0	0	4

Pre-requisite Courses	20MEC502J	**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 aware in basic theory of Bending of plates and shells*
CLR-2 :	*Be aware in Formulation of the Continuum Mechanics*
CLR-3 :	*Be aware in Nonlinear equations in dynamic analysis*
CLR-4 :	*Be aware in concept of Finite Element Analysis of Heat Transfer*
CLR-5 :	*Be aware in concept of Finite Element Analysis of Incompressible Fluid Flows*
CLR-6 :	*Be aware in Error estimation and shear locking phenomena*

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 Disciplinary Knowledge	PLO 2 Critical Thinking	PLO 3 Problem Solving	PLO 4 Analytical Reasoning	PLO 5 Research Skills	PLO 6 Team Work	PLO 7 Scientific Reasoning	PLO 8 Reflective Thinking	PLO 9 Self-Directed Learning	PLO 10 Multicultural Competence	PLO 11 Ethical Reasoning	PLO 12 Community Engagement	PLO 13 ICT Skills	PLO 14 Leadership Skills	PLO 15 Life Long Learning
CLO-1 :	*Understand the Classical and Mindlin theory*	*H*	*85*	*75*	*H*	*H*	*H*	*H*	*H*	*L*	*H*	*H*	*H*	*L*	*L*	*L*	*H*	*L*	*H*
CLO-2 :	*Understand the Non-linear analysis of bar and beams*	*H*	*75*	*70*	*H*	*H*	*H*	*H*	*H*	*L*	*H*	*H*	*H*	*L*	*L*	*L*	*H*	*L*	*H*
CLO-3 :	*Understand the non-linear dynamics problems and numerical techniques*	*H*	*75*	*70*	*H*	*H*	*H*	*H*	*H*	*L*	*H*	*H*	*H*	*L*	*L*	*L*	*H*	*L*	*H*
CLO-4 :	*Understand the Basic concept of non-linear Finite Element Analysis of Heat Transfer, and Incompressible Fluid Flows*	*H*	*75*	*70*	*H*	*H*	*H*	*H*	*H*	*L*	*H*	*H*	*H*	*L*	*L*	*L*	*H*	*L*	*H*
CLO-5 :	*Understand the error and rate of convergence study*	*H*	*75*	*70*	*H*	*H*	*H*	*H*	*H*	*L*	*H*	*H*	*H*	*L*	*L*	*L*	*H*	*L*	*H*
CLO-6 :	Understand the shear locking zero-energy modes for finite elements	*H*	*75*	*70*	*H*	*H*	*H*	*H*	*H*	*L*	*H*	*H*	*H*	*L*	*L*	*L*	*H*	*L*	*H*

		BENDING OF PLATES AND SHELLS	NON – LINEAR STATIC ANALYSIS OF BARS AND BEAMS	DYNAMIC ANALYSIS	FLUID MECHANICS AND HEAT TRANSFER ANALYSIS	ERROR ESTIMATES, CONVERGENCE, ZERO-ENERGY MODE AND ADAPTIVE REFINEMENT
Duration (hour)		**12**	**12**	**12**	**12**	**12**
S-1	**SLO-1**	***Bending of Plates-*** *Basic concept of Finite Element Method*	*Nonlinear Problems- Introduction-Types of Nonlinearities-*	*Introduction-Dynamic equations-Mass and Damping matrices*	*Basic concept of Finite Element Analysis of Heat Transfer, Field Problemsand Incompressible Fluid Flows*	Shear locking and its remedy for triangular and quadrilateral elements
	SLO-2					
S-2	**SLO-1**	*Basic concept of Classical plate and Shear deformable plate theory Confirming and non-Confirming Elements*	Formulation of the Continuum Mechanics Incremental Equations of Motion - *The Basic Problem, -The Deformation Gradient, Strain, and Stress Tensors,*	*Natural frequencies-and modes Damping-Proportional damping-modal damping*	*Heat Transfer Analysis -Governing Heat Transfer Equations- Incremental Equations-Finite Element Discretization of Heat Transfer Equations*	Rate of convergence and types of error norms triangular and quadrilateral elements
	SLO-2					
S-3	**SLO-1**	*Simple examples to Basic concept of Classical plate*	Simple examples- *Basic Problem, -The Deformation Gradient, Strain, and Stress Tensors,*	*Simple example- Natural frequencies-and modes Damping*	*Simple examples –formulation of non-linear heat transfer analysis*	zero- energy mode triangular and quadrilateral elements
	SLO-2					
S-4	**SLO-1**	*Bending of plate model-Displacement model and Finite Element model- Co and C1 Continuity –Elements*	*Displacement based Isoparametric Continuum Finite Elements-Truss and bar elements*	*Mass matrices – Particle mass lumping and Consistent mass matrices*	*Numerical examples to simple nonlinear heat transfer problems*	**Computer coding/ FEM existing software** Assembly of elements and load calculation for non-linear FEM USING direct iteration
	SLO-2					
S-5	**SLO-1**	*plate model- to sample problems – solution by hand*	*Elastic Material behavior-Rubber like material-Basic concept of Inelastic material -Visco Plasticity-Formulation*	*Direct Integration methods-Central difference method-Houbolt method-Newmark Methods*	*Numerical examples to nonlinear heat transfer problems using triangular elements*	**Computer coding/ FEM existing software** Assembly of elements and load calculation for non-linear FEM using Newton's Methods
	SLO-2					
S-6	**SLO-1**	*plate model- to sample problems – solution by hand*	*Elastic Material behavior-Rubber like material-Basic concept of Inelastic material -Visco Plasticity-Formulation*	*Direct Integration methods-Central difference method-Houbolt method-Newmark Methods*	*Numerical examples to nonlinear heat transfer problems using rectangular*	Assembly of elements and load calculation for non-linear FEM using Newton's Methods
	SLO-2					
S-7	**SLO-1**	*Classical plate model- to sample problems – solution by hand*	*Procedure to Tangent Stiffness matrix formulation Numerical Examples-by hand calculation*	*Mode superposition- Change of basis to modal generalized displacement-with damping and without damping*	*Numerical examples to nonlinear heat transfer problems using rectangular*	**Introduction to viscous ow problems** Governing equations
	SLO-2					
S-8	**SLO-1**	*Introduction to shells-Circular Arches and Arch Elements*	*Numerical Examples-by hand calculation*	*Numerical Examples-by hand calculation*	*Analysis of incompressible fluid flow-Finite element Governing equations*	Weak Formulation to Mixed nite element model (2D)
	SLO-2					

S-9	**SLO-1**	*Shells of Revolution-Thin shell-Mindlin shell formulation*	*Large deflection bending of bars and beams*	*Basic concept and Solution to Nonlinear equations in dynamic analysis*	*Simple example-Solution to Navier-stroke equation using weighted residual method*	Numerical examples using in-house coding/ **FEM existing software**
	SLO-2					
S-10	**SLO-1**	*General Isoparametric formulation-Three and four node shell elements -sample Examples*	Basic concept of Geometric Non linearity - Large displacement Formulation-Green strain-Corotational Formulation	*Basic concept of Explicit integration-Implicit Integration-mode superposition method*	*Basic concept of fluid –structure interactions*	Weak Formulation to Penalty nite element model (2D)
	SLO-2					
S-11	**SLO-1**	*Three and four node shell elements -sample Examples*	*Application in Metal Forming Process & Contact Problems. Numerical Examples-by hand calculation*	*Basic concept of Explicit integration-Implicit Integration-mode superposition method*	*Numerical examples to simple heat transfer and fluid mechanics problems*	Numerical examples using in-house coding/ **FEM existing software**
	SLO-2					
S-12	**SLO-1**	*Four node shell elements -sample Examples*	*Application in Metal Forming Process & Contact Problems. Numerical Examples-by hand calculation*	*Numerical examples like simple pendulum, cantilever beam*	*Numerical examples to simple heat transfer and fluid mechanics problems*	Numerical examples using in-house coding/ **FEM existing software**
	SLO-2					

Learning Resources	1. Rao, S.S., *he finite element method in engineering.* Butterworth-Heinemann. 2017 2. Bathe K.J. "Finite Element Procedures in Engineering Analysis", Prentice Hall, 2016.	3. J N Reddy "Introduction to Non-Linear Finite Element Analysis" McGraw Hill Book Company New York; 2016 4. Cook R.D., "Concepts and Applications of Finite Element Analysis", John Wiley and Sons Inc., New York, 1989.

	Bloom's Level of Thinking	**Continuous Learning Assessment (CLA) (60% weightage)**					**Final Examination (40% weightage)**	
		CLA-1 (20%)		**CLA-2 (25%)**		**CLA-3 (15%)**		
		Theory	**Practice**	**Theory**	**Practice**		**Theory**	**Practice**
Level 1	**Remember** **Understand**	20%	20%	20%	20%	20%	20%	20%
Level 2	**Apply** **Analyze**	20%	20%	20%	20%	20%	20%	20%
Level 3	**Evaluate** **Create**	10%	10%	10%	10%	20%	10%	10%
	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.Karthic Sethuraman, Valeo Pvt Ltd	Dr.Sundarajan Natarajan; IIT-madras	Dr.P.V.Jeyakarthikeyan, SRMIST
	Dr.Velamurali; ANNA university -chennai	Dr.P.Nandakumar, SRMIST

Course Code	20MEE602J	**Course Name**	*COMPOSITES MATERIALS - MECHANICS, DESIGN, AND MANUFACTURING*	**Course Category**	*E*	*Professional Elective*	L	T	P	C
							3	0	2	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:	Know the basics of composite materials.
CLR-2:	Acquire skills required in characterization of fiber-reinforced composites.
CLR-3:	Analyze the laminated composite beams.
CLR-4:	Predict the failure and design laminated composite.
CLR-5:	Acquire skills required in processing of different composite materials.
CLR-6:	Know the basic concepts, characterization, laminate analysis, failure prediction and processing techniques of composites.

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 (%)	Disciplinary Knowledge	Critical Thinking	Problem Solving	Analytical Reasoning	Research Skills	Team Work	Scientific Reasoning	Reflective Thinking	Self-Directed Learning	Multicultural Competence	Ethical Reasoning	Community Engagement	ICT Skills	Leadership Skills	Life Long Learning
CLO-1:	Understand the basics of composite materials.	1, 2	90	85	H	M	L	L	M	M	L	L	M	L	L	L	L	L	M
CLO-2:	Understand and practice the characterization of fiber-reinforced composites.	1, 2, 3	90	85	H	H	H	M	H	M	M	M	M	L	L	L	M	L	M
CLO-3:	Understand the analysis of laminated composite beams.	1, 2, 3	90	85	H	H	H	M	H	M	M	M	M	L	L	L	M	L	M
CLO-4:	Understand the failure prediction and design of laminated composite.	1, 2, 3	90	85	H	H	H	H	H	M	M	M	M	L	L	L	M	L	M
CLO-5:	Understand and practice the processing of different composite materials.	1, 2, 3	90	85	H	H	H	M	H	M	M	M	M	L	L	L	L	L	M
CLO-6:	Understand the basic concepts, characterization, laminate analysis, failure prediction and processing techniques of composites.	1, 2, 3	90	85	H	H	H	H	H	M	M	M	M	L	L	L	M	L	M

		Introduction	Mechanics and Performance	Analysis	Design	Manufacturing
Duration (hour)		**15**	**15**	**15**	**15**	**15**
S-1	SLO-1	Overview of materials - metals, polymers, ceramics	Develop concepts of volume and mass fractions, density, void content, and Rule of mixtures	Structural analysis of laminated beams	Failure theories for fiber-reinforced composites - Maximum stress theory and Maximum strain theory	Manufacturing of polymer matrix composites – Hand lay-up techniques
	SLO-2	Composite materials - Definition, Characteristics	Characteristics of fiber-reinforced lamina	Governing equations for beams	Azzi–Tsai–Hill theory, Tsai–Wu failure theory	Bag moulding process
S-2	SLO-1	Classification of composites	Elastic properties of lamina, stress – strain relationship for a thin lamina	Application of beam theory – bending	Problems on failure theories	Compression moulding process
	SLO-2	Fiber reinforced composites	Problems on stress – strain relationship for a thin lamina	Problems on laminated beams - bending	Failure prediction in unnotched laminates	Pultrusion process
S-3	SLO-1	Particle reinforced composites	Compliance and stiffness matrices of lamina	Application of beam theory – buckling	Failure prediction in notched laminates	Filament winding process
	SLO-2	Applications of composites	Problems on compliance and stiffness matrices of lamina	Problems on laminated beams - buckling	Problems on unnotched and notched laminates	Resin transfer molding, Resin film infusion process
S-4 & S-5	SLO-1	Demonstration on various constituent materials of composite	Measurement of density of lamina using Archimedes principle	Practice on stress – strain analysis of beams using software	Practice on modelling and analysis of laminates using software	Practice on fabrication of fiber reinforced polymer composites
S-6	SLO-1	Fibers – types, Characteristics	Lamination theory –laminate stresses and strains	Vibration analysis of composite beams	Laminate design consideration - Design philosophy	Structural reaction injection molding, Tube rolling process
	SLO-2	Characteristics of glass fibers	Force and moment resultants	Longitudinal vibration of laminated beam - governing equations	Design criteria, Design allowables	Forming methods - matched die forming, hydroforming, and thermoforming.
S-7	SLO-1	Characteristics of carbon fibers	Laminate stiffness matrix: A, B, D Matrix	Problems on longitudinal vibration of laminated beams	General design guidelines	Manufacturing of metal matrix composites - solid state processing – powder metallurgy
	SLO-2	Characteristics of ceramic, boron and aramid fibers	Problems on laminate stiffness matrix	Transverse vibration of laminated beams - governing equations	Laminate design for strength	Liquid state processing - different casting methods
S-8	SLO-1	Natural fibers - types	Interlaminar stresses in laminates	Problems on transverse vibration of laminated	Laminate design for stiffness	Manufacturing of ceramic matrix composites -

				beams		hot pressing technique
	SLO-2	Characteristicsof natural fibers	Mechanical properties of laminates – tensile, compressive properties	Reliability of composites	Design of bolted joints	Reaction bonding process, infiltration technique
S-9 & S-10	SLO-1	Practice on fiber surface treatments	Practice on mechanical testing of laminates	Practice on vibration analysis of composites using software	Practice on design and fabrication of composite bolted joints	Practice on fabrication of metal matrix composites
S-11	SLO-1	Matrix materials - characteristics	Shear, flexural properties of laminates	Finite element methods of analysis	Design of bonded joints	Quality inspection method – Radiography technique
	SLO-2	Polymer – characteristics of thermoset matrix	Fatigue properties of laminates	Problems on finite element methods of analysis	Design of an automotive drive shaft	Ultrasonic inspection
S-12	SLO-1	Characteristics of thermoplastic matrix	Impact properties of laminates	Analysis of hygrothermal stresses in laminates	Design of a beam	Acoustic Emission technique
	SLO-2	Characteristics of metal matrices	Thermal properties of laminate	Problems on hygrothermal analysis of laminated composites	Design of corvette leaf springs	Acousto-Ultrasonic method
S-13	SLO-1	Characteristics of ceramic matrices	Environmental effects on laminates	Analysis of sandwich structures	Design of thin pressure vessels	Thermography
	SLO-2	Fillers and other additives,	Fracture behavior and damage tolerance	Problems on analysis of sandwich structures	Design of tubes for space station truss structure	Laser Shearography
S-14 & S-15	SLO-1	Practice on incorporation of fillers in polymers	Practice on water absorption and flammability testing of laminates	Practice on thermal analysis of composites using software	Practice on design of composite product for certain applications	Practice on inspection of composites

Learning Resources	1. Mallick, P.K., "Fibre Reinforced composites: Materials, Manufacturing and Design", CRC Press, 2007 2. Agarwal, B.D and Broutman L.J, "Analysis and Performance of Fibre Composites", John Wiley and Sons, New York, 1990 3. Autar K. Kaw, "Mechanics of Composite Materials", CRC Press, New York, 2006	4. Gibson, R.F., "Principles of Composite Material Mechanics", McGraw-Hill, 2007 5. Halpin, J.C., "Primer on Composite Materials, Analysis", Techomic Publishing Co., 1984

	Bloom's Level of Thinking	Continuous Learning Assessment (CLA) (60% weightage)					Final Examination (40% weightage)	
		CLA-1 (20%)		CLA-2 (25%)		CLA-3 (15%)		
		Theory	Practice	Theory	Practice		Theory	Practice
Level 1	Remember Understand	20%	20%	20%	20%	20%	20%	20%
Level 2	Apply Analyze	20%	20%	20%	20%	20%	20%	20%
Level 3	Evaluate Create	10%	10%	10%	10%	20%	10%	10%
	Total	100 %		100 %		100 %	100 %	

CLA – 3 can be from any combination of these: Assignments, Seminars, Tech Talks, 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. Thanigaivelan, ,CSIR-Central Leather Research Institute, Adyar, Chennai thanik8@gmail.com	Prof. Debes Bhattacharyya, d.bhattacharyya@auckland.ac.nz University of Auckland, Newzeland	Dr. M. Kamaraj, SRMIST
2. Dr.R.Kalimuthu, ISRO, Mahendragiri, r_kalimuthu@vssc.gov.in		Dr. Shubhabrata Datta, SRMIST

3. Skill Enhancement Courses (S)

Course Code	20GNS501J	Course Name	RESEARCH PUBLISHING AND PRESENTING SKILLS	Course Category	S	Skill Enhancement	L	T	P	C
							1	0	2	2

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 :	*Practice different oral presentation material preparations*
CLR-2 :	*Practice presenting techniques suitable for different audiences*
CLR-3 :	*Prepare and typeset scientific documents for disseminating research findings*
CLR-4 :	*Analyze different disseminating techniques available*
CLR-5 :	*Utilize different intellectual property sharing mechanisms*
CLR-6 :	*Evaluate amongst different options available to present, publish research findings*

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 (%)	Disciplinary Knowledge	Critical Thinking	Problem Solving	Analytical Reasoning	Research Skills	Team Work	Scientific Reasoning	Reflective Thinking	Self-Directed Learning	Multicultural Competence	Ethical Reasoning	Community Engagement	ICT Skills	Leadership Skills	Life Long Learning
CLO-1 :	*Identify different oral presentation elements, materials and technologies*	*3*	*85*	*80*	*L*	*H*	*H*	*M*	*M*	*-*	*L*	*H*	*M*	*-*	*H*	*-*	*L*	*-*	*M*
CLO-2 :	*Practice high impact presentation skills*	*3*	*85*	*80*	*L*	*H*	*H*	*M*	*M*	*-*	*L*	*H*	*M*	*-*	*H*	*-*	*L*	*-*	*M*
CLO-3 :	*Identify ways to present technical / scientific content structure and elements*	*3*	*85*	*80*	*L*	*H*	*H*	*M*	*M*	*-*	*L*	*H*	*M*	*-*	*H*	*-*	*L*	*-*	*M*
CLO-4 :	*Practice the different disseminating techniques used in scientific research findings*	*3*	*85*	*80*	*L*	*H*	*H*	*M*	*M*	*-*	*L*	*H*	*M*	*-*	*H*	*-*	*L*	*-*	*M*
CLO-5 :	*Identify intellectual property and its components, ways to protect, share intellectual information*	*3*	*85*	*80*	*L*	*H*	*H*	*M*	*M*	*-*	*L*	*H*	*M*	*-*	*H*	*-*	*L*	*-*	*M*
CLO-6 :	*Analyze the different oral and written publishing techniques to disseminate research findings*	*3*	*85*	*80*	*L*	*H*	*H*	*M*	*M*	*-*	*L*	*H*	*M*	*-*	*H*	*-*	*L*	*-*	*M*

		Oral Content Preparation	Presenting Methods	Written Content Preparation	Publishing Methods	Intellectual Property & Plagiarism
Duration (hour)		9	9	9	9	9
S-1	SLO-1	*Oral Presentation Structure: Manuscript, Impromptu, Memory, Extempore*	*Describe Audience; knowledge, Experience, Needs, Goals*	*Writing Preface, Prelude, Prologue, foreword, Introduction, Abstract,*	*Typesetting: LaTex, Word, XML etc.,*	*Public License, Creative Commons, Share-alike, Reciprocal License,*
	SLO-2	*context, need, agenda ,task, and object of the presentation document*	*Plan, Prepare, Practice, Present Creating a Positive First Impression,*	*Writing Dedication, Acknowledgement, Forward, Background*	*Indexing: ISI, SCI, SCIE, SCOPUS, SCIMAGO, ESCI, WoS,*	*Copyleft, Patentleft, Open patent, Public Domain*
S 2-3	SLO-1 SLO-2	*Practice-1: Create Structure of a Presentation*	*Practice-4: Building rapport with Audience*	*Practice-7: Writing Preface, Prelude, Prologue, foreword, Introduction, Abstract*	*Practice-12: LaTex Editor, Word Editor*	*Practice-13: GNU-GPL, Public License Creative Commons License, Unlicense*
S-4	SLO-1	*Gather data, evidence to present, visual-auditory balance, engagement techniques*	*Increasing Credibility, Presenting Complex Material, Communicating with Impact*	*Literature Review: Narrative, Systematic, Argumentative, Integrative, Theoretical*	*Disseminating Research Findings: Public Domain, Open Information, Wikipedia*	*Intellectual Property Rights, Copyrights, Patents, Trademarks, and Trade secrets*
	SLO-2	*Introduction, body, closure, question-answer*	*Motivating Others, Responding to Pressure Situations, Inspiring People*	*Writing Problem Statement, Limitations, Method Adapted, Tools & Technology used*	*Media, Press Release, Flyers, Brochure, Research Summary, Posters, Websites*	*Industrial design rights, Plant variety rights, trade dress, geographical indications*
S 5-6	SLO-1 SLO-2	*Practice-2: Create a structured oral presentation module*	*Practice-5: Communicating with Greater Impact, Rehersals and Retrials*	*Practice-8: Writing Literature Review*	*Practice-11: Study of Various Open Publishing Methods*	*Practice-14: IPR Law, Private Domain*
S-7	SLO-1	*Tools: Presentation Slides, Whiteboard Animators, Immersive Technologies*	*Delivery Styles: Visual, Freeform, LessigInstructor, Coach, Storytelling, Connector*	*Main Body: Analysis, Design, Development Steps, Implementation Steps, Evaluations*	*Patents, Journals, Conferences, Reports, RFCs etc.,*	*Infringements: Copylefts, Copyrights, Patentlefts, Patentrights,*
	SLO-2	*Handouts, Visual Aids, Demonstrative Aids, Thought Provoking Questions*	*Persuasive, Interactive, Decision Making, Educational, Takahasi Arousing*	*Referencing: Documentary, Parenthetical, Numbered, Vancouver, IEEE, Harvard etc.,*	*Journal Index, Impact Factor, Quality Standards*	*Plagiarism: Paraphrasing, Verbatim, Mosaic, Global, Self, Accidental etc.,*
S 8-9	SLO-1 SLO-2	*Practice-3: Demonstrating a multi technology oral presentation*	*Practice-6: Presenting same content using different delivery styles*	*Practice-9: Writing Main Body*	*Practice-12:Study of h-index, i10-index, g-index, r-index, π - index*	*Practice-15: Plagiarism checking and correcting techniques*

Learning Resources	
	1. Dale Carnegie, "Develop Self-Confidence, Improve Public Speaking", Amazing Reads, 2018 *2. Dale Carnegie, "The Art of Public Speaking", Amazing Reads, 2018* *3. Joseph Mugah, "Essentials of Scientific Writing: How to Write Effective Titles and Abstracts for Research Papers and Proposals", Authorhouse, 2016*
	4. Rajesh Singh, Sanjeev Kumar Sinha, Samir Kumar, "Unfolding Intellectual Property Rights : A Practical Patent Guide for Researchers, Academicians and start-ups", Notion Press, 2019 *5. Robert P. Merges, Peter S. Menell, Mark A. Lemley, " Intellectual Propertyin New Technological Age",2016*

Learning Assessment

	Bloom's Level of Thinking	Continuous Learning Assessment (60% weightage)						Final Examination (40% weightage)	
		CLA – 1 (20%)		CLA – 2 (25%)		CLA – 3 (15%)			
		Theory	Practice	Theory	Practice	Theory	Practice	Theory	Practice
Level 1	Remember Understand	*20%*	*20%*	*15%*	*15%*	*15%*	*15%*	*15%*	*15%*

Level 2	Apply	*20%*	*20%*	*20%*	*20%*	*20%*	*20%*	*20%*	*20%*
	Analyze								
Level 3	Evaluate	*10%*	*10%*	*15%*	*15%*	*15%*	*15%*	*15%*	*15%*
	Create								
	Total	100 %		100 %		100 %		100 %	

CLA – 3 can be from any combination of these: Assignments, Seminars, Tech Talks, 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. Sainarayanan Gopalakrishnan, HCL Technologies, sai.jgk@gmail.com	*1. Dr. Venkat Adhikari, Technology Licensing Manager, IISC, venkatadhikari@iisc.ac.in*	*1. Dr. Rajeev Sukumaran SRMIST*
2. Dr. Sricharan Srinivasan, Wipro Technologies, sricharanms@gmail.com	*2. Mr.Ateet Palmurkar, Senior Manager IP Licensing, IITM, ipmarketing@iitm.ac.in*	*2. Dr. V. Nithyananthan SRMIST*

Course Code	20MES501J	Course Name	RESEARCH METHODS IN MECHANICAL SCIENCES	Course Category	S	Skill Enhancement Course	L	T	P	C
							2	0	2	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		
		1	2	3
		Level of Thinking (Bloom)	Expected Proficiency (%)	Expected Attainment (%)
CLR-1:	formulate the research problem			
CLR-2:	explain carrying out a literature search, its review, developing theoretical and conceptual frameworks and writing a review			
CLR-3:	explain the details of sampling designs, measurement and scaling techniques and also different methods of data collections.			
CLR-4:	devise and design an experimentation set-up			
CLR-5:	explain the art of interpretation and the art of writing research reports.			
CLR-6:	give an overview of the research methodology and explain the technique of defining a research problem			

Course Learning Outcomes (CLO):	At the end of this course, learners will be able to:	Level of Thinking (Bloom)	Expected Proficiency (%)	Expected Attainment (%)	Disciplinary Knowledge	Critical Thinking	Problem Solving	Analytical Reasoning	Research Skills	Team Work	Scientific Reasoning	Reflective Thinking	Self-Directed Learning	Multicultural Competence	Ethical Reasoning	Community Engagement	ICT Skills	Leadership Skills	Life Long Learning
		1&2	100	95	L	M	M	L	H	M	L	L	H	M	H	L	H	L	H
CLO-1:	formulate the research problem	1&2	100	95	L	M	M	L	H	M	L	L	H	M	H	L	H	L	H
CLO-2:	explain carrying out a literature search, its review, developing theoretical and conceptual frameworks and writing a review	1&2	100	95	L	M	M	L	H	M	L	L	H	M	H	L	H	L	H
CLO-3:	explain the details of sampling designs, measurement and scaling techniques and also different methods of data collections.	1&2	100	95	L	M	M	L	H	M	L	L	H	M	H	L	H	L	H
CLO-4:	devise and design an experimentation set-up	1&2	100	95	L	M	M	L	H	M	L	L	H	M	H	L	H	L	H
CLO-5:	explain the art of interpretation and the art of writing research reports.	1&2	100	95	L	M	M	L	H	M	L	L	H	M	H	L	H	L	H
CLO-6:	give an overview of the research methodology and explain the technique of defining a research problem	1&2	100	95	L	M	M	L	H	M	L	L	H	M	H	L	H	L	H

Program Learning Outcomes (PLO): 1 2 3 4 5 6 7 8 9 10 11 12 13 14 15

		Research Preparation and Planning	Research Resource)	Data Collection, Analysis, and Inference	Scientific Experimentation	Academic writing and Presentation
Duration (hour)		9	9	9	9	9
S-1	SLO-1	Introduction - Meaning of research	Sources of information	Basic statistical measures and their uses	Principles of experimentation	Proposal submission for funding agencies, Elements of style.
	SLO-2					
S-2	SLO-1	Objectives of Research	Literature survey - World wide web – Online data bases	Measures of central tendency and dispersion, Skewness, and Kurtosis.	Basic experimental designs: Completely randomized design, randomized block design and Latin square design	Organization of proposals
	SLO-2					
S-3	SLO-1	Characteristics of a research problem	Citation indices - Principles underlying impact factor – literature review	Sample size determination and sampling techniques: Random sampling, stratified sampling		Research report writing
	SLO-2					
S-4	SLO-1	Critical thinking	Case studies, review articles and Meta-analysis	systematic sampling, and cluster sampling.	Factorial designs:22, 23, and 24	Communication skills
	SLO-2					
S-5	SLO-1	Techniques for generating research topics	record of research review -- Role of the librarian	Large sample tests and small sample tests: Test for sample mean, difference between two sample properties.		Tailoring the presentation to target audience – Oral presentation, poster presentation.
	SLO-2					
S-6	SLO-1	Topic selection and justification	Ethical and Moral Issues in Research	Student test, F-test, and $\chi 2$ test and their applications in research studies.	Types of research designs: Explorative, descriptive, and diagnostic.	Submission of research articles for publication in refereed journals
	SLO-2					
S-7	SLO-1	Techniques involved in designing a questionnaire	Plagiarism, tools to avoid plagiarism	Correlation and Regression Analysis – Time series analysis: Forecasting methods.		Thesis writing, research report writing
	SLO-2					

S-8	SLO-1	Methods of scientific enquiry	Intellectual Property Rights	Basic statistical distribution and their applications: Binomial, Poisson, Normal, Exponential, Weibull and Geometric distributions.	Factor analysis. Cluster analysis and discriminant analysis (basic ideas only)	Elements of excellent presentation, Preparation and Visual delivery.
	SLO-2					
S-9	SLO-1	Development of a research proposal	Copy right laws – Patent rights			Oral communication skills and oral defense
	SLO-2					

Learning Resources	1. Ganesan R, Research Methodology for Engineers, MJP Publishers, Chennai. 2011. 2. Walpole R.A., Myers R.H., Myers S.L. and Ye, King: Probability & Statistics for Engineers and Scientists, Pearson Prentice Hall, Pearson Education, Inc. 2007. 3. Anderson B.H., Dursaton, and Poole M.: Thesis and assignment writing, Wiley Eastern 1997. 4. Bijorn Gustavii: How to write and illustrate scientific papers? Cambridge University Press. 5. Bordens K.S. and Abbott, B.b.: Research Design and Methods, Mc Graw Hill, 2008.	6. Graves N, Varma V: Working for a doctorate Toutledge 1997. 7. Graziano, A., M., and Raulin, M.,L.: Research Methods – A Process of Inquiry, Sixth Edition, Pearson, 2007. 8. Leedy., P., D.: Practical Research – Planning and Design, Eighth Edition, Pearson., 2005. 9. Kothari C.K., Research Methodology- Methods and Techniques (New Age International, New Delhi), 2004.

	Bloom's Level of Thinking	*Continuous Learning Assessment (CLA) (60% weightage)*					*Final Examination (40% weightage)*	
		CLA-1 (20%)		*CLA-2 (25%)*		*CLA-3 (15%)*		
		Theory	*Practice*	*Theory*	*Practice*		*Theory*	*Practice*
Level 1	*Remember* *Understand*	*20%*	*20%*	*20%*	*20%*	*20%*	*20%*	*20%*
Level 2	*Apply* *Analyze*	*20%*	*20%*	*20%*	*20%*	*20%*	*20%*	*20%*
Level 3	*Evaluate* *Create*	*10%*	*10%*	*10%*	*10%*	*20%*	*10%*	*10%*
	Total	*100 %*		*100 %*		*100 %*	*100 %*	

CLA – 3 can be from any combination of these: Assignments, Seminars, Tech 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. KR. Arun prasad, SRMIST

4. Open Elective Courses (O)

5. Project Work, Internship in Industry / Higher Technical Institutions (P)

Course Code	20MEP601L	Course Name	INTERNSHIP	Course Category	P	Internship In Industry / Higher Technical Institutions	L	T	P	C
							0	0	8	4

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

Course Learning Rationale (CLR):	The purpose of learning this course is to:
CLR-1 :	Provide an exposure to an industrial environment or research laboratory / institution
CLR-2 :	Acquire practical knowledge of theoretical concepts
CLR-3 :	Understand the organization structure, functions and protocols

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 :	Appreciate the functioning of an organization	1	70	65
CLO-2 :	Apply the theoretical concepts to solve engineering problems	2	80	75
CLO-3 :	Take up different roles in a career with confidence	3	65	60

Program Learning Outcomes (PLO)	1 Disciplinary Knowledge	2 Critical Thinking	3 Problem Solving	4 Analytical Reasoning	5 Research Skills	6 Team Work	7 Scientific Reasoning	8 Reflective Thinking	9 Self-Directed Learning	10 Multicultural Competence	11 Ethical Reasoning	12 Community Engagement	13 ICT Skills	14 Leadership Skills	15 Life Long Learning
CLO-1	H	H	H	H	M	H	H	H	M	H	M	M	M	L	M
CLO-2	H	H	H	H	H	H	H	H	H	M	H	M	H	H	H
CLO-3	H	M	L	L	M	M	M	M	L	L	L	L	L	M	M

1. It is mandatory for every student to undergo this course.
2. Every student is expected to spend a minimum of 4 to 6 weeks in an Industry/ Company/ Organization, during the summer vacation between II and III semester
3. The type of industry must be NOT below the Medium Scale category in his / her domain of the degree programme.
4. The student must submit the "Training Completion Certificate" issued by the industry / company / Organisation as well as a technical report not exceeding 15 pages, within the stipulated time to be eligible for making a presentation before the committee constituted by the department.
5. The committee will then assess the student based on the report submitted and the presentation made.
6. Marks will be awarded out of maximum 100.
7. Appropriate grades will be assigned as per the regulations.
8. Only if a student gets a minimum of pass grade, appropriate credit will be transferred towards the degree requirements, as per the regulations.
9. It is solely the responsibility of the individual student to fulfill the above conditions to earn the credits.
10. The attendance for this course, for the purpose of awarding attendance grade, will be considered 100%, if the credits are transferred, after satisfying the above (1) to (8) norms; else if the credits are not transferred or transferable, the attendance will be considered as ZERO.
11. The committee must recommend redoing the course, if it collectively concludes, based on the assessment made from the report and presentations submitted by the student, that either the level of training received or the skill and / or knowledge gained is NOT satisfactory.

Assessment for Semester Internship

	Final Evaluation (100% weightage)	
	Report along with completion certificate from company	Viva-Voce
Semester Internship	50 %	50 %

Course Code	20MEP602L	Course Name	MINOR PROJECT	Course Category	P	Project Work	L	T	P	C
							0	0	8	4

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

Course Learning Rationale (CLR):	The purpose of learning this course is to:	Learning		
		1	2	3
		Level of Thinking (Bloom)	Expected Proficiency (%)	Expected Attainment (%)
CLR-1 :	Conceptualize a novel idea / technique			
CLR-2 :	Think in terms of social or commercialapplications			
CLR-3 :	Understand the management techniques of implementing a project			
CLR-4 :	Prepare a technical report and presentin a professional manner			

Course Learning Outcomes (CLO):	At the end of this course, learners will be able to:	Level of Thinking (Bloom)	Expected Proficiency (%)	Expected Attainment (%)	Program Learning Outcomes (PLO)														
					1	2	3	4	5	6	7	8	9	10	11	12	13	14	15
					Disciplinary Knowledge	Critical Thinking	Problem Solving	Analytical Reasoning	Research Skills	Team Work	Scientific Reasoning	Reflective Thinking	Self-Directed Learning	Multicultural Competence	Ethical Reasoning	Community Engagement	ICT Skills	Leadership Skills	Life Long Learning
CLO-1 :	Identify and solve simple engineering / biological problems	1	70	65	H	H	H	H	M	H	H	H	M	H	M	M	M	L	M
CLO-2 :	Assess the feasibility of project commercialization	2	80	75	H	H	H	H	H	H	H	H	H	M	H	M	H	H	H
CLO-3 :	Manage the implementation of a project	3	65	60	H	M	L	L	M	M	M	M	L	L	L	L	L	M	M
CLO-4 :	Document a project report	3	75	70	H	H	H	H	L	M	H	M	H	M	M	M	H	M	H

- An in-house project to be taken up by the individual student and complete the minor project before the end of III semester
- The project can be a development of an experimental kit/ method, an innovative concept or idea or methodology or algorithm / technique, a 3D model, simulation, prototype product, blueprint for a larger project or any other similar developmental work that the respective department approved by the department, are permitted.
- The student must be attached to a faculty supervisor / mentor
- A comprehensive report is to be submitted.
- A presentation is to be made on the work done by the student to committee of reviewers

Learning Assessment weightage

	Continuous Learning Assessment (70% weightage)		Final Evaluation (30% weightage)	
	Review I	Review II	Report	Viva-Voce
Minor Project	20 %	50 %	15 %	15 %

Course Code	20MEP603L	Course Name	PROJECT WORK PHASE - I	Course Category	P	Project Work	L	T	P	C
							0	0	12	6

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

Course Learning Rationale (CLR):	The purpose of learning this course is to:	Learning		
CLR-1 :	Provide students with the opportunity to explore a problem or issue of particular personal or professional interest	1	2	3
CLR-2 :	Address the problem or issue through focused study and applied research	Level of Thinking (Bloom)	Expected Proficiency (%)	Expected Attainment (%)
CLR-3 :	**Prepare a technical report and presentin a professional manner**			

Course Learning Outcomes (CLO):	At the end of this course, learners will be able to:	Level of Thinking (Bloom)	Expected Proficiency (%)	Expected Attainment (%)
CLO-1 :				
CLO-2 :				
CLO-3 :				

Program Learning Outcomes (PLO)														
1	2	3	4	5	6	7	8	9	10	11	12	13	14	15
Disciplinary Knowledge	Critical Thinking	Problem Solving	Analytical Reasoning	Research Skills	Team Work	Scientific Reasoning	Reflective Thinking	Self-Directed Learning	Multicultural Competence	Ethical Reasoning	Community Engagement	ICT Skills	Leadership Skills	Life Long Learning

- The project work (Phase – I) is the preparatory phase for the major project to be taken up during the final semester of the programme.
- Each student is expected to identify an engineering problem in his / her specialization of study.
- Each student must study in-depth the issues / causes & effects underlying the problem and define the objective of the subsequent work.
- A faculty supervisor / mentor will be assigned to each project.
- A report of the work done during Phase – I must be submitted at the end of the semester, for evaluation.
- Assessment will be made as per the table below:

	Continuous Learning Assessment (70% weightage)			Final Evaluation (30% weightage)	
	Review - 1	Review -2	Review - 3	Project Report	Viva-Voce
Project Work (Phase I)	15 %	25 %	30 %	15 %	15 %

Course Code	20MEP604L	Course Name	PROJECT WORK PHASE - II	Course Category	P	Project Work	L	T	P	C
							0	0	32	16

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

Course Learning Rationale (CLR):	The purpose of learning this course is to:	Learning		
		1	2	3
CLR-1 :	Provide students with the opportunity to explore a problem or issue of particular personal or professional interest	Level of Thinking (Bloom)	Expected Proficiency (%)	Expected Attainment (%)
CLR-2 :	Address the problem or issue through focused study and applied research			
CLR-3 :	Demonstrate the student's ability to synthesize and apply the knowledge and skills acquired in his/her academic program to real-world issues and problems			
CLR-4 :	Affirm students' ability to think critically and creatively, to solve practical problems, to make reasoned and ethical decisions, and to communicate effectively			
CLR-5 :	Prepare a technical report and present in a professional manner			

Course Learning Outcomes (CLO):	At the end of this course, learners will be able to:	Level of Thinking (Bloom)	Expected Proficiency (%)	Expected Attainment (%)
CLO-1 :				
CLO-2 :				
CLO-3 :				

Program Learning Outcomes (PLO)															
1	2	3	4	5	6	7	8	9	10	11	12	13	14	15
Disciplinary Knowledge	Critical Thinking	Problem Solving	Analytical Reasoning	Research Skills	Team Work	Scientific Reasoning	Reflective Thinking	Self-Directed Learning	Multicultural Competence	Ethical Reasoning	Community Engagement	ICT Skills	Leadership Skills	Life Long Learning

- The project work Phase - II is to extend their academic experience into areas of personal interest, working with new ideas, issues, organizations, and individuals.
- The project shall be driven by realistic constraints like that related to economic, environmental, social, political, ethical, health & safety, manufacturability and sustainability.
- A report of the work done during Phase – II must be submitted at the end of the semester, for evaluation.
- Assessment will be made as per the table below:

	Continuous Learning Assessment (70% weightage)			Final Evaluation (30% weightage)	
	Review - 1	Review -2	Review - 3	Project Report	Viva-Voce
Project Work (Phase I)	15 %	25 %	30 %	15 %	15 %

NOTE:

1. The CLO must be filled by each department as per their programme objectives
2. Learning and Programme Learning Outcomes will vary for each project and must be filled for each project, documented and kept in the department for future reference.

6.Audit Courses (M)

7. Mandatory Courses (M)

Course Code	20PDM501T	Course Name	Career Advancement Course for Engineers-I	Course Category	M	Mandatory	L	T	P	C
							1	0	1	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 :	Become an expert in communication and problem solving skills
CLR-2 :	Recapitulate fundamental mathematical concepts and skills
CLR-3 :	Strengthen writing skills professionally and understand commercial mathematical applications
CLR-4 :	Identification of relationships between words based on their function, usage and characteristics
CLR-5 :	Sharpen logical and critical reasoning through skillful conceptualization
CLR-6 :	Acquire the right knowledge, skill and aptitude to face any competitive examination

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 :	Acquire communication and problem solving skills	2	80	75	-	H	-	H	-	-	-	-	H	H	-	H	-	-	-
CLO-2 :	Build a strong base in the fundamental mathematical concepts	2	75	70	-	H	-	H	-	-	-	-	H	H	-	H	-	-	-
CLO-3 :	Acquire writing skill to communicate with clarity	2	80	75	-	H	-	H	-	-	-	-	H	H	-	H	-	-	-
CLO-4 :	Use apt vocabulary to embellish language	3	75	70	-	H	-	H	-	-	-	-	H	H	-	H	-	-	-
CLO-5 :	Gain appropriate skills to succeed in preliminary selection process for recruitment	3	85	80	-	H	-	H	-	-	-	-	H	H	-	H	-	-	-
CLO-6 :	Enhance aptitude skills though systematic application of knowledge	2	85	80	-	H	-	H	-	-	-	-	H	H	-	H	-	-	-

Duration (hour)		6	6	6	6	6
S-1	SLO-1	Types of numbers, Divisibility tests	Fractions and Decimals, Surds	Percentage - Introduction	Sentence Correction	Number and Alphabet Series
	SLO-2	Solving Problems	Solving Problems	Solving Problems	Practice	Direction Test
S-2	SLO-1	LCM and GCD	Square roots, Cube roots, Remainder	Percentage Problems	Reading Comprehension	Blood Relations
	SLO-2	Solving Problems	Solving Problems	Solving Problems	Practice	ArrangementsLinear, Circular
S-3	SLO-1	Unit digit, Number of zeroes, Factorial notation	Identities	Profit and Loss	Reading Comprehension	Ranking
	SLO-2	Solving Problems	Solving Problems	Solving Problems	Practice	Practice
S-4	SLO-1	Verbal Reasoning-Vocabulary	Spotting Errors	Discount	Reading Comprehension	Critical Reasoning-Strengthening
	SLO-2	Practice	Practice	Solving Problems	Practice	Practice
S-5	SLO-1	Verbal Reasoning-Vocabulary	Spotting Errors	Sentence Correction	Linear Equations	Critical Reasoning-Weakening
	SLO-2	Practice	Practice	Practice	Solving Problems	Practice
S-6	SLO-1	Verbal Reasoning-Vocabulary	Spotting Errors	Sentence Correction	Logical Reasoning-Intro	Critical Reasoning-Assumption
	SLO-2	Practice	Practice	Practice	Coding and Decoding	Practice

Learning Resources

1. Khattar D. "Quantitative Aptitude", Pearson's Publications, Third Edition (2015).
2.Praveen R.V. "Quantitative Aptitude and Reasoning", EEE Publications, Third Edition (2016)
3.Guha A. "Quantitative Aptitude", TATA McGraw Hill Publications, Sixth Edition (2017).
4. P.A. Anand, "Quantitative Aptitude for Competitive Examination", WILEY Publications (2019)
5. Arihant. "IBPS PO - CWE Success Master", Arihant Publications(I) Pvt.Ltd – Meerut, First Edition (2018)
6.Nishit Sinha. "Verbal Ability for CAT", Pearson India, First Edition (2018).
7. Archana Ram, "Placementor", Oxford University Press, (2018)
8.Bharadwaj A.P. " General English for Competitive Examination", Pearson Education, First Edition (2013)
9. Thorpe S. "English for Competitive Examination", Pearson Education, Sixth Edition (2012).

Learning Assessment :

	Bloom's Level of Thinking	Continuous Learning Assessment (CLA) (60% weightage)				Final Examination (40% weightage)	
		CLA-1 (30%)		CLA-2 (30%)		Fully Internal	
		Theory	Practice	Theory	Practice	Theory	Practice
Level 1	Remember Understand	40 %	-	30 %	-	30 %	-
Level 2	Apply Analyze	40 %	-	40 %	-	40 %	-
Level 3	Evaluate Create	20 %	-	30 %	-	30 %	-
	Total	100 %		100 %		100 %	

Note: CLA-2 (Surprise Test, Assignment -1, Assignment -2)

Course Designers		
Experts from Industry	Internal Experts	
1. Mr. Ajay Zener, Career Launcher, ajay.z@careerlauncher.com	*1. Dr. P. Madhusoodhanan, Head CDC, SRMIST*	*2. Dr. M. Snehalatha,, Assistant Professor, SRMIST*
	3. Mr. J.Jayapragash , Assistant Professor, SRMIST	*4. Dr.A.Clement, Assistant Professor, SRMIST*

Course Code	20PDM502T	Course Name	Career Advancement Course For Engineers - II	Course Category	M	Mandatory	L	T	P	C
							1	0	1	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 building the resume*
CLR-2 :	*Become an expert in communication and problem solving skills*
CLR-3 :	*Sharpen interpretational skills through skillful conceptualization,*
CLR-4 :	*Sharpen analytical reasoning skills and professional skills*
CLR-5 :	*Utilize professionalism with idealistic, practical and moral values that govern the behavior*
CLR-6 :	*Acquire the right knowledge, skill and aptitude to face any competitive examination*

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 :	*Build a strong base in the fundamental mathematical concepts and resume*	2	80	75	-	H	-	M	-	-	-	-	H	H	-	H	-	-	-
CLO-2 :	*Acquire communication and problem solving skills.*	2	75	70	-	H	-	M	-	-	-	-	H	H	-	H	-	-	-
CLO-3 :	*Gain appropriate skills to succeed in preliminary selection process for recruitment*	2	80	75	-	H	-	M	-	-	-	-	H	H	-	H	-	-	-
CLO-4 :	*Acquire interpretational skills and professional skills*	3	75	70	-	H	-	M	-	-	-	-	H	H	-	H	-	-	-
CLO-5 :	*Develop professionalism with idealistic, practical and moral values*	3	85	80	-	H	-	M	-	-	-	-	H	H	-	H	-	-	-
CLO-6 :	*Enhance lexical skills through systematic application of concepts and careful analysis of style, syntax, semantics and logic*	2	85	80	-	H	-	M	-	-	-	-	H	H	-	H	-	-	-

Duration (hour)		6	6	6	6	6
S-1	SLO-1	*Ratio and Proportion-Intro*	*Sets-Rules*	*Group Discussion-3*	*Data Sufficiency-Intro*	*Personal Interview*
	SLO-2	*Solving Problems*	*Solving Problems*	*Practice*	*Solving Problems*	*Practice*
S-2	SLO-1	*Ratio and Proportion*	*Sets-Identities, Venn Diagram*	*Group Discussion-4*	*Data Sufficiency*	*Personal Interview*
	SLO-2	*Solving Problems*	*Solving Problems*	*Practice*	*Solving Problems*	*Practice*
S-3	SLO-1	*Mixture and Solutions-Intro*	*Functions-Intro*	*Group Discussion-5*	*Analytical Reasoning-Intro*	*Mock Interview*
	SLO-2	*Solving Problems*	*Solving Problems*	*Practice*	*Solving Problems*	*Mock Interview*
S-4	SLO-1	*Mixture and Solutions*	*Group Discussion- Do's and Don'ts*	*Data Interpretation-Intro*	*Analytical Reasoning*	*Mock Interview*
	SLO-2	*Solving Problems*	*Practice*	*Solving Problems*	*Solving Problems*	*Mock Interview*
S-5	SLO-1	*Profile Building*	*Group Discussion-1*	*Data Interpretation-Tables, Pie Chart*	*Personal Interview-Do's and Don'ts*	*Mock Interview*
	SLO-2	*Profile Building*	*Practice*	*Solving Problems*	*Practice*	*Mock Interview*
S-6	SLO-1	*Resume Building*	*Group Discussion-2*	*Data Interpretation-Lines, Bar Graphs*	*Personal Interview*	*Quantitative Reasoning Revision*
	SLO-2	*Resume Building*	*Practice*	*Solving Problems*	*Practice*	*Solving Problems*

Learning Resources

1. Khattar D. "Quantitative Aptitude", Pearson's Publications, Third Edition (2015).
2.Guha A. "Quantitative Aptitude", TATA McGraw Hill Publications, Sixth Edition (2017).
3.Butterfield J. "Soft Skills for Everyone", Cengage Learning India Private Ltd, First Edition, (2011).
4. Bono E.D. "Six Thinking Hats is a book" , Little Brown and Company, First Edition (1981)
5.P.A. Anand, "Quantitative Aptitude for Competitive Examination", WILEY Publications (2019)
6. Archana Ram, "Placementor", Oxford University Press, (2018)

Learning Assessment :

	Bloom's Level of Thinking	Continuous Learning Assessment (CLA) (60% weightage)				Final Examination (40% weightage)	
		CLA-1 (30%)		CLA-2 (30%)		Fully Internal	
		Theory	Practice	Theory	Practice	Theory	Practice
Level 1	Remember Understand	40 %	-	-	30 %	30 %	-
Level 2	Apply Analyze	40 %	-	-	40 %	40 %	-
Level 3	Evaluate Create	20 %	-	-	30 %	30 %	-
	Total	100 %		100 %		100 %	

Course Designers		
Experts from Industry	Internal Experts	
1. Mr. Ajay Zener, Career Launcher, ajay.z@careerlauncher.com	*1. Dr. P. Madhusoodhanan, Head CDC, SRMIST*	*2. Dr. M. Snehalatha,, Assistant Professor, SRMIST*
	3. Mr.P.Priyanand , Assistant Professor, SRMIST	*4. Mrs.Kaviatha Srisarann, Assistant Professor, SRMIST*

Course Code	20PDM601T	Course Name	Career Advancement Course For Engineers - III	Course Category	M	Mandatory	L	T	P	C
							1	0	1	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 :	acquire knowledge on planning, preparing and designing a learning program
CLR-2 :	prepare effective learning resources for active practice sessions
CLR-3 :	facilitate active learning with new methodologies and approaches
CLR-4 :	create balanced assessment tools
CLR-5 :	hone teaching skills for further enrichment
CLR-6 :	define standards, goals and objectives

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 :	Build a strong foundation in designing a lesson plan	2	80	75	-	H	H	H	M	-	-	-	H	H	-	H	-	-	-
CLO-2 :	Acquire knowledge of learning resources for effective delivery	2	75	70	-	H	H	H	M	-	-	-	H	H	-	H	-	-	-
CLO-3 :	Sharpen teaching skills with the latest methodologies and techniques	2	80	75	-	H	H	H	M	-	-	-	H	H	-	H	-	-	-
CLO-4 :	Develop practical assessment tools to ensure validity and flexibility	3	75	70	-	H	H	H	M	-	-	-	H	H	-	H	-	-	-
CLO-5 :	Enhance effective presentation and teaching methods	3	85	80	-	H	H	H	M	-	-	-	H	H	-	H	-	-	-
CLO-6 :	Reinforce Bloom's Taxonomy of educational goals and objectives	2	85	80	-	H	H	H	M	-	-	-	H	H	-	H	-	-	-

Duration (hour)		6	6	6	6	6
S-1	SLO-1	Lower and Higher order learning	Definition and purpose of assessment	Peer Teaching practice	Live Teaching Sessions	Live Teaching Sessions
	SLO-2	Outcomes from lower order learning	Practice	Discussion and feedback	Live Teaching Sessions	Live Teaching Sessions
S-2	SLO-1	Planning and preparing a learning programme and session	Distinction between formative and summative assessment	Peer Teaching practice	Live Teaching Sessions	Live Teaching Sessions
	SLO-2	Practice	Examples and discussions	Discussion and feedback	Live Teaching Sessions	Live Teaching Sessions
S-3	SLO-1	Teacher and Student-Centered class room	Instructional materials	Cooperative learning procedure	Live Teaching Sessions	Live Teaching Sessions
	SLO-2	Discussion	Examples and discussion	Different models of cooperative learning	Live Teaching Sessions	Live Teaching Sessions
S-4	SLO-1	Roles of teachers and students	Instructional design	Limitations of cooperative learning	Live Teaching Sessions	Live Teaching Sessions
	SLO-2	Discussion	Practice	Discussion	Live Teaching Sessions	Live Teaching Sessions
S-5	SLO-1	Discussion Strategies	Presentation of lesson plans	Structure of a lecture	Live Teaching Sessions	Live Teaching Sessions
	SLO-2	Practice	Discussion	Practice	Live Teaching Sessions	Live Teaching Sessions
S-6	SLO-1	Bloom's Taxonomy of educational goal	Group Work in learning	Live Teaching Sessions	Live Teaching Sessions	Live Teaching Sessions
	SLO-2	Practice	Discussion	Live Teaching Sessions	Live Teaching Sessions	Live Teaching Sessions

Learning Resources	
	1. Barker I. "Cambridge International Diploma for Teachers and Trainers", Cambridge University Press, 2006. 2.Whitehead Jack, Creating a Living Educational Theory from Questions of the kind: How do I improve my Practice? Cambridge Journal of Education, 2006 3. Vicki Phillips and Lynn Olson, "Ensuring Effective Instruction: How do I improve teaching using multiple measures?"Bill & Melinda Gates Foundation, 2013 4. Dr G M Chaudhary, "Teaching Methodology: Effective Teaching Strategies", Independently Published , 2019

Learning Assessment :

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

Note: **CLA-1 (Lesson Plan Design)** **CLA-2 (Assessment Tools)** **CLA-3 (Teaching Practice)**

Course Designers		
Experts from Industry	Internal Experts	
1. Mr Ajay Zener, Career Launcher, ajay.z@careerlauncher.com	*1. Dr. P. Madhusoodhanan, Head CDC, SRMIST*	*2. Dr. M. Snehalatha,, Assistant Professor, SRMIST*
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